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Supply-Chain Network Monitoring System using Power BI: Information-Collaboration Based

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Declaration

I hereby confirm that the attached master thesis is my own work and that it has not been used for other examination purposes; I have named all the sources and auxiliary material used, and I have marked appropriately quotations used verbatim or which I have given the gist of. I tolerate the check using anti-plagiarism software.

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Table of contents

Table of Figures

List of Abbreviations

BI	Business Intelligence
DAX	Data Analysis Expressions
DBMS	Database Management System
DSC	Digital Supply Chain
ERP	Enterprise Resource Planning
GUI	Graphical User Interface
KPIs	Key Performance Indicators
PwC	Price Waterhouse Cooper
RFC	Remote Function Calls
RFID	Radio Frequency Identification
SaaS	Software as a Service
SC	Supply Chain
SCC	Supply Chain Collaboration
SCM	Supply Chain Management
SMEs	Small & Medium-Sized Businesses
UCC	University Competence Center

1. Introduction

1.1 Overview

In today's competitive business world, organizations try to improve their company performance and strength. This motivates businesses to adopt smart business strategies and work toward cost optimization to facilitate quick and informed decision-making. The increased use of information technology in today's world is causing a radical shift in how to conduct business and make decisions (Seyedghorban, Tahernejad et al. 2020). As the volume and diversity of organizational data grow, businesses need business intelligence (BI) solutions to translate vast volumes of data into useful business insights (Jalil, Prapinit et al. 2019). Businesses utilize supply chain analytics to better understand their datasets and make more informed decisions about their operational and logistical processes. With Power BI, it is simple to create dashboards for supply chain networks (SCN) and analyses data. A company's performance is impacted by the deployment of a SCN that manages all supply chain levels, from stakeholders and business processes to the end customer. To retain the management of this network across all business stakeholders, it is essential to secure the contribution paradigm between all organizational levels (Oncioiu, Bunget et al. 2019).

Supply chain management (SCM) is now essential for any large-scale or small-scale industry. The primary objective of any industry is to enhance the supply chain and select the key indicators for optimization and improve the efficiency of the system (Allaoui, Guo et al. 2019). Nowadays suppliers and their customers do not contribute enough in terms of data sharing and compliance sharing. This issue will have a major influence on the development of BI monitoring systems using Power BI and other visualization tools (Darwiesh, El-Baz et al. 2022). Businesses are suffering, though, from the high cost of SCN monitoring systems and the various regulatory standards because of it. Numerous third-party companies are developing BI systems, but the prices for client participation are unaffordable. The real problems exist not only in creating the key performance indicators (KPIs) that are meaningful for SCN dashboards but also in developing a low-cost monitoring system that businesses can rely on to increase decision-making accuracy (van de Ven, Lara Machado et al. 2022).

In this thesis, will be used BI for SCM data analysis. The word "BI" is widely used to refer to the methods and tools used to collect data, store it, make it accessible to users, and then analyze

it to help in decision-making. BI provides the information and analysis needed to make choices and take actions that will improve organizational performance.

BI is a set of tools and methods that supports strategic planning and well-informed decision-making. Additionally, it provides beneficial and actionable business information that can boost productivity, give a company a competitive edge, encourage more innovation, and generally assist in its expansion (Shiau, Chen et al. 2022). The majority of businesses are attempting to make use of the enormous amounts of data by transforming complex data into useful information and business insights. Business managers constantly require business insights, not just information, at the right time and in the right format to make timely and effective decisions and successfully complete organizational goals. BI helps transform data into useful information so that businesses can gain a competitive edge (Wang and Wang 2019).

Many researchers have given a lot of definitions of the supply chain (SC). SC is composed of several interconnected tasks that are regulated, coordinated, and managed from the supplier to the client. The exchange of products, information, and money links every activity in a supply chain together. The control of these flows may belong to one of the stages or an intermediate, and they typically flow in the directions (Mathew 2021).

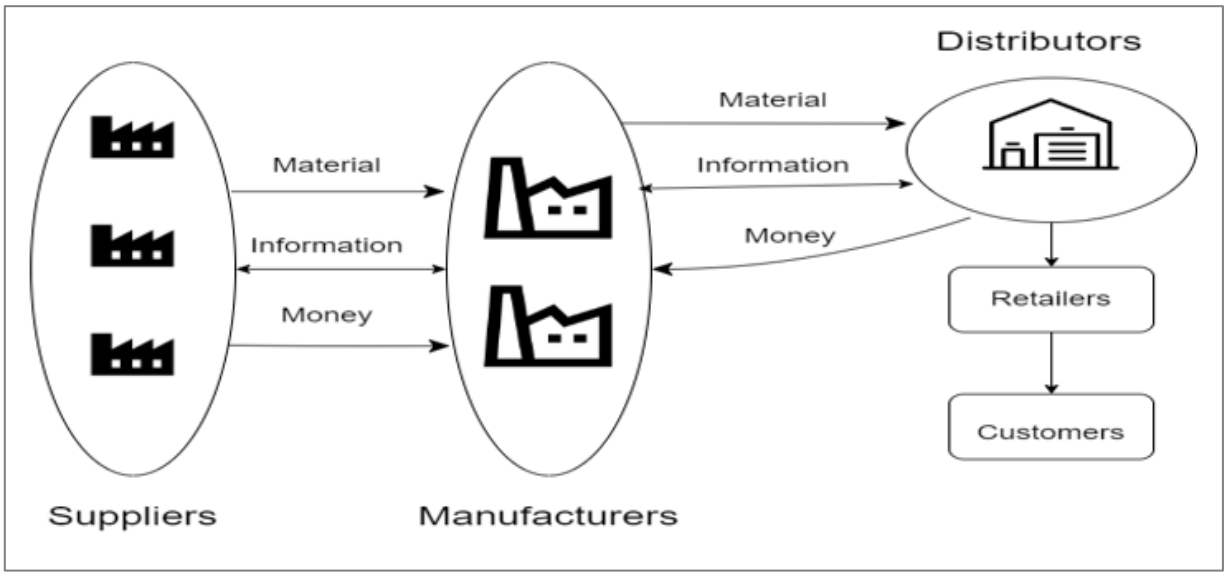


Figure 1. Supply Chain Network Model. Adapted after (Novas 2020)

A supply chain is a group of organizations that collaborate to turn raw materials into finished products for consumers. Each entity carries out a particular function that is necessary for this transformation. A simple SCN framework is shown in Figure 1.

A supply chain is the network of all parties involved in fulfilling a consumer request. This supply chain links suppliers, manufacturers, distributors, retailers, customers, and information. The primary characteristic of the supply chain is the combination of processes used for supplier, manufacturing, and delivery. Three possible categories for supply chain constraints are cost, time, and uncertainty. First, the cost of the individual product may be the primary competitive factor. Second, the lead time for the finished product, production of a new product, or the ramp-up of manufacturing, time may be of the essence. Third, uncertainty could be the largest issue due to the lack of management and accurate predictive results (Verhoef and Bijmolt 2019).

1.1.1 Main elements of Supply Chain

The most important task for an efficient SC is maintaining high flexibility by the control of cost-efficiency. Financial efficiency can be improved by controlling costs. During the process, accurate and adequate collection of information on the costs is the major key element. (Calleja, Corominas et al. 2018).

The entire process of planning, monitoring, and measuring stage needs the support of cost-saving at each step which can be only done by collecting and analyzing information. To have a proper flow, expense reports must be logically implemented.

Cost management can be structured as: defining goals and objectives, identifying supply chain costs, defining key cost drivers, identifying opportunities for cost elimination or reduction, developing a road map, implementing and monitoring the supply chain business objectives. To increase the profit and competitiveness of a company, the focus is the reduction in cost and the creation of relationships with other participants.

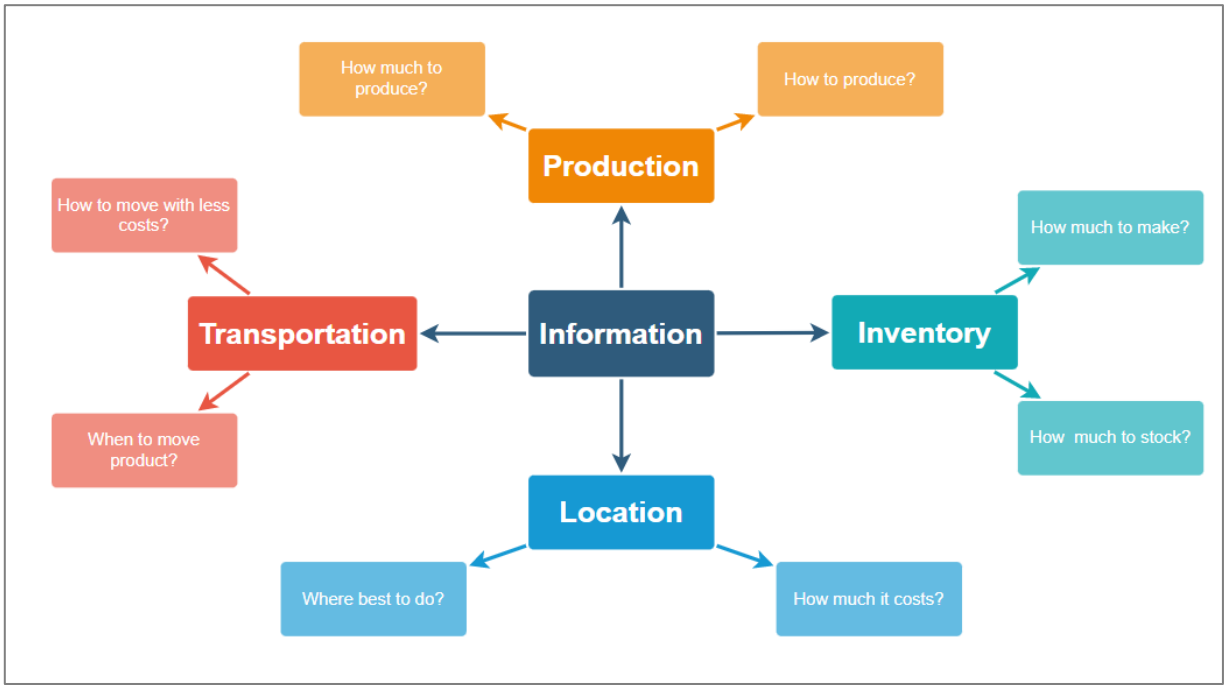


Figure 2. Supply Chain Drivers. Adapted after (Mhugos 2020)

To optimize the responsiveness, efficiency, and capabilities of SC is important to show the five structural drivers (Figure 2). Once goals and objectives are set, the Supply Chain cost, and flow must be classified. At this point, the company to meet the customer necessity, needs to make strategic choices through the structural drivers (information, production, inventory, location, and transportation).

1.1.2 Performance measures of Supply Chain Management

Measuring SC performance is crucial for both direct and indirect performance as well as behavior control (Gunasekaran, Patel et al. 2001).

There are two general categories for supply chain performance measures:

- Qualitative analyses (consumer satisfaction)
- Quantitative analyses (latency time, response time, usage of resources, and effectiveness of delivery)

Quantitative measures are divided into two primary categories: non-financial and financial. Non-financial performance measures include for cycle time, customer service standards, inventory levels, and resource use. A few examples of financial measurements are the cost of raw materials, sales revenue, and activity-based expenses like those related to material handling,

production, assembly, etc., inventory costs, transportation costs, information costs, etc. The performance measures must be picked carefully to determine current performance (Leończuk 2016).

1.1.3 Supply Chain Risks and Uncertainties

Risks are often interpreted as unreliable and uncertain resources leading to supply chain interruptions. Whereas uncertainties are related to supply and demand mismatches in SC processes. The outcome of the risk and the expectation of its sources are the key determinants of it. If the outcome of an event is not sure, and the worst cases are known, it is a risk and even if the worst cases are not known, it becomes uncertainty (Tchernykh, Schwiegelsohn et al. 2019). SC risks can be classified into three categories:

- Likelihood that an event will occur
- Consequences of the event
- Sources and causal processes of the event

In general, SC risks fall into two major categories such as

- Supply risks
- Operational risks

Supply risks relate to any adverse event in the inbound supply causing failures from suppliers or the supply market results in the inability of the main firms to meet the demand within the anticipated costs or time (Brindley 2017).

Operational risks account for the possibility of any adverse event affecting the internal ability of the firm to produce goods/services, maintain quality and timelines of the production or the profitability of the company (Xu, Pinedo et al. 2017).

Risks that occur in supply networks can come from many different sources and can vary in severity. Risk elements can be categorized as follows:

- Material flow risks: involve the risk related to the physical flow of supply chain elements. A majority of supply risks, process risks and demand risks are material flow risks (Shahbaz, Rasi et al. 2019).
- Financial flow risks: are any type of risks related to financing. This includes all financial transactions, credit terms, payment schedules, and other accounting activities. It is

frequently assumed that it exclusively refers to downside risk, which is the possibility of suffering a financial loss and the unknown size of that loss (Pfohl and Gomm 2009).

- Information flow risks are essentially any damage that occurs in the company`s data, vital systems, and operational procedures. It is the risk connected to ownership, operation, involvement, and firms' business processes such as schedules, dispatched orders, and orders delivery status (Kang 2013)

1.2 Problem Statement

Most businesses find it extremely difficult to track their logistic operations, deliveries, sales, etc. There are, indeed, currently, two major issues with SC networks. First, what is frequently addressed in this industry, is the lack of collaboration between suppliers and their clients originating from a variety of challenges that can be categorized in many ways (Kanda and Deshmukh 2008). Second, nowadays a lot of money is spent on current SC network monitoring systems, which can be a big investment for the companies once they subscribe in a third-party service providers. Knowing that, such monitoring systems can be implemented as a low-cost system by the company itself. As a result, businesses that provide these services are responsible for getting what their clients want to pay and complying with their requirements.

1.3 Research Objectives

The research objectives for this project are mentioned below:

- Describing the absence/lack of cooperation between suppliers and their clients.
- Identifying the enablers, barriers, and resistors of SC collaboration issue.
- Providing possible solutions for the lack of collaboration problem through the SCN monitoring system.
- Power BI is used to build a low-cost SCN monitoring system.
- Implementing this monitoring system by measuring some relevant metrics.

1.3.1 Research Motivation

In this thesis, will be highlighted the lack of supply chain collaborations (SCC) and pinpointed the key issues that suppliers and their clients face. Several barriers and enablers of SCC issue will be discussed and will focus on those enablers involved in the monitoring system. Power BI

(a BI tool) can handle and enhance the entire supply chain process through a powerful analysis and monitoring of the processes, especially for small and medium-sized businesses (SMEs) (Büyüközkan and Göçer 2018). The supplier will only need to provide data to its client 'Watchmaker AG' (a proposed company that produces watches). The supplier is not required to participate in the entire monitoring system and invest their time and effort in supporting their clients. After both the 'Watchmaker AG' and the supplier give the data, several requirements to acquire a Power BI-based low-cost monitoring system will be listed and discussed, to make more confident decisions. Depending on the number of pertinent KPIs, two reports will be created which will be summarized in one interactive dashboard. The dashboard will track a few metrics describing and evaluating the relationship between the supplier and 'Watchmaker AG' company.

1.3.2 Research Questions

The research questions for this project are:

- What are the current obstacles between suppliers and their customers in supply chain network collaboration? And what are the possible enablers?
    - Which enabler/s should be considered in the supply chain network monitoring system to minimize the lack of collaboration problem?
- What are the requirements to build up a low-cost supply chain network monitoring system using Power BI? And what are the main steps to implement it?
    - Which KPIs should be shown to represent this supply-chain network monitoring system?

2. Literature Review

2.1 Supply Chain Management

SCM is the most vital, complex, wide ranging and at the same time also the most ignored sphere in the functioning of a traditional business organization (Zekhnini, Cherrafi et al. 2020). The efficiency or performance of an organization is a direct function of its SC efficiency. The human factor is the most important attribute in determining the efficiency of a supply chain. A well-managed supply chain, manned by motivated employees ensures timely deliveries at competitive prices thereby, saving two most important resources for a business enterprise namely- time and money. This would result in improved performance and efficiency of an organization providing a competitive edge to it in a highly complex and dynamic business environment (Min, Zacharia et al. 2019).

Controlling the development and distribution of goods from suppliers to customers is known as SCM. The team or supply chain manager in charge, is managing the supply chain processes, is responsible to ensure that the success of the operations. The network of all people, organizations, resources, tasks and technological developments involved in manufacture and distribution of an item is known as SC. The transfer of raw materials from the supplier to the producer to the ultimate delivery to the client is all included in the SC (Rajeev, Pati et al. 2017).

There are no identical supply chains (Wieland and Durach 2021). In every organization, there are various factors like the nature of the industry, its geographic location and the scope of its work, the suppliers, the products to be manufactured, the variety of products, local laws & regulations, and the most important one is the demand pattern or the customer base which influences its supply chain.

Differently from other disciplines, like economics or accountancy, SC does not have an old history. It can be called ‘new discipline’, but then its importance since decades cannot be undermined. The principle “Getting the right people and the appropriate supplies to the right place at the right time and in the proper conditions” is followed since centuries and therefore, it is possible to say that the supply chain may be a new discipline, but its importance is still the same as it was centuries ago (Covert 2020).

From the business perspective, the supply chain originated decades ago. The activities involved in a supply chain like purchasing materials, managing stocks, storing the material in warehouses,

processing orders, transportation of orders and ultimately making it available to the end-users are carried out since the beginning of the trade. In earlier times, the term 'Supply Chain Management' did not exist even though each of the said activities had its own priority, its own budget, and process. The costs involved were too high and gradually the owners, managers, and leaders realized the problem faced due to fragmented activities and therefore started integrating all the involved activities. This integration resulted in an increase in profits, saving of time and resources, and better customer satisfaction. Hence the concept of 'Supply Chain Management' evolved (Gualandris, Longoni et al. 2021).

Supporting manufacturing, work inbound transportation, purchase of material and other activities related to the production of goods were coordinated. Further, management of inventory, processing of the orders, and other outbound transport were categorized under physical distribution. These were later known as 'logistic' functions of a supply chain. The supply chain is formed when many related organizations synchronize their respective specializations and thereby result in the formation of a brand new and fully abled system called a 'supply chain'. These specializations include raw material procurement, finances, marketing products, planning, and use of the latest technology in processing the product, packing, transportation, warehousing and finally reaching the product into the hands of the end-user (Cutting-Decelle, Young et al. 2007).

Supply chain as a discipline has evolved over a period of three decades, and, still, many organizations are in the primary stage of its adoption as a complete process for itself. Whereas many others have a very strong supply chain on their own. Once an organization channelizes its internal resources with the external relationships of the supporting enterprises, it is said to have come a long way in making and maintaining its effective ties with the supporting companies, thereby creating a supply chain. This integration is bound to help the organization in taking its profit graph higher (Asgari, Nikbakhsh et al. 2016).

2.1.1 The Importance of Supply Chain

The supply chain helps businesses in saving money. It enables manufacturers and retailers to move only what they can sell. By doing this, the unnecessary costs related to creating, securing, and shipping inventory that a business cannot sell are eliminated (Lambert and Cooper 2000).

In the supply chain most companies face challenges and experience inefficiency. It is basically about proper planning of all the activities which are carried out till the final product reaches the

end-user ‘customer’. This includes planning, sourcing, processing, and delivering goods. These activities collectively help in deciding the cost and quality of the product finally reaching the customer as per the market demand. It is one of the longest processes involved in the company activities and if not handled properly may lead to complete failure (Chu, Yang et al. 2017). A survey conducted by Deloitte in 2014, found that 79% of companies with best performing supply chains achieve a much higher percentage of growth in their revenues compared to the mean revenues in the same industry (Marchese 2014) .

This confirms the fact that a successful and productive supply chain can improve the bottom line of any industry.

2.1.2 Supply Chain Training and Cost Reduction

The main aim of an organization is to minimize its input costs and maximize its profits. The costs can be reduced by improving and optimizing its supply chain in a streamlined manner. To enable this, the company shall ensure to have well trained employees. Organizing trainings and development of its employees to reduce costs related to material handling, inventory management, transportation, procurement, etc. Training also helps employees to become more competitive and productive. In a study by ‘Price waterhouse Cooper’ (PwC), emerged that businesses that have an optimal supply chain were found to have a 15% cost reduction (Jaharuddin, Mohamed et al. 2014).

There is always a fine line when it comes to differentiating between appropriate cost and excessive cost-cutting in a supply chain. When the employees are imparted training, they should be taught to cut down the activities which have no value addition to the work. The employees also should endeavor to reduce poorly managed costs such as that transportation, procurement, inventory, and storage. A well-trained employee can lead to successful cost-cutting in a supply chain, thereby making it more cost-effective (Lambert and Enz 2017).

2.1.3 Customer Satisfaction in Supply Chain

The most important factor which decides the success of any business is customer service and customer satisfaction (Omoruyi and Mafini 2016). A satisfied customer will spread the positive word, which would eventually lead to better business opportunities and higher profits for the business organization. Therefore, the main focus should always be on customer satisfaction

through proper supply chain strategies. Employees should also be trained similarly wherein their main emphasis should be on maintaining cordial relations with the customer.

The consulting firm Gartner, in 2014, predicted that by the year 2016, 89% of the companies would compete based on their customer service. Organizations with a poor supply chain can never satisfy their customers (Sorofman J. 2014). Issues such as delayed customer service, shortage of inventory, delay in launching competitive products, poor quality products, bad services, etc. can have an adverse effect on the supply chains of the company (Pant and Mahapatra 2018).

2.2 Differences between Supply Chain Management and Supply Chain

The logistic network is commonly referred to as supply chain (Creazza, Dallari et al. 2010). It is generally made up of manufacturers, retailers, warehouses, distribution centers, and suppliers. It also includes raw materials, inventories for work-in-progress, and finished goods that move between the sites. SCM is a set of strategies used to effectively connect suppliers, manufacturers, warehouses, and retail outlets to create and deliver items in the appropriate amounts, to the right locations, and at the right time. As a result, service level requirements are met, and system expenses are decreased.

By optimizing various supply chain components, companies can expand, reduce prices, and raise revenue. Figure 3 shows a list of the major SC dimensions:

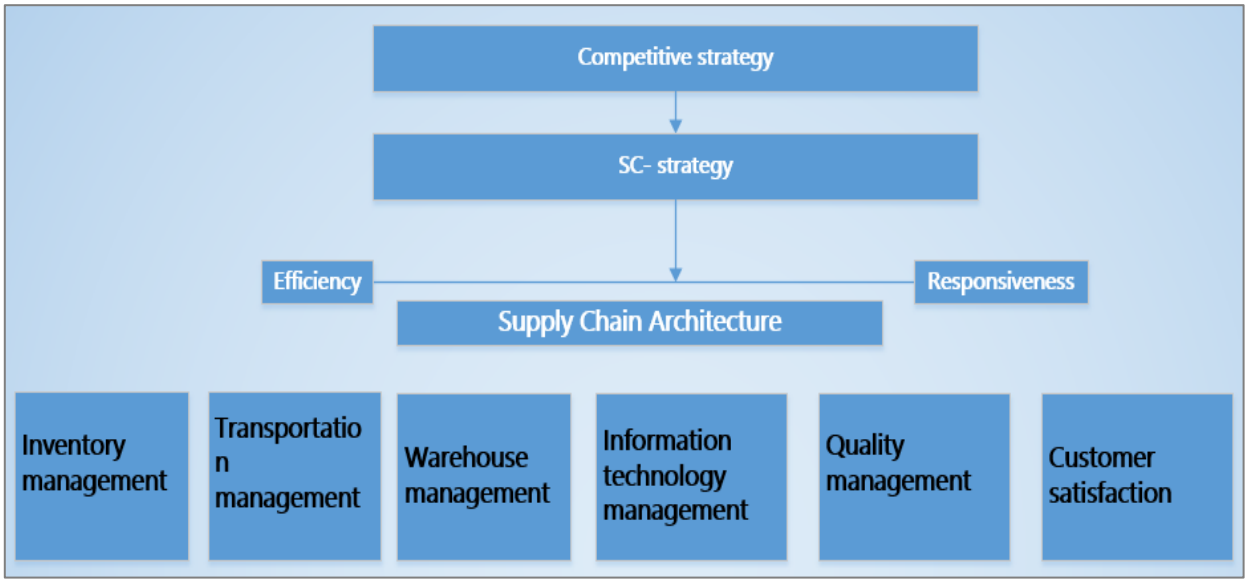


Figure 3. SC Architecture Diagram. Adapted after (Anderson, Jacobs et al. 2008)

Here is a basic explanation of the above-mentioned dimensions:

1. Inventory management

The management of the supply chain effectively depends on inventory decisions (Singh and Verma 2018), which are one of the central problems in SCM research. The inventory decision's goals are to satisfy external demand while minimizing total inventory costs by regulating the order point, and the order quantity, and maintaining items at the proper time, amount, and location. Today's businesses use Stock Keeping Unit level data to manage inventory in addition to Radio Frequency Identification (RFID) Technology to maintain inventories in remote areas.

2. Transportation management

Transportation is the act of moving commodities from one distribution channel node to another. Transportation promotes a larger & deeper penetration of new markets distant from the source of production by allowing the swift and uninterrupted flow of commodities back and forth across the distribution channel. Optimizing vehicle, and material handling capacity, cargo demands, and effective transportation also enable distributors to benefit from economies of scale by lowering the per-unit cost of transporting the goods (Crainic and Laporte 2016).

3. Warehouse and storage management

The "warehousing" portion of a company's logistics operation oversees handling and storing inventory from the point of supplier receipt to the point of consumption. Keeping current, accurate records of the inventory's condition, location, and distribution is essential for managing this operation. A company's choice to construct a warehouse may be influenced by a variety of elements, including the kind of distribution business, the firm's worth, the amount of inventory, its potential for obsolescence, the level of competition, and the status of the economy (Ackerman and Brewer 2017).

4. Information technology management

Information is essential to a supply chain's effectiveness since it serves as the basis for organizational processes and the execution of transactions. Information technology serves as management's eyes and ears in a supply chain by integrating hardware and software to acquire and analyze the data necessary to make informed choices (Singh and Teng 2016).

5. Quality management

The supply chain idea is becoming more and more popular, and one of the reasons for this is the quality revolution. Quality management practices have been shown to assist businesses in delivering high-quality goods and services, doing well overall, controlling expenses, and eventually gaining a competitive edge. Quality plays a significant role in the value-adding process involved in the production and distribution of commodities along the supply chain. Additionally, organizations may avoid merely responding to client requests and instead try to satisfy them more proactively by incorporating quality management into all aspects of the supply chain (Bastas and Liyanage 2018).

6. Customer satisfaction

The pressure on enterprises to find innovative ways to provide higher value to customers and gains in profitability, ease of maintenance, and lower supply chain costs has significantly increased as a result of the rapidly evolving global economy and marketplace. Effective SCM makes high-value-added business prospects, better and enhanced customer satisfaction, and greater profits for designers and manufacturers possible (Lekkakos and Serrano 2016).

2.3 Business Intelligence in Supply Chain Management

Business intelligence (BI) enhances real-time data analyses by granting them self-service features. BI takes a step further by giving users the ability to create their reports and run their own ideas, even if they have no prior knowledge of statistical methods. BI enables businesses to extract patterns and current trends from their data to help in avoiding overstocking due to the improved market demand understanding. Additionally, it aids supply chain managers in real-time order tracking and precise arrival forecasting, which enhances customer service access (Habul and Pilav-Velic 2010).

BI principles relate to the application of digital computing tools, such as data warehousing, analytics, and visualization, to locate and examine crucial business-based data to provide the most updated and useful corporate insights (Kasemsap 2018).

A shipping company may use business intelligence to get insights into several areas, including shipping routes, check and drop-off timings, payload capacities, rates, turnovers, bookings, on-time performances, and packing and unpacking times. Businesses may use business intelligence to gain insights into what their opponents are doing and to create plans after performing their background research. Furthermore, a business that continuously monitors its internal systems has an advantage over one that does not (Kasemsap 2018).

The main purpose of BI is to help managers, senior executives, and other operational staff members make better decisions that are backed up by solid facts. Ultimately, it will help them to find new business opportunities, cost reductions, or ineffective processes that need to be re-engineered. Business intelligence software are used to transform enormous volumes of data into clear insights. The application receives data from other data sets as well as an organization's Enterprise Resource Planning (ERP) system using a sync tool. The BI tool analyses the data sets and then presents the findings in meaningful reports and dashboards. To maintain compliance requirements, the manufacturer obtains the data they require from BI. The monitoring and improvement of each component, which results in long-term increases in profitability, is the most important function that BI performs in boosting production processes (Niu, Ying et al. 2021).

2.3.1 Data warehouse: definition and method of construction

A data warehouse is characterized by (Inmon 1992):

- Organized by subjects: in decision support systems, data are organized to analyze subjects of interest like transaction focus, operational systems, specific applications, or business functions.
- Integrating: the integration of data from heterogeneous sources occurs through a process of extracting, transforming, and loading data from various sources to the data warehouse.
- Non-volatile: data are characterized by read-only access and are not subject to changes. Therefore, they maintain their integrity over time.
- Time Variation: while operational databases keep only the most recent data, a data warehouse is designed to provide strategic decision support.
- Decision support: is the ability to respond quickly to business questions from company executives.

Data warehouse is a database organized by subject; each subject of interest can be considered, in turn, as a smaller data warehouse, a subset of the source database known as a data mart.

A data mart is a subset of the data in the data warehouse and is generally designed to meet the needs of a specific function of a business (PE, Amadi et al.). Therefore, the data warehouse represents the company's entire information system, while the information within an individual data mart is closely related to the business area of interest.

A data warehouse can be created through a top-down or bottom-up approach (Figure 4).

The top-down approach consists of designing the entire data warehouse and only then extracting individual data marts from it. This solution is based on a global view of the objective and ensures the realization of a consistent and well-integrated data warehouse known as a data-driven approach (Inmon 1992).

In the bottom-up approach, on the other hand, the data warehouse is built by iteratively assembling different data marts. This solution allows, in the

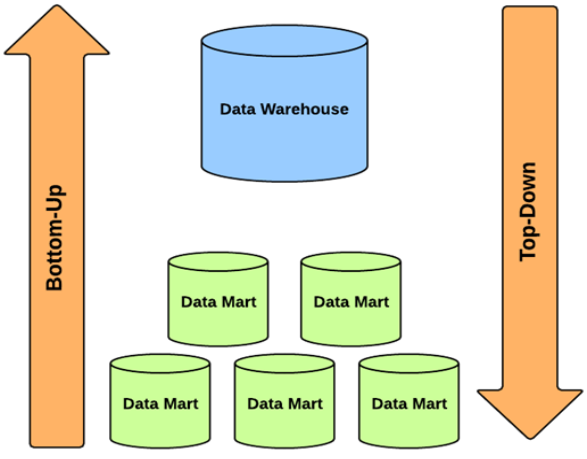


Figure 4. Data Warehouse Structure. Adapted after(Albano 2015)

design phase, to shift the focus to the individual business area and thus to build the individual data marts in a short time known as an analysis-driven approach (Kimball 1996).

2.3.2 BI accessibility in Supply Chain Management

While appealing to customers that are seeking supply chain visibility, SCM is critical for organizations. Businesses may see the movement of items through the system by mapping and monitoring the supply chain. This allows for a better understanding of the flow from suppliers and the identification of issues (Perboli, Musso et al. 2018).

2.3.3 BI and significance of monitoring systems in Supply Chain Network

The most significant role of BI is to ensure that the product is delivered to the consumer on time. The tracking of transient services accompanying area deliveries is aided by business intelligence tools. If delivery takes longer than intended, the responsible management can swiftly take corrective actions.

BI is not only concerned about product monitoring; it also keeps track of external aspects such as gasoline costs, delivery prediction charges, and other company expenses. In other terms, to maximize revenues, the company gets every small detail that needs to be recorded (Huang, McIntosh et al. 2017).

Demand planning is another component of SCM that heavily relies on business intelligence. Demand management is essential since it provides the volume of output needed for the company to turn a profit. Solutions for business intelligence assist in demand forecasting. The tools predict the amount of time and resources required to meet customer expectations by combining historical data, market segmentation, and sales pipeline data (Agrawal and Narain 2018).

The following are some of the main factors assuring why supply chain businesses require BI (Jalil, Prapinit et al. 2019):

- It increases sales.
- Its acceptance rate in the industrial and supply sectors is around 40%.
- It improves client satisfaction and the user experience.
- It improves the business application.
- It promotes consumer interaction (increases the time spent within the application).

2.4 Collaboration issues in Supply Chain

Collaboration between supply chain partners, may promote higher moral and environmental standards, seek to increase supply chain transparency, and exert more control over areas of the supply chain that are difficult to modify. Working with suppliers has benefits such as shorter lead times for products, faster order fulfillment, access to continuous supply, and greater resource use. To have product design and more efficient market responses, companies and their clients have to commit to (Silvestre, Monteiro et al. 2018):

- Effective collaboration is affected by traditional approaches to supplier relationships, organizational warehouses, and network infrastructure.
- Close collaboration with suppliers helps to acquire corporations to support their suppliers in expanding their skills and capabilities to better meet future needs and reduce supply risk.
- Generally, a lack of trust among trading partners demands the investigation and validation of every transaction, raising transaction costs to unacceptably high levels. The two pillars of supply chain goals, effectiveness, and efficiency, suffer and production declines.
- Businesses are finding it harder and difficult to encourage cooperation. Their challenges include minimizing competitiveness, getting to know each other better, and enhancing communication among team members, companies, and consumers.
- One of the things supply chain partners must think about when building their network, is the value of the connection, each party's operational responsibilities and decision-making authority, the execution of contractual arrangements, and the formation of dispute resolution procedures.
- People do not spend enough time getting to know each other. Their respective skills, backgrounds, and expertise are unknown. As a result, they do not recognize the value that each team member can bring to the table. For this, there is a lack of transparency, possession, and clarity to move things forward.

From the description above, it should be clear that the ensuing lack of coordination has a substantial detrimental influence on the operation of the supply chain.

2.4.1 Successful Supply Chain Collaboration

The following six steps will help the company and its SCC to succeed (Duong and Chong 2020):

1. Making sensible partner selections

A company before deciding partner has to look into its reputation, current infrastructure, and marketing strategies. Talking about their interests and values can help the company to determine whether the businesses are compatible or not. Make sure to choose a logistics partner that upholds the brand standards and offers a high-quality customer experience.

2. Sharing the expertise

True success in cooperation requires that all participants are eager to share the information and skills they have. Take the lead and make the effort to explain to the logistic partners the difficulties related to the requirements. This will give the partner the knowledge needed to create the best plan of action for everyone concerned.

3. Creating a framework for shared performance management

The company wants a set of expectations for behavior that the company itself and the partners can both agree upon. Using this, they can ensure the greatest levels of efficiency and assess efficacy. Over the duration of the project.

4. Acquiring the relevant tools

Make sure all the partners have the necessary tools, resources, and labor to carry out their tasks. If not, investing now will be effective rather than waiting until issues arise.

5. Thinking about the future

Effective partnerships keep the long term in mind and look beyond the currently assigned task. Companies can ensure to have effective systems in place to support their business as it grows by making future plans. Long-term collaborative supply chain partnerships frequently promote innovation, creating new opportunities and product ideas.

6. Establishing communication first

Teams can not function effectively without good communication strategies. To take advantage of opportunities and overcome hurdles, is important to make sure to have the processes and strategies in place to communicate successfully throughout time. This may help to avoid any major problems that might later develop and harm the business by taking the time now to implement these six actions.

These are necessary actions necessary to grow and succeed as a partnership. By following these guidelines, it is possible to create a SCC that is worth and efficient in both the short and long term (Duong and Chong 2020).

3. Methodology

3.1 Solutions/enablers to cooperation problems

According to all managers, the biggest hurdles to efficient SC cooperation are information infrastructure, measurement, and technology. Tradition, trust, refusal to change and tolerance for collaboration are some of the recorded aspects of human issues to solve (Sarkar, Omair et al. 2020). One argument is that advancements in technology, information systems, and measurement lead to findings that can be confirmed as accurate. Members may or may not utilize the same measures, and different systems can or cannot be aligned. It is possible to overcome each obstacle by using the same measurement method. When dealing with human barriers such as mistrust and selfishness, solutions become more of a question of interpretation than a problem. Managers should not overlook to issues such as organizational structure and culture, as well as team dynamics while establishing solutions to SC (Yudhistyra, Risal et al. 2020).

3.1.1 People are connecting factor (human behavior across several aspects)

More than half of the managers said that training is one of the requirements for a long-term SC implementation's success in a wide variety of ways. SC training boosts overall organizational member support for SC decisions and provides top management with a vantage point to determine priorities and delegate tasks. Managers competent in their field and good communicators with a wide range of functional coworkers are preferable (Gupta, Kumar et al. 2020). Several SC organizations are formed by committees made up of senior-level executives, to promote cross-functional collaboration and get buy-in from particular initiatives inside their own company. Whereas the tasks and responsibilities of working groups vary greatly, commissioners usually convene to discuss and review ideas. The benefits and drawbacks of SC projects are publicly discussed during sessions to fully explain, modify, and ultimately promote usable solutions. Most managers surveyed stated, that, without dedicated pilot efforts, to demonstrate the value of SCM, SC projects would fail to sell themselves effectively. These case studies are required to build confidence and justify substantial funding for SC efforts. The mix of success stories and expertise makes well-designed schemes an essential link to SC success (Yadav and Singh 2020). Active SC corporations create supplier councils also for services or technologies, which serve as factors that have an impact on new concepts. Forums of customer

advisors are also employed in this way. To get input on how the business could better serve their requirements as customers, representatives of the consumers are asked to engage as active members of boards. None of the firms, interviewed by Chang and Chen in 2020, created advisory councils that include members from each of the three groups previously discussed: the organization, its vendors, and its users.

The major point from the survey questionnaire (Chang and Chen 2020) is that enhancing people's business practices through expanded teamwork, collaboration, and cross-communication fills the existing gaps in SCM. Moreover, it also allows middle, upper-middle, and senior-level managers to succeed more quickly and obtain more from SC cooperation. SCM is greatly facilitated using modern information technology. However, people are the backbone of the SCM's success. Indeed, when he was interviewed, one SCM director clearly stated, "Humans are the bridge or the hurdle for SC coordination."

3.1.2 Corporations need to interact with their vendors

Many businesses keep distant their vendors. As a result, while corporations may have access to basic information about their suppliers, the true business plans of their manufacturers stay hidden. Working with suppliers would be a fundamental first step in raising understanding of supply chain operations. Like suppliers relate to environmental responsibility, also companies are under pressure to take environmental responsibility across the organizations in their supply chains (Adobor and McMullen 2007).

Because of the importance of close relationship between vendors and suppliers, Baker formed the vendor support services unit in 2014 (Backer 2016). Because of this collaboration, suppliers were more cost-effective and environmentally responsible. Lee & Tang were able to increase their review project capacity throughout the supply chain (Lee and Tang 2018).

Fan et.al analyzed which information any SC should share with the public after achieving supply chain visibility (Fan, Cheng et al. 2016). This example generates the terms of scalability: How and why should businesses collaborate with their suppliers to improve transparency? Working with suppliers can help a company boost its visibility in the supply chain and consumer transparency (Sodhi and Tang 2019).

3.1.3 The importance of reliable information exchange as an enabler

Information security requires the development of security policies to protect all business partners against the disclosure of confidential information. Prior literature has recognized the

value of sharing information and secure information interchange in an environment of supply chain integration (Panahifar, Byrne et al. 2018).

A study conducted by Panahifar et.al highlights, the significance of ensuring safe information distribution in cooperation since it can have a positive impact on providing a supportive environment between partners. To deploy collaboration models based on information sharing, a safe IT architecture for exchanging data is required. "Information exchange" and "safety" should be balanced to produce the optimum benefits for the companies participating in the partnership (Panahifar, Byrne et al. 2015).

3.1.4 Sharing information

When networks are scattered, collaboration among supply chain members is required. Sharing information and knowledge transfer are related and used concurrently in the banking business. In studies on supply chain cooperation, are all emphasized the nature of learning, shared vision and objectives, trust and commitment, and collaboration in knowledge generation (Mehdikhani and Valmohammadi 2019).

According to Fawcett et al., the role of SC expands beyond merely enabling companies to be compatible and versatile (Fawcett, Wallin et al. 2011). Strategic planning collaboration enables supply chain partners to concentrate on coordinated efforts to achieve common goals rather than individual possibilities (Wu, Huang et al. 2017). The SC is described as an incentive for knowledge development among partners through reciprocal learning. In addition, the key concerns for organizations are knowledge sharing and collaborative efforts, because the information is usually inconsistent across upstream and downstream supply chain participants. Analysis to examine a greater range of options for decision-makers to conduct smart judgments is produced through information and knowledge. To handle and decrease complexity, risks, and uncertainties and be aware of market possibilities, knowledge and information are important. The interaction between customers and providers generates new information (Wu, Huang et al. 2017).

According to Ryan and O'Connor engaging in member interactions provide immediate access to information. Therefore, collaboration and interaction, facilitate the flow of knowledge and information (Ryan and O’Connor 2013). According to Mehdikhani et.al and other studies, collaborative culture has a major impact on knowledge and information sharing. Businesses may increase SC to respond to changing market demands, generate new data and knowledge (about

technology, competitors, and consumers), and gain knowledge from employees, groups within the organization, and supplier partners (Mehdikhani and Valmohammadi 2019).

3.1.5 The enabling role of information accuracy

In a collaborative planning process, the reliability of information is recognized as a critical criterion of information quality (Azevedo, Silva et al. 2018). The phrase "information inaccuracy" refers to information inaccuracies produced by weak forecasting and planning procedures by the partners. Because a lack of precise information may impair supply chain decision-making, information flow between partners may be postponed until higher precision is acquired (Tang and Musa 2011).

According to Lee & Tang's study, the correctness of the information is crucial. They claimed that to be useful for scheduling and re-planning purposes in all export markets, information such as inventory, demand, forecasts, production and shipment plans, and work-in-progress should be accurate and consistent in an information-centered collaborative supply chain (Lee and Tang 2018).

Boosting supply chain partner confidence and supply chain performance metrics, such as accuracy and timeliness, are connected. Organizational profitability and supply chain cooperation are linked to developments in characteristics like information accuracy. When a person receives information from multiple sources, the information's quality can also affect their level of trust. People who deal with the data should feel confident in its reliability (Fu, Dong et al. 2016, Azevedo, Silva et al. 2018).

3.1.6 The enabling action for information availability

Information accessibility or availability are playing a key role in promoting collaboration. The responsiveness of information suggests that implementing company managers must verify that their buyers and sellers agree to the specified data flow. The "information competence" of each trading partner's current systems and their ability to interface with one another are conditions for effective collaboration. Trust between users and service providers improves information quality sharing, which takes into consideration characteristics such as information accessibility, honesty, availability, and dependability (Barari, Paul et al. 2022).

Getha-Taylor claimed that partners can evaluate product inventory levels more effectively. It is argued that information accessibility might significantly boost trust levels by serving as a motivator for collaboration (Getha-Taylor 2018).

3.1.7 The Utilization of Technology

According to Büyüközkan et al., technological enablers are necessary to implement new technologies to take advantage of Digital Supply Chain (DSC) (Büyüközkan and Göçer 2018). These enablers help in boosting company profits and introduce a new value practice. Moreover, the three key elements of a successful technology implementation process are the relationship between people and technology, the creation of a technology framework, and technological enablers. Examples of the relationship between people and technology include interaction with people, the development of knowledge, and technical collaboration. Simultaneously, the technological frame formulation refers to the organization's infrastructure, methods, and consumer items. Technical enablers, on the other hand, encompass technology platforms, business enablers, and market enablers. Vieira et.al described a variety of popular digital business technologies that have a substantial influence on SCM as well as the retail and manufacturing sectors forming a new framework that covers several technology enablers (Vieira, Dias et al. 2020).

3.2 Overall System Processes & Data Sources

Humans, information, infrastructures, and technologies are considered the solutions to the collaboration problems. On one hand, the upcoming proposal will show the overall requirements of developing a low-cost SCN monitoring system using Power BI. This developed system will be built up by the organization itself to avoid the high costs of third-party software. On the second hand, this solution will be enriched through the collaboration of the company's supplier. The information exchange will be provided through an up to dated software and technical process forming a modern data-driven solution in the new infrastructure at a low cost.

To better understand the concept, a hypothetic case was proposed. The case company produces watches, and it is called 'Watchmaker AG'.

The 'Watchmaker AG' IT department, decided to upgrade its analytic tasks by developing automated dashboards to improve its business objectives and evaluate better supplier behavior. Usually, 'Watchmaker AG' purchases frequent orders from its main supplier X and send back all the order records to Power BI. This is done through the company ERP SAP software. Similarly, the supplier delivers back the ordered finished goods to 'Watchmaker AG' and shares the shipping records. However, these data will be connected to Power BI as Excel/CSV files through the sales operations department (as shown in Figure 5).

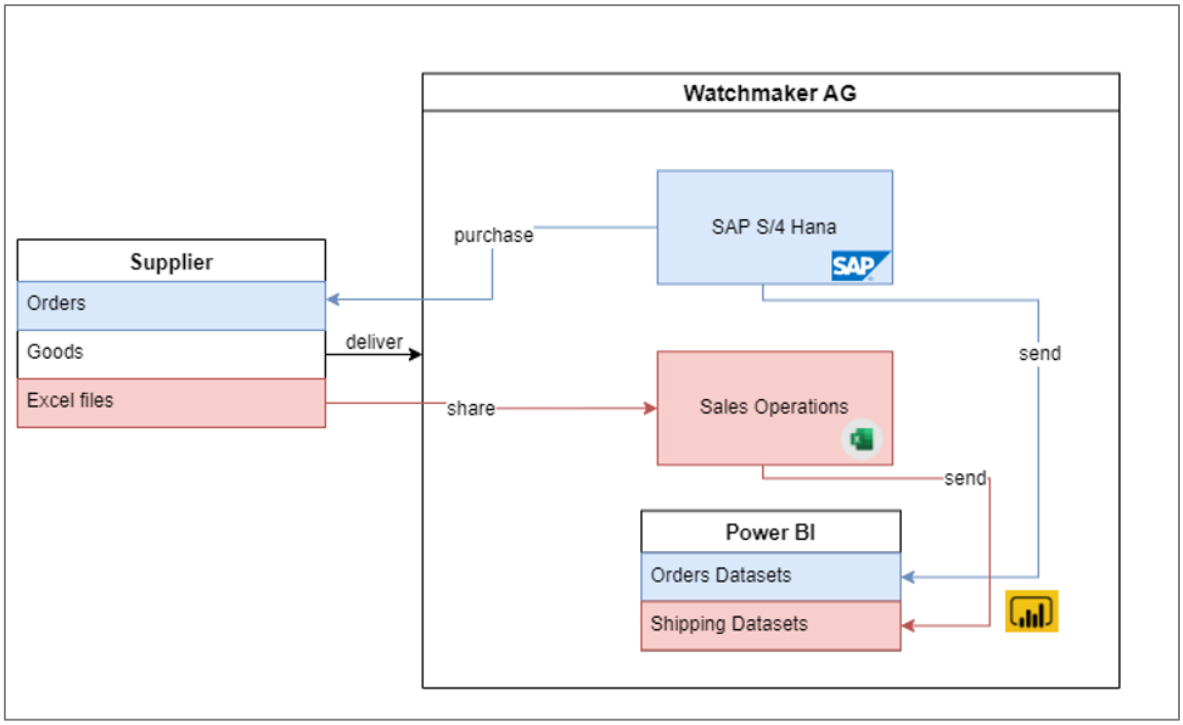


Figure 5. Business Processes of Monitoring System

With the 'Watchmaker AG' case-example, a model of a solid SCN monitoring system that can be provided between the supplier and their customers was shown.

3.2.1 Low-Cost System

Low cost is an economic and marketing concept based on the practice of lower prices than the market average, which can be obtained by a drastic policy of limitation or reduction of costs.
The concept of 'low-cost' is mainly used in the field of services. It is also used in the field of organizations when it comes to their assets and infrastructure.
The low price, the objective of the low-cost model, is generally obtained by reducing costs. This reduction generally comes from the elimination of ancillary services or characteristics considered to be non-essential (advertising, packaging, point of sale environment, etc.). Moreover, the company's internal infrastructure is also considered such as the supply chain processes software. Many companies are relying on third-party service providers to let their business processes running properly. However, this software can be self-implemented to avoid the high costs of third-party subscriptions (Slagmulder 2002). 'Watchmaker Ag' is one of these companies who decided to implement its own system focusing on SCN monitoring for powerful dashboards and analytical insights.

3.2.2 Metrics & Measures

Every company has its own objectives in decision making and for this reason the Measuring KPIs goals can not be generalized to all companies. Each company, depending on their suggested business questions, decides the analysis approach whether is a qualitative or quantitative. In this project, 'Watchmaker AG' decided on a quantitative analysis that is giving the best answers to their questions.

Th attention was focused on the first part of the SCN that restricts relationships between the supplier and 'Watchmaker AG' company to track and evaluate their business performance goals. The used measures in this project were one of the most important used KPIs like the Perfect Order KPI and its sub-metrics that show the effectiveness of a SCN beside other sub-KPIs.

The following table 1 shows the specified measure details:

Metric	Unit	Formula
Supplier Lead Time	(Days)	Delivery date – Order date
On-time Delivery	%	(Number of orders delivered on-time) / (Total number of orders delivered) * 100
Supplier Performance	%	Quantity received / Quantity ordered *100
Perfect Order	%	((Total Number of Orders – Number of Error Orders) / Total Number of Orders) * 100

Table 1. Measured Metrics List (Huang and Keskar 2007, Bulavina 2013)

Here there are some clarifications for the measures used, whether they are main KPIs or sub ones.

- **Perfect Order:** This KPI has many components to be measured. It can be used to have more insights in the order fulfillment process such as tracking delivery operations, storage, and cost management. To know the number of orders received in perfect condition the 'Damage-Free Delivery' metric was measured.
- **Supplier Lead Time:** It is a sub-KPI from the 'Customer Order Cycle Time' and measures the average number of days, from the purchase order date, needed to receive the goods.

- **On-time Delivery:** It is also known as ‘On Time in Full on Request’. This measure shows the percentage of orders that are delivered on time according to the schedule.
- **Supplier Performance:** There are several ways to measure the supplier performance. In the dashboard, the quantity of goods received over the quantity of goods ordered was measured. In this way, will be evaluated the accuracy of the completed orders per items/quantities.

3.2.3 Data Mart Conceptual Model

After the definition of the data warehouse and the possible data marts approaches, it remains to characterize the methodology of the data warehouse design.
For this, the method reported by Antonio Albano, which divides the design of a data warehouse into 4 phases was used as follows (Albano 2015):

- **Requirements analysis:** It is also known as business process phase. The objective is to collect analytical requirements through understanding the business process and interpreting the analytical needs to create effective and consistent data models based on bottom-up approach (Albano 2015).

  From a practical standpoint, requirements gathering consists of several meetings in which the client explains the analysis they would like to see extracted from the data they have. It is essential to consider the overall process of orders done by ‘Watchmaker AG’ company. One of the main requirements that must be listed in the model is the ability to track all purchasing orders/transactions from the point they are placed until to be the company receives them.
- **Conceptual design:** is a conceptual model of the data that have to be analyzed and is defined by mentioning facts, dimensions, and dimensional attributes in this phase.

  With the fact, or table of facts, is possible to define the event, that has to be recorded in its singularity. In commercial contexts, it may be the single sale, or a single order made by the company’s employee.

  By defining what is the single event of interest to record, the granularity of the fact is defined.

  Are meant by dimensions the "viewpoints" from which the facts have to be analyzed, through the specification of the dimensional attributes. Is specifically defined "the point of view" in relation to what individual facts want to be aggregated.

In this project, the following fact and dimensions are:

1. **Orders:** for the conceptual design of the data mart regarding orders, the order id was identified as the optimal granularity of the table of facts. By doing so, the table of fact results in having a row for each purchased order known by order id.
2. **Calendar:** this dimension was specially added to allow a temporal type of analysis by aligning the unique specific order dates to the targeted (needed for calculations) dates such as purchase, shipping, and delivery dates. In the data model, the purchase date was set as an active relationship because of its frequent need, whereas the other dates as inactive relationship which will be activated manually or using Data Analysis Expressions (DAX) upon request.
3. **Shipped Orders:** This data mart was created to bring out all the shipping information related to the orders placed. The shipping orders table show the shipped orders information supported by the previous linked order and calendar tables. Therefore, the granularity here is each line of the fact order will represent a shipped order.

The **final conceptual model** of the final data warehouse, depending on the conceptual models of the individual data marts that comprise it, can be explicated in three possible schemas: star schema, snowflake schema, and constellation schema(Albano 2015).

The snowflake schema can be considered a "variant" of the star schema that returns only one dimension table to the fact table after normalizing (ignore redundancy) two or more tables. The constellation schema involves multiple fact tables that share one or more dimensions of analysis.

Here, the star schema is used and consists of a single fact table (Orders table) linked to the dimensions of analysis (Shipped Orders and Calendar).

- **Logical design:** transforms the conceptual model into the logical structures/model to be used in the data warehouse management through a relational Database Management System (DBMS) (Albano 2015).

At this stage of the data warehouse creation process, the concept of fact table and analysis dimension take on a more precise meaning. The fact table is linked to each analysis dimension

of all the measures defined on them and any information consistent of the granularity of the fact itself through a foreign key. While analysis dimensions are tables composed of their own dimensional attributes and of a primary key, added to the natural key already present in the table. Specifically, the primary key (order id and date in the Shipped Orders and Calendar tables respectively) is added to the dimensions of analysis as column containing only integers to optimize the speed of searching for the fact in the table. In addition, a fundamental step is the elimination of duplicates in the table since the primary key, must uniquely identify each row of the dimension and a wrong implementation would make its presence useless.
The foreign key (order id and purchase date in the Orders table), on the other hand, represents the relationship between the fact table and the related analysis dimension table. This foreign key (present only in the fact table) contains values present in the primary key of the dimension to which it refers. Differently from the primary key, the foreign key can contain duplicates.

When a single value of a primary key corresponds to multiple rows in the fact table, it means that a one-to-many cardinality relationship is represented by (1, *). While, once a fact table has single rows, it means one-to-one relationship symbolled by (1,1) as the case between order ids and shipping ids in this project.

- **Physical design:** the necessary data structures (indexes and materialized views) store the tables defined during the logical design and facilitate analysis operations. This physical design phase will not be analyzed in the project since the tables will not be stored in the company's current system.

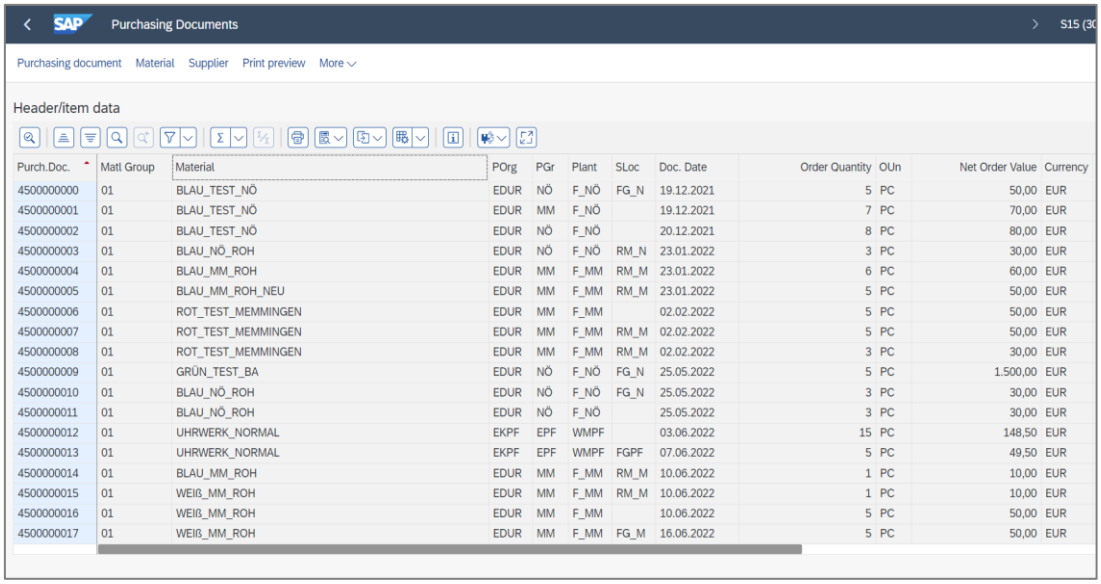
4. Development

4.1 Data Collection

Before starting any technical implementation of the chosen approach is necessary to point out the data sources and the flow of information, regardless of an automated flow or not. As shown previously (Figure 5), there are two main data flows: the orders data generated by SAP S/4 HANA software and the goods data received from the supplier itself. These two flows are known as order and shipping datasets respectively.

In this project, to generate orders SAP NetWeaver hosted by SAP UCC (University Competence Center) at the Technical University of Munich was used. The orders were generated as real purchasing transactions with detailed information about each order.

The figure below shows a quick view of the graphical user interface (GUI) in SAP/Purchase Order/General Analysis (Figure 6):



Purch.Doc.	Matl Group	Material	POrg	PGr	Plant	SLoc	Doc. Date	Order Quantity	OUn	Net Order Value	Currency
4500000000	01	BLAU_TEST_NÖ	EDUR	NÖ	F_NÖ	FG_N	19.12.2021	5	PC	50,00	EUR
4500000001	01	BLAU_TEST_NÖ	EDUR	MM	F_NÖ		19.12.2021	7	PC	70,00	EUR
4500000002	01	BLAU_TEST_NÖ	EDUR	NÖ	F_NÖ		20.12.2021	8	PC	80,00	EUR
4500000003	01	BLAU_NÖ_ROH	EDUR	NÖ	F_NÖ	RM_N	23.01.2022	3	PC	30,00	EUR
4500000004	01	BLAU_MM_ROH	EDUR	MM	F_MM	RM_M	23.01.2022	6	PC	60,00	EUR
4500000005	01	BLAU_MM_ROH_NEU	EDUR	MM	F_MM	RM_M	23.01.2022	5	PC	50,00	EUR
4500000006	01	ROT_TEST_MEMMINGEN	EDUR	MM	F_MM		02.02.2022	5	PC	50,00	EUR
4500000007	01	ROT_TEST_MEMMINGEN	EDUR	MM	F_MM	RM_M	02.02.2022	5	PC	50,00	EUR
4500000008	01	ROT_TEST_MEMMINGEN	EDUR	MM	F_MM	RM_M	02.02.2022	3	PC	30,00	EUR
4500000009	01	GRÜN_TEST_BA	EDUR	NÖ	F_NÖ	FG_N	25.05.2022	5	PC	1.500,00	EUR
4500000010	01	BLAU_NÖ_ROH	EDUR	NÖ	F_NÖ	FG_N	25.05.2022	3	PC	30,00	EUR
4500000011	01	BLAU_NÖ_ROH	EDUR	NÖ	F_NÖ		25.05.2022	3	PC	30,00	EUR
4500000012	01	UHRWERK_NORMAL	EKPF	EPF	WMPF		03.06.2022	15	PC	148,50	EUR
4500000013	01	UHRWERK_NORMAL	EKPF	EPF	WMPF	FGPF	07.06.2022	5	PC	49,50	EUR
4500000014	01	BLAU_MM_ROH	EDUR	MM	F_MM	RM_M	10.06.2022	1	PC	10,00	EUR
4500000015	01	WEIß_MM_ROH	EDUR	MM	F_MM	RM_M	10.06.2022	1	PC	10,00	EUR
4500000016	01	WEIß_MM_ROH	EDUR	MM	F_MM		10.06.2022	5	PC	50,00	EUR
4500000017	01	WEIß_MM_ROH	EDUR	MM	F_MM	FG_M	16.06.2022	5	PC	50,00	EUR

Figure 6. SAP GUI/Generating Orders

To assure how the 'human' enabler can be involved in SCN monitoring systems shipping datasets were created manually to be exported to Power BI through the sales operation's employees. The supplier will share each month's shipping data records with 'Watchmaker AG'.

Hence, ‘Watchmaker AG’ will receive 3 excel files for June/ July/ August months from the supplier which are connected logically to the order datasets.

4.2 Technologies used

4.2.1 Microsoft Power BI

Power BI is a Microsoft data analysis solution. It allows the creation of personalized and interactive data visualizations with simple interfaces for end-users to create their reports and dashboards. Power BI is a collection of software services, applications, and connectors that work together to transform data from several data sources into visual, useful, and interactive information. Multiple data sources, such as Excel files, SQL sources, or on-premises or cloud hybrid data warehouses, can be used. The objective is to facilitate the creation of dashboards to improve Microsoft's means of communication and collaboration (Rad, Rad et al. 2018). Therefore, makes it possible to collect, construct and display data through indicators. Its ergonomics make possible to animate interactive presentations, which will help in decision-making.

Power BI is made up of several building blocks (Figure 7) that all work together, starting with these three basics (Rad, Rad et al. 2018):

- A Windows desktop application called Power BI Desktop.
- An online Software as a Service (SaaS) called Power BI Service.
- Power BI Mobile apps for Windows, iOS, and Android devices.

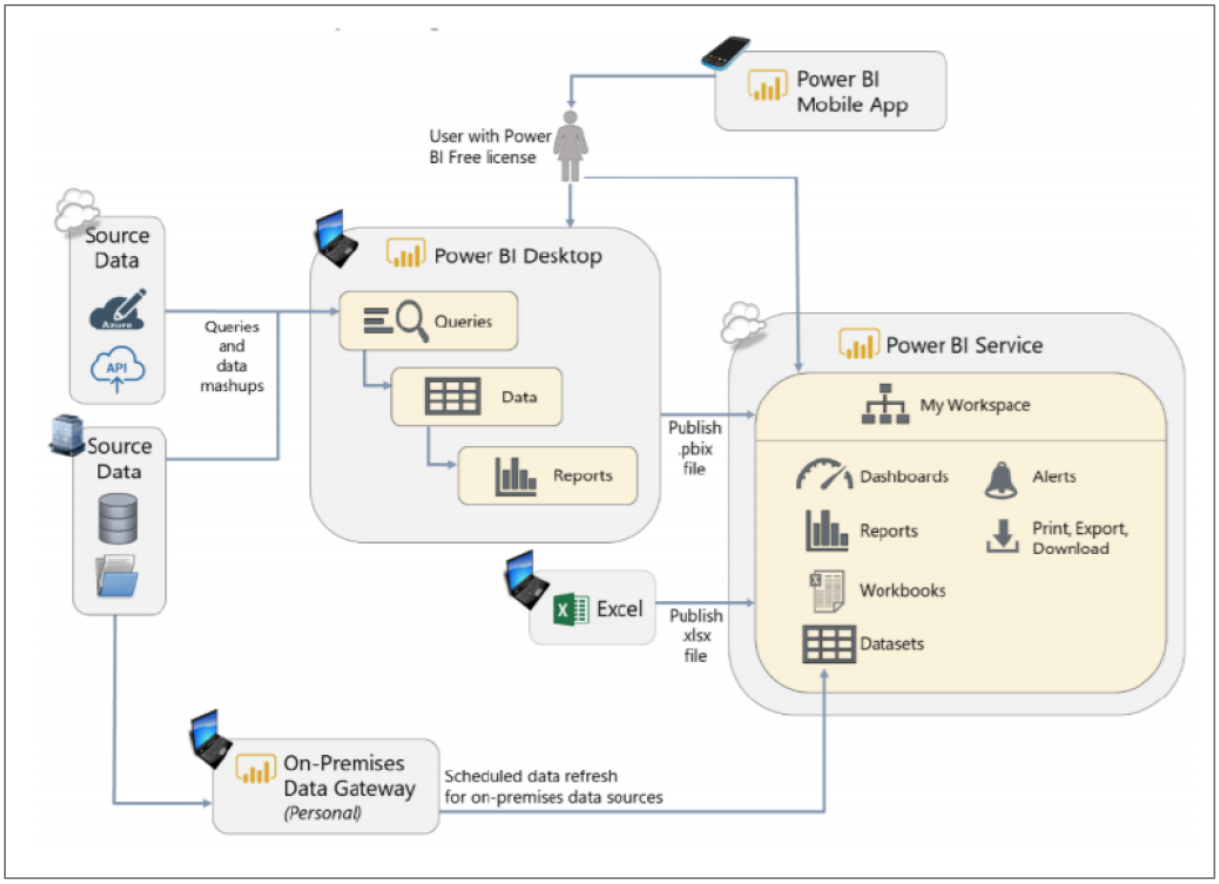


Figure 7. Power BI Building Blocks (Diagram 2022)

Power BI Desktop allows the connection to multiple different data sources and combines them (often called modeling) into a data model. This model builds collections of visuals that can be shared as reports with other people within the organization. Most users who work on BI projects use Power BI Desktop to create reports and support their sharing in the cloud through Power BI Service (dashboard publishing). While Power BI Mobile App is an automated tool to access the dashboard anywhere at any time such as on tablets and mobile phones.

Power BI has 7 components that are (Rad, Rad et al. 2018):

- **Power Query:** this is a data transformation and integration tool that allows connection to a wide range of data sources.
- **Power Pivot:** an in-memory data modeling application that supports building analysis models and adding calculated columns and fields. It also manages the relationships among tables in the data model.

- **Power View:** a data visualization tool that offers a fair variety of customizable graphical elements.
- **Power Map:** a geospatial data visualization tool that complements Power View to extend its functionality toward geolocated data.
- **Power Q&A:** functionality that enables natural language queries for ad hoc data visualization.
- **Power BI Service:** it is a complementary tool of Power BI.
- **Data Management Gateway:** it joins data to the cloud.

4.2.2 SAP S/4 HANA

The ERP system SAP S/4HANA utilizes SAP HANA database, the in-memory database of SAP. It was developed to enhance radically the daily business processes in a company. It combines functions and utilities from all departments of the business reaching the whole company at once. All departments within the organization can benefit from this software such as finance, supply chain, sales operations, procurement, engineering, and others.

SAP HANA S/4 cannot be run on all types of environments such as Oracle applications, IBM, Teradata databases, etc. However, it runs only on the SAP HANA database, which is why they come both together as one package. SAP HANA S/4 is a flexible and cost-efficient solution. It is built on principles that best meet customer and market needs: scalability, performance and reliability, industry-specific features, and expertise in BI. It offers customers an array of advanced business analytics based on the latest technology to solve real-world business problems in the organization, which is suitable for all organizations sizes with 3 different platforms: on-premises, cloud, and hybrid (Kollár and Martiško).

Some of the main business concepts needs of SAP are (Pratiwi and Tamtana):

- SAP allows focusing on the actions that drive the business, helping in getting ahead of the competition.
- It provides universal BI data that is adapted to users' work habits and needs.
- Innovative functionality to drive productivity and ensure ease of use for all users to encourage adoption and improve decision-making processes.
- Provide powerful migration tools to facilitate the evolution of existing deployments.

4.3 Connection possibilities between SAP and Power BI

There are several ways to bring data from many different data sources into the company's data warehouse. In this section, two possible procedures to connect data are described.

1. Pipes

Pipes developed by 'Data Virtuality' automatically load the data into the data warehouse, giving quick and simple access to all the data in a matter of minutes. Without writing a single line of code, always up to date, and without any performance concerns (Golovin 2022). It is true that this option is entitled under third-party software. However, it covers only the data connection service with low fees. It is still important to mention this option since it is suitable for small companies that in most cases have collapsed technical skills to perform analytics tasks, or for some startups that need quick information about their initial data. To use SAP through pipes, it is necessary:

- be connected to SAP: data Pipes centralize the database of SAP by supporting the most popular relational data warehouses in the cloud and on-premises. As a data warehouse with native SQL compatibility, it will enable extending business analysis capabilities while providing solid performance and scalability.

- access SAP data with Microsoft Power BI: with SAP Hybris integration, data can be connected to Power BI through a data warehouse. Here, SAP data can be viewed as standardized tables in Power BI.

The general connection will be configured as shown:

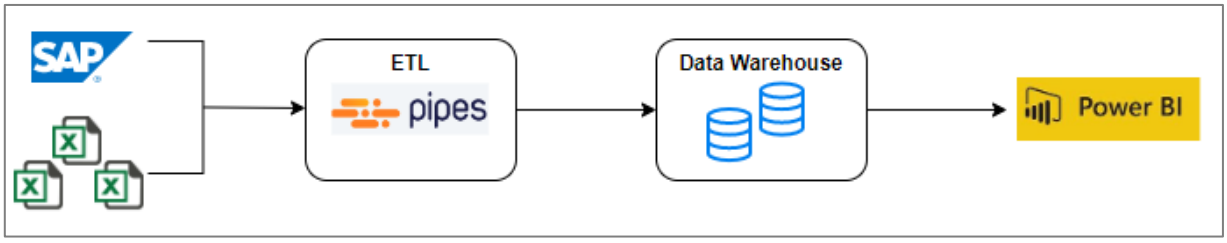


Figure 8. Pipes Database Connection Structure. Adapted after (Golovin 2022)

2. SAP HANA Database Connector

The 7 components described previously make Power BI a complete business intelligence platform under all aspects: from loading data to its visualization by the end user. It is possible to perform data integration operations with Power Query and load the resulting dataset into a Power Pivot model. This model is the basis for subsequent visualizations in Power View or Power Map. The development tool that combines the three components is Power BI Desktop: this solution enables the creation and sharing of interactive dashboards, bringing business intelligence and data analysis to the cloud.

To connect to the data source, Power BI offers 3 modes depending on the type of report needed (Rad, Rad et al. 2018):

- Import: Power BI imports data from the SAP HANA into its own dataset, via a database engine in a form of Tabular models. Even if this connection mode needs memory and disk space, it allows local work improving the platform's performance and fully supporting the DAX necessary to define the measures. A minus is that any changes that occur in the data source will not be visible unless a refresh is performed.
  Keep in mind that this import mode is limited to a small dataset (not bigger than 1 GB).
- Direct Query: Power BI creates an empty dataset by importing only the metadata from the SAP HANA database using a Remote Function Calls (RFC) for every data refresh. When is essential to visualize the data, Power BI Desktop queries the necessary data source and retrieves the data on the fly. Obviously, the connection to the data source is always kept active, allowing the data, and the changes that occur on it, to be viewed in real-time. With this mode, since only the metadata are stored in the 'pbix' file, the file turns out to be always light while allowing analysis with all the data, circumventing the limit of 1 GB. Nevertheless, by consulting the data in real-time through queries made directly on the data source, the calculations turn out to be slower; in addition, the rows that can be consulted cannot be more than 1 million, multiple data sources cannot be consulted simultaneously, temporal analyses cannot be performed, and DAX functions cannot be fully exploited for writing measurements.

- Real-time streaming: this mode has the same characteristics of Import mode, with the only difference that, here, a systematic and constant import is made from the data source to keep the data up to date.

Before continue explaining the technical steps, it is important to define DAX briefly:

DAX is a language developed specifically for Analysis Services, Power BI, and Power Pivot in Excel. It is based on functions and allows the construction of measures in the previously mentioned platforms. Although Power BI is code-free, the development of complex analyses is still required the use of DAX especially for measures where time (date) is involved (Russo and Ferrari 2019).

Here, most of the measures required to develop the report were written using DAX.

Power BI Desktop has one steady connector to the SAP HANA database, which supports both Import/Real-time and Direct Query modes (BI_SAP-HANA 2021).

To connect to SAP HANA databases in Power BI Desktop, the SAP HANA ODBC driver must be installed on the local user's computer to function properly. This can be done simply by downloading the latest version from the SAP Software Download Center by searching for the SAP HANA Client for windows users in the software portal using this link: Installing SAP HANA ODBC Driver on Windows 64 Bits | SAP Help Portal.

Once the driver is successfully installed select **Get data**, choose **Database** > **SAP HANA Database**, and then select **Connect** to enter the server credentials as shown in figure 9.

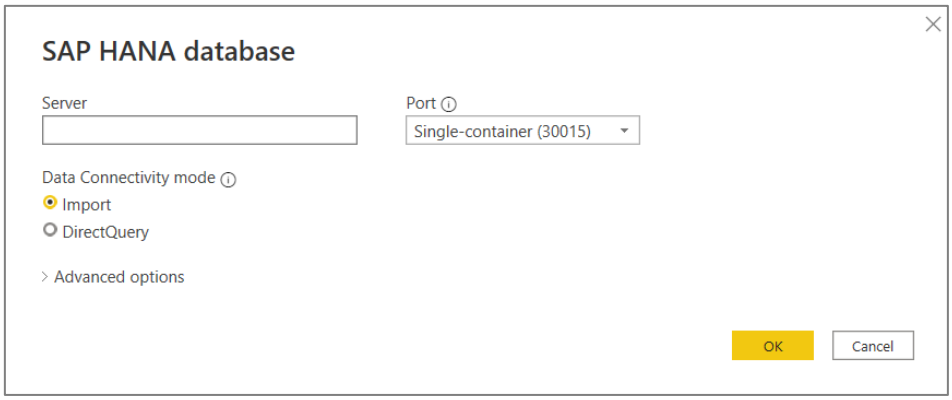


Figure 9. SAP HANA Connecter

After specifying the SAP HANA server name and port, the user can select which data connectivity mode he prefers. In this case, the import mode was selected because the UCC SAP S/4 HANA license does not support all the business features and the SAP HANA server's external IP address (and name) was missed to connect to the database.

The following link can be used for more information about SAP Software: Online help: Software downloads (sap.com)

4.4 Extraction, Transformation & Loading (ETL)

The most challenging part in creating a BI system, is handling the ETL (Extract - Transform - Load) process. Albano defined it as "a series of operations employed to obtain data from operational sources (extraction phase), clean, unify and prepare such data (transformation phase) for their actual loading into the data warehouse (loading phase)" (Albano 2015). The criticism of this step lies in the consequences of an error in this phase. If there were errors in the conceptual and logical design phase, they would be manifested in terms of model efficiency, and subsequently in the calculation of measures or space-consuming. A poorly executed ETL phase has repercussion in the data analysis phase, leading to an untruthful analysis result.

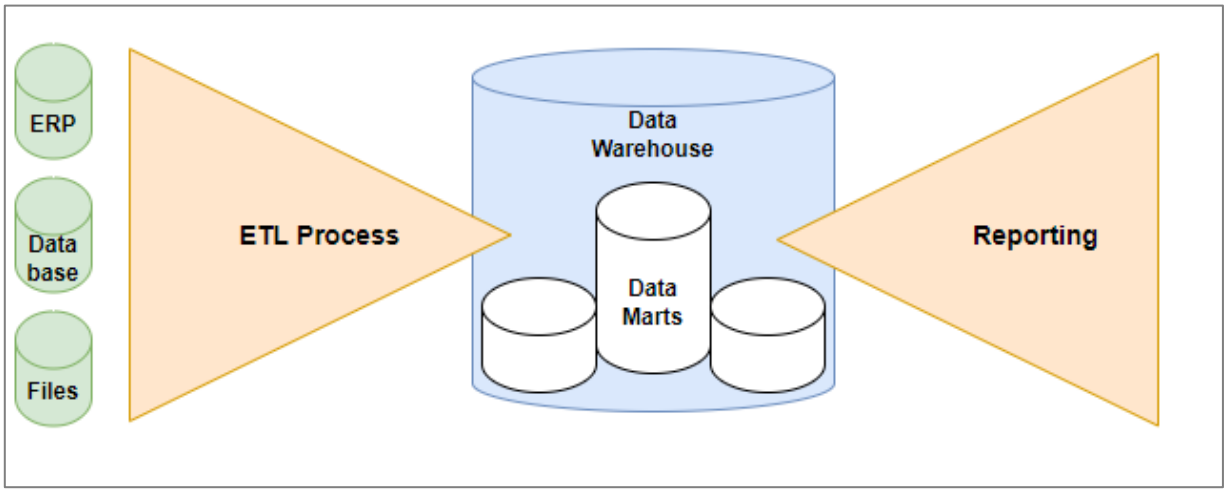


Figure 10. BI System Blocks. Adapted after (Albano 2015)

The ETL process, as per the acronym, consists of 3 sequential steps (Albano 2015):

- **Extraction:** data are extracted from source systems that can be transactional databases, web pages, applications, and text files. In this phase, Power BI Desktop is connected to the SAP database where data have been imported. There is no need to immediately display any changes to the data, since in import mode rather than in direct query one, the refresh on demand mode (the manual refresh option offered by Power BI) would be sufficient to keep the data updated. In this project, the imported tables in the extraction phase are:

- Order
- Shipped orders June
- Shipped orders July
- Shipped Orders August

- **Transformation:** It consists in integrating and unifying the extracted data by applying the rules derived from the analysis requirements; through a series of techniques, correctness, consistency, and the absence of ambiguity. The objective of this phase is the application of all those transformations necessary to obtain the star schema defined in the conceptual and logical design phases. The advantage, is to reduce the number of tables required compared to a normal relational database with a consequent gain in the space. Moreover, it offers the possibility of measures time-based analysis and reduces the number of joins essential to obtain the analysis. For instance, in the Power Query Editor, the 3 extracted shipping orders tables were transformed into one table (using append queries option) and then joining them with the order table through the order id dimension (using merge queries option).

  Moreover, Power Query was used to clean and organize the datasets before starting to model and aggregate data in the analysis. Power Query has a user-friendly interface to easily simplify a complex model, transform data types, replace values, rename objects, remove duplicate, and create a pivot table from the data.

  Some overall understanding concepts in this process (Raviv 2018) are:

  - Assessment of data types in each column: when data tables are imported. Power BI Desktop automatically scans the first 1,000 rows to determine the type of data in each column. It may occasionally fail to recognize the appropriate data type. When improper data types are present, evaluation is required to correct the data type. It is always recommended to change the data type in the Power Query Editor before loading the data. For example, if there are calculations that employ date values, it is essential to change the date column data type.
  - Profile data: profiling data involves examining the data details. It enables to shape and arrange the data in a way that makes working with it, spotting abnormalities, and creating underlying simple structures. This improves the

ability to work with the data upfront and helps in the creation of report components. This idea is crucial because it makes possible to organize the data and find statistics like averages, minimum and maximum values, row counts, and value distributions.

- **Loading:** Once the data transformation is finished, and the transformation rules that the data will have to undergo at each refresh are applied, the following step is the phase of loading the data into the data warehouse.

  Based on the purpose for which this data warehouse was created and the current small size of the model, the refresh mode was set as “refresh on demand”. This will allow for up-to-date data whenever management wants to consult the reports by direct refreshing or setting a scheduled one for the datasets.

  Adding new shipping orders datasets can be done automatically once the datasets files are collected in the same folder. Once the supplier sends the shipping details for each month to the sale operations department, the datasets will be saved in the same folder that both sales operations and analytical departments can access it. These new datasets will be loaded automatically to the model, by saving this folder path previously in the ‘Get data’ section in Power BI Desktop.

  Loading the data into the data warehouse means that the structured model is at all effects corresponded to the previewed steps in logical phase. The "Calendar" dimension was built "manually," i.e., a dimension where each row corresponds to a single date within a chosen interval. This dimension must be organized hierarchically from the minimum granularity of the day to a maximum granularity corresponding to the year, allowing to drill down or roll up to the various time-type analyses passing through the intermediate values of month, quarter, and day (Albano 2015).

4.5 Final Data Mart Model

At the time of loading the data into the data warehouse, Power BI proceeds to automatically recognize the relationships between the various tables and create them. All relationships were checked by correctly recognizing their cardinality construction and were also added the relationships that Power BI did not recognize.

Figure 11 shows the data model of relationships in Power BI Desktop:

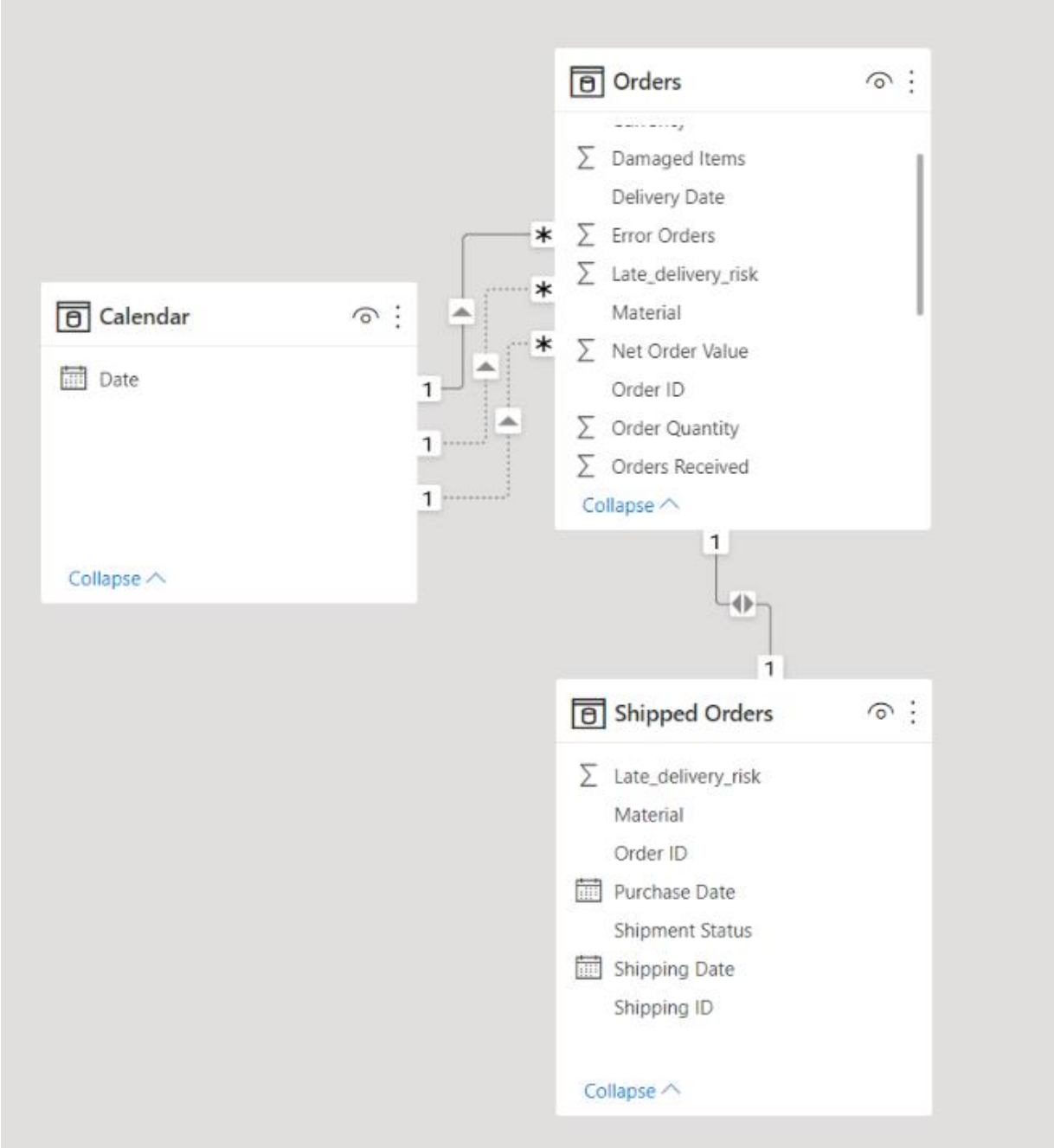


Figure 11. Data Mart Model

5. Results Analysis (Part I)

5.1 Barriers in Supply Chain Collaboration

Integrated continuous improvement processes involving customers, organizations, and other participants essentially form businesses. This interactive businesses reality force companies to review and improve their strategies to better serve their customers (Sridharan and Simatupang 2013). This issue is comparable in terms of supply networks. Businesses are under pressure to find innovative methods to develop and provide value to consumers through SCM. According to Simatupang et.al., a major purpose of a supply chain is to eliminate sources that prohibit members from maximizing profit by giving value to end consumers, and this goal may be reached via coordinated supply chains. As these sectors become more globally integrated, the production of goods and services becomes more complex. Likewise, as consumer demands for quality and price rise, producers and retailers encounter increased competition (Simatupang and Sridharan 2008). Arnold et.al gave rise to the term "supply chain management." SCM refers to the integration of operations along the value chain, from product creation at suppliers to relationship building with customers (Arnold, Benford et al. 2010).

In a SCC, at least two or more companies work together. SCM looks at the entire value chain across companies. Here, SCC is a component of SCM. This component refers to the optimization of interfaces between the companies involved. Customers and suppliers collaborate to create the supply chain. Companies may assure synchronized, fact-based logistics planning and administration by establishing shared business processes and workflows with set norms and obligations between customers and suppliers. This is also protected using Internet technologies and the setting of target and measurement parameters. Data and information exchange should also be standardized (Kampstra, Ashayeri et al. 2006).

The problems associated with employing a supply chain differ depending on the industry, commodity, investment level, customers, consumption pattern, delivery dates, production technique, and other aspects (Chen, Liu et al. 2019). In different settings, several researchers have focused on some of these challenges.

During years were described a lot of barriers in SCN. The barriers described in the following section are not universal among all companies (based on the relationship between the company and the supplier can be defined as barriers or enablers).

1. Sensitive information:

The degree to which partners exchange resources (such as experience, skills, and knowledge) and the partners' ability to use these resources successfully in changing environments appear to determine whether strategic supply chains are successful.

Only a few businesses have successfully built the high-level collaboration required to achieve incredible results (Brau, Fawcett et al. 2007). Despite years of effort and major investment in splitting technology, still persist fully flexible and collaborative supply chains persist (Allred, Fawcett et al. 2011).

Some of the issues that prevent collaboration are conflict between departments and companies, misaligned goals that encourage opportunistic behavior, trust and a reluctance or inability to share sensitive information. Such behavioral constraints make it difficult to combine supplier and customer resources for a distinct competitive advantage (Hutt and Speh 2007).

In this section, the main reasons why SC partners are unable to successfully share and use resources (when they are shared) are dissected. Logistics executives ranked "a lack of readiness to exchange information" as the second most significant barrier Because of their cross-functional responsibilities, logistics managers understand the importance of sharing information(Fawcett, Magnan et al. 2008).

Missing or incorrect information typically necessitates expensive processing. Poor or incompatible information systems are a significant barrier because information is so crucial to collaboration. Information systems that are inefficient or inappropriate create two problems.

- First, to regulate a complicated SC network, a huge amount of data must first be obtained and examined. Although data warehouses that collect and store information which are widely used, analyzing data on which individuals can make judgments is still a difficult and complex task(Fawcett, Magnan et al. 2008).
- Second, information becomes helpful only when it is in the hands of the right people at the right time. It will be difficult to realize the full benefits of integration if all chain

members do not have access to the essential information to analyze resource opportunities. In principle, these constraints fall under the category of management complexity (Fawcett, Magnan et al. 2008).

2. Human Nature:

According to the researchers, the primary impediment to good SC collaboration is human nature. Most people are resistant to change and prefer to keep things as they are. Managers commonly stated that their staff were wary of the types of changes brought about by SCM and preferred to avoid them at all costs (Zahedirad and Shivaraj 2011).

Management also noted that most people do not grasp what SCM means in terms of their responsibilities. Several executives have stated that high management either lacks a clear vision of SC integration or fails to communicate a vision to which other employees can relate. According to respondents, most organization's SCM vision is still unclear. This lack of vision in training might lead to a misunderstanding of what SCM is. The inevitable result of unknown potential and confusion is resistance to change, and even measures to prevent any significant adoption of SC approaches(Fawcett, McCarter et al. 2015)..

All through the interviews, more significant challenges to SCM were raised. Human conduct was discovered to be at the base of nearly all of them (i.e. Organizational framework, lack of supervisory commitment, inconsistent processes, policies, and measures, evaluation depth, lack of trust, source constraints and quality information about SC networks). So, the survey results suggested that the main hurdles to SCM were uneven information technology, cooperation regulations, and goals of the company, these interview findings are highly significant (Beth, Burt et al. 2003).

The interview results serve as a gentle reminder that humans are ultimately responsible for information gathering, processing, sharing, and interpretation, alliance rule writing and enforcement, and operational goal setting and reliability trust. These findings support a recent comment made in an SCM forum: Despite years of process changes and magnificent technological developments, an agile, adaptive supply chain remains a faraway dream. Perhaps it is the people who are holding back progress by Harvard Business review (Beth, Burt et al. 2003).

3. Poor Systems Connectivity:

Generally, technology investments are primarily defensive in nature. Managers claim that they are "forced to remain in the game. “In the pre Covid-19, only few organizations had created Internet portals to communicate with suppliers about former sales data, current sales volumes, and rolling manufacturing predictions. Whereas this became the normality during and after Covid-19 (Ilyas, Carpitella et al. 2021, Tareq, Rahman et al. 2021).

Managers noted that innovations were necessary to prevent performing today's competitive conflicts with yesterday's technology because competitors were bringing cutting-edge technologies like information systems and RFID (Oghazi, Rad et al. 2018). Significant and consistent spending over time suggests that the link is a structural resistor in which mitigation efforts have produced real results over time. Connection benefits were deemed to be insignificant in comparison to the claims made in the business case analyses of the corporations (Fawcett, McCarter et al. 2015).

The complexity caused by protectiveness and corporate strategy mismatch remains at the center of the interconnection problem. Group members, for example, commonly encounter access troubles. Common observations are: “IT infrastructure at various points along the chain are inefficient”; “Vendors or clients failed to make the essential technology investments, and partners lack the critical technologies to enable information sharing” and “The most significant hurdle is the system”. (Mahmud, Paul et al. 2021)

Everyone can have poor communication abilities. When partners are unable to support relationship goals due to a lack of commitment, passion for the collaborative approach declines. In general, old institutions and infrastructure costs, establish personalities, focus on local optimums, and add complexity, which increases opposition to cooperation. The interaction of structural resistors strengthens them while demotivating managers (Fawcett, Wallin et al. 2011).

4. Organizational Silos:

Departments that are unable or unwilling to share information originate a silos effect. The silo effect restricts communication between employees in various departments within an organization which significantly reduces economic output. Consequently, departmental priorities receive priority over the company's long-term goals (Hofstetter, De Marchi et al. 2021).

5. Too busy to assist others:

Ensure that everyone in the team can communicate clearly about when an item will be back in stock and what else could be provided as a substitute. Give the employees proper right to help without making them wait for permission from a manager. Allow the staff to assist without waiting for approval from manager (Mahmud, Paul et al. 2021).

6. Not rewarded:

Customer loyalty increases revenue, enhances sales performance, and facilitates long-term growth. A carefully loyalty programed can help attracting new clients, keep hold of old ones, lower attrition, and boost sales. Customers will be motivated to attach to the same values that are so important to the brand. Since more customers will make recurring purchases, customer satisfaction will increase. Loyalty programs can generate up to 20% of a company's earnings. Likewise, 84% of consumers say that a brand with a loyalty program is more likely to keep their business (Khan, Salamzadeh et al. 2022).

7. Ineffective Tools:

It is difficult to trace the causes of problems when there is insufficient visibility into the supply chain. It may be difficult to determine where or how a product went lost, or the data may have been erased or are unrecoverable. Mislabeled products, wasteful packing material use, bar code problems, missing delivery instructions, and inappropriate product selection are all the causes of hurdles in supply chain performance (Hofstetter, De Marchi et al. 2021).

8. Not viewed as important:

Trust-building is a customer-focused strategy that can help the business in a variety of ways. Customer trust is critical since it may help the company attracting and keeping loyal customers. The ability to retain customers may have a direct impact on a company's performance because it can increase revenue. Business cannot be conducted without trust, influence is lost, leaders risk losing their employees, and salespeople risk losing their clients. The list goes on. Trust and connections, not money, are the currency of business. Trust is the result of numerous little actions, words, ideas, and intentions (Fawcett, Magnan et al. 2008).

9. Intellectual property concerns:

The ownership rights over items generated as a result of original ideas are referred to as intellectual property rights. If the creation has financial worth, is important to understand how to safeguard the intellectual property against those who may attempt to exploit it. Participation in organization projects usually raises ethical concerns about the evaluation and pay of group members' labor, as well as the prospect that firms, consultants, and other organizations may be able to claim intellectual property generated through projects (Fredendall, Letmathe et al. 2016).

5.2 Behavioral Barriers in Supply Chain Collaboration

Decision-makers need collaborative mindsets and skills if organizational procedures must adopt collaboration strategies. Manager's sense of vulnerability will cause them to refuse collaborations if they are unable to create an environment that encourages interactions (Wen and Liao 2021). Managers emphasize how functional thinking is encouraged over process thinking and authoritarian decision-making over collaborative problem-solving in today's organizations, negatively affecting interpersonal superiority of any business. All of these are examples of so called 'Behavioral Barriers' (Figure 12). They have to be taken under consideration when it comes to SCC, indeed these barriers should be minimized for a fruitful collaboration between suppliers and clients (Stamer, Buschle et al.).

Figure 12. Behavioral Barriers in SCC. Adapted after (Stamer, Buschle et al.)

5.3 Evaluation of Suppliers

A company (‘Watchmaker AG’ in this case) may deal with hundreds of suppliers, depending on the scale of its corporate structure. Tracking the performance of each supplier is a difficult process. A method for monitoring, evaluating, and managing is necessary to decrease costs, eliminate risks, and better quality of materials (Bhagwat and Sharma 2007).

The evaluation of suppliers is a method used to evaluate and approve potential suppliers quantitatively. This is done to select best in class suppliers. The assessment is done based on their delivery, prices, production capacity, and quality of management, technical capabilities and services. There are different formats for assessment of suppliers and differ from one company to another. In many cases the suppliers are selected based on the suitability and narrowing the list to a few critical parameters.

The parameters that have to be considered are the following (Ližbetin, Černá et al.):

- There is no best supplier evaluation technique to evaluate suppliers.
- Quality is another factor during the procurement of the item. Otherwise, this will affect the production.
- The entire cost of ownership which includes the material unit price, cash discounts, shipping costs, and maintenance costs, among other things, is a critical concern.
- Suppliers must be able to provide good services. For example, when product information or certificate of conformance, suppliers must response quickly based on requirement. The firm must also assess whether the supplier has the capacity to meet needs and, if necessary, fill large orders.
- Another potential obstacle in supplier selection is the provider's location. This has an impact on delivery time, transportation, and logistical costs. To decrease transportation costs, several firms demand their suppliers to be located close to their operations.
- During the supplier evaluation, the financial condition must be considered which includes for example: if a provider may invest in resources, pay its subcontractors and employees, and so on.
- There should be a proper planning and control systems that can share the plan to the organization as well as outside parties. In the plan ensure that the delivery lead time is short so that small lot sizes can be ordered on a more frequent basis to reduce inventory holding costs.

- Environmental rules must be followed by suppliers, which is a key criterion for SCCs. This includes the proper disposal of hazardous material.
- Suppliers should be chosen by corporations who are prepared to share their innovations and knowledge. By increasing the supplier's engagement in the design process, the buyer is free to concentrate on key capabilities.

Evaluation of suppliers has to be done in a structured way to select the best suppliers. A supplier selection scorecard may be used as a decision support tool. Supplier assessment should happen timely, and buyers (Watchmaker AG) must track the performance. They should also rank suppliers across multiple criteria which will help the buyer to identify which vendors are performing well and which need to improve their performance(Ližbetin, Černá et al.).

In the next chapter, the results of the supplier performance analysis will be shown to evaluate the selected supplier performances and make the best decisions.

6. Results Analysis (Part II)

6.1 Reporting

The activity of reporting is the periodical detection and measurement of results. Its effectiveness depends on the type of tools used and the methodologies adopted. It provides a set of in-depth and detailed information organized to meet the needs of each business area or operational function.

The determinants of the quality of a reporting system are punctuality, reliability, clarity, and essentiality. Reports should be easy to interpret and unambiguous to be provided to the responsible management in a timely manner (Legenchuk and Polishchuk 2017). According to Albano, there are several tools to do this, and the most common presentation techniques are (Albano 2015):

- Traditional report: The results are shown in a tabular manner with a possible partial summary of data layers.
- Dual input table: The results of aggregate measures are shown at the combination of two or more dimensions along Cartesian axes. Adding and removing dimensions results in drill-down and roll-up operations.

In addition, there are three ways of making decision (Rad, Rad et al. 2018):

- Offline reporting: offline, or standard, reporting that represents the lowest level of decision support. The reports generated can be static, if presented in a format that cannot be manipulated by the end user, or dynamic, whose content can vary according to selectable parameters.
- Online reporting: also known as ‘Multidimensional Analysis’, allow end users to perform interactive analysis on the data collected in the data warehouse.
- Exploratory Analysis. Data Mining algorithms are employed to extract predictive patterns from the data.

In this project, the online reporting was used and therefore will be extensively described in the next section.

The ability that online reporting offers to build visuals that are "talking" to each other means that to obtain certain information, for which in the past a query would have been required for each piece of information requested, it is enough to simply select a given value in one visual for this selection to propagate to the other visuals showing the information about that particular value.

Once reports are prepared and published from Power BI Desktop, Power BI Service was used to prepare the final dashboard. Through ‘My workspace’ section, Figure 14 shows the process flow in Power BI in a lineage view from importing all datasets, transforming them, creating reports, till adjusting the dashboard.

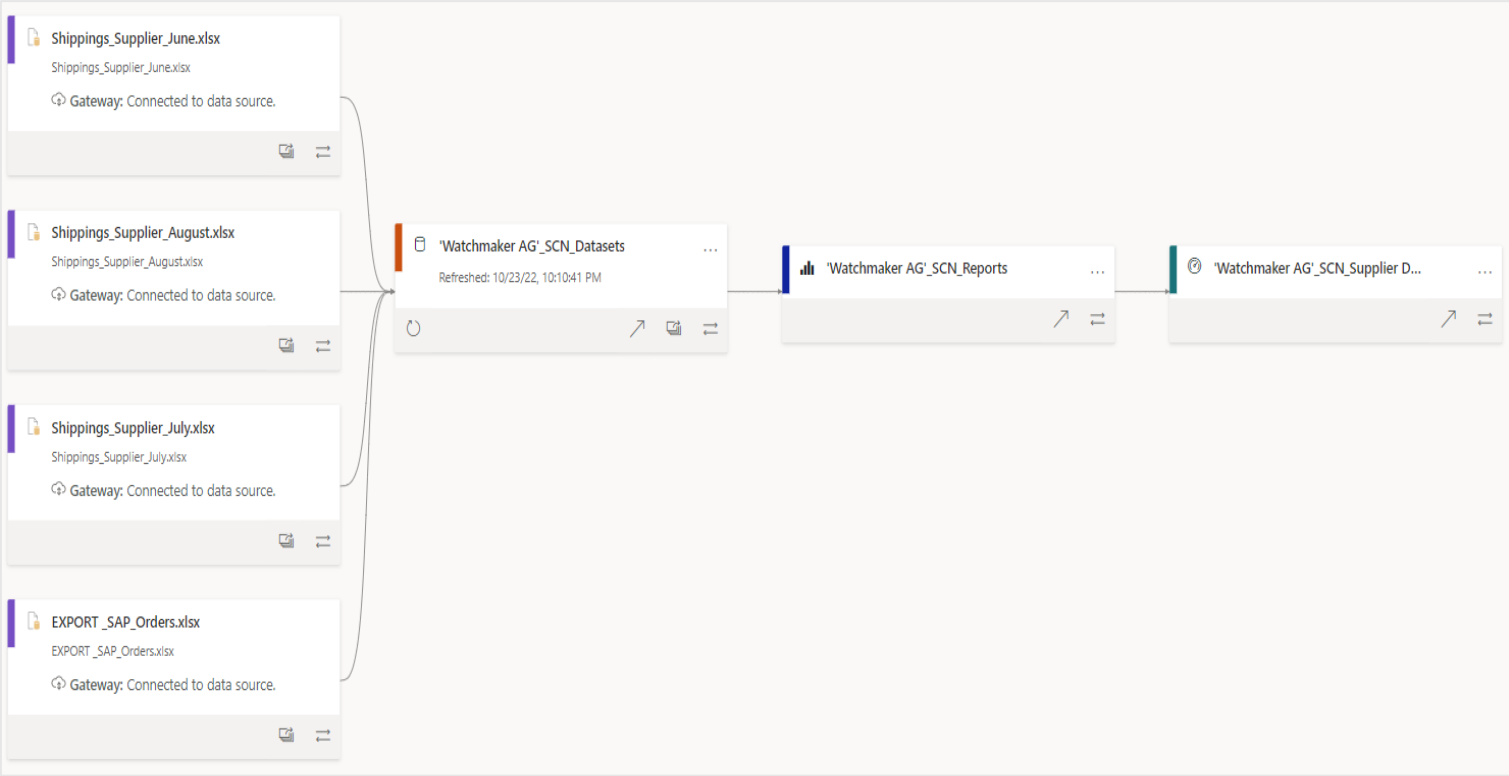


Figure 13. Power BI Process Stages

6.2 Dashboard

Nowadays, dashboard is considered as a controlling tool that evolved to become a real steering tool for making decisions. The dashboard displays all the elements that allow to evaluate and analyze the situation in which the company finds itself (Rad, Rad et al. 2018). ‘Watchmaker

AG' can provide a general view of the entire SCN concerning supplier activity, as it summarizes most information in a few essential indicators. Figure15 shows the SCN dashboard representing clear insights of the figures that are no longer scattered in the different branches of the company but centralized in a single medium.

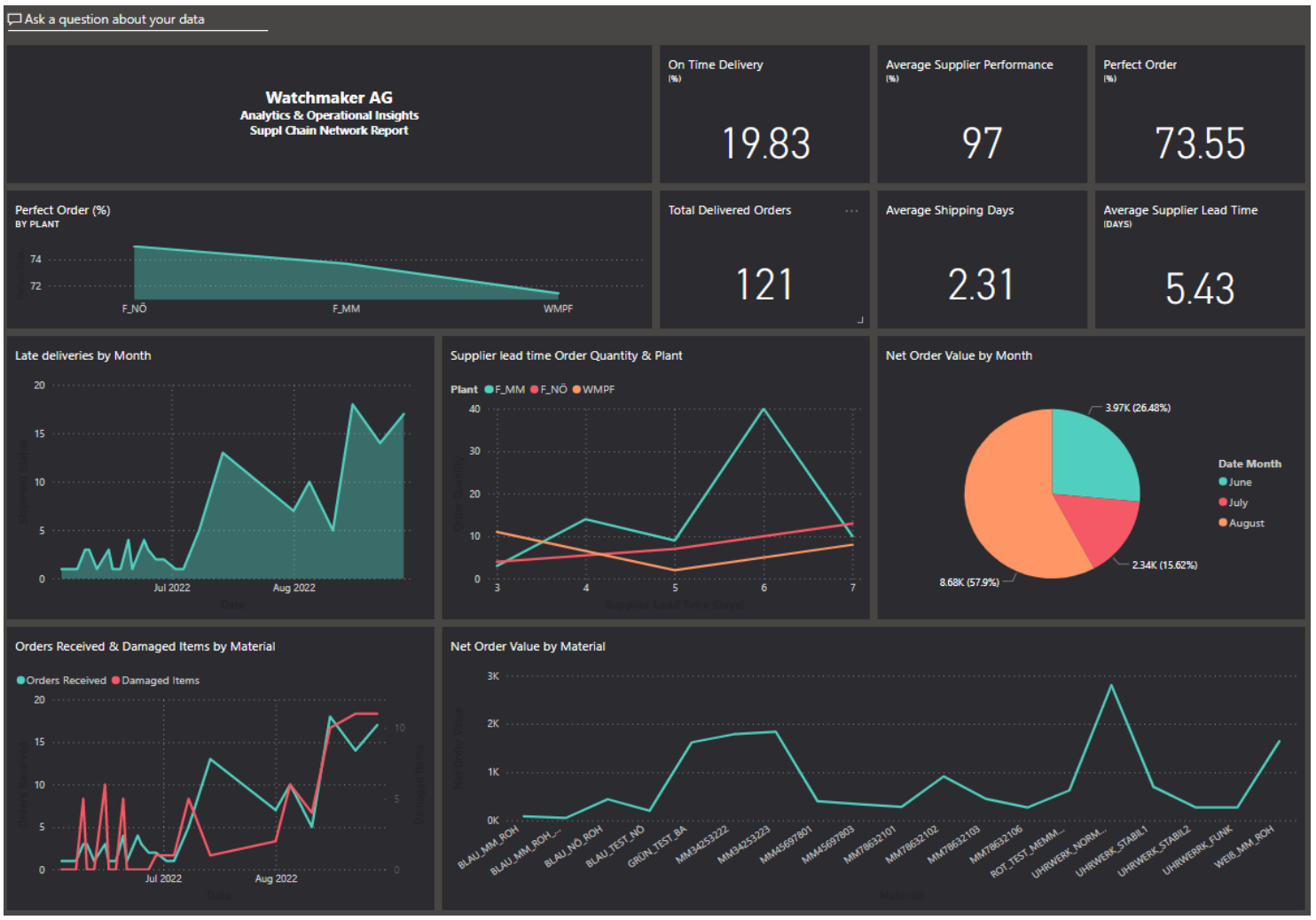


Figure 14. SCN Dashboard-Supplier Management

The results show various informative and meaningful information that 'Watchmaker AG' can consider in its decisions making process (Figure 15). The overall perfect order percentage (upper right corner of Figure 15) is 73.55 which is quite less comparing it to the optimal perfect order percentage especially for order coming from 'WMPF' plant with 71.43% (upper left of Figure 15). Whereas this plant has quite good supplier lead time with less than 3 days. Knowing that, the average supplier lead time is 5.43 days (upper right of Figure 15).

Summing up all delivered 121 orders, only few orders arrived on time with a percentage of 19.83% (Figure 15). Especially, in August, where the late deliveries by material is the highest with 71 later deliveries (Figure 15).

The average shipping days was 2.31 day (Figure 15), meaning that usually the supplier needed this number of days to finish preparing the orders to be shipped from the order purchased date.

This dashboard also shows the damaged items of the orders received by material which was quite high in June to decrease again between July and August and continue to be stable in August.

In this analysis, the overall average supplier performance was 97% (Figure 15) which is quite good, whereas the previous low values should be analyzed and then take the proper actions from the SC analytics managers concerning their supplier. Moreover, Watchmaker AG managers can take benefit from the net order amounts measured by months and material to have a clear and quick idea how much they are spending from this particular supplier.

Note: Power BI is smart enough to have the 'Questions and Answer' feature (upper left corner of Figure15) where managers can ask questions with the real language about their data, without any technical skills and manual aggregations/calculations to be performed. The answers regarding these questions will be visualized as data card.

Power BI Mobile App

Power BI offers a various collection of mobile apps for iOS, Android, and Windows mobile devices. Users can view and interact with their reports whether they were on-premises or cloud. For more accessibility, mobile layout (Figure 16), in which managers can view their real-time shipment status and other important insights we also created. Power BI Mobile is a free license version that can be downloaded with the Power BI components using the following link: Mobile | Microsoft Power BI

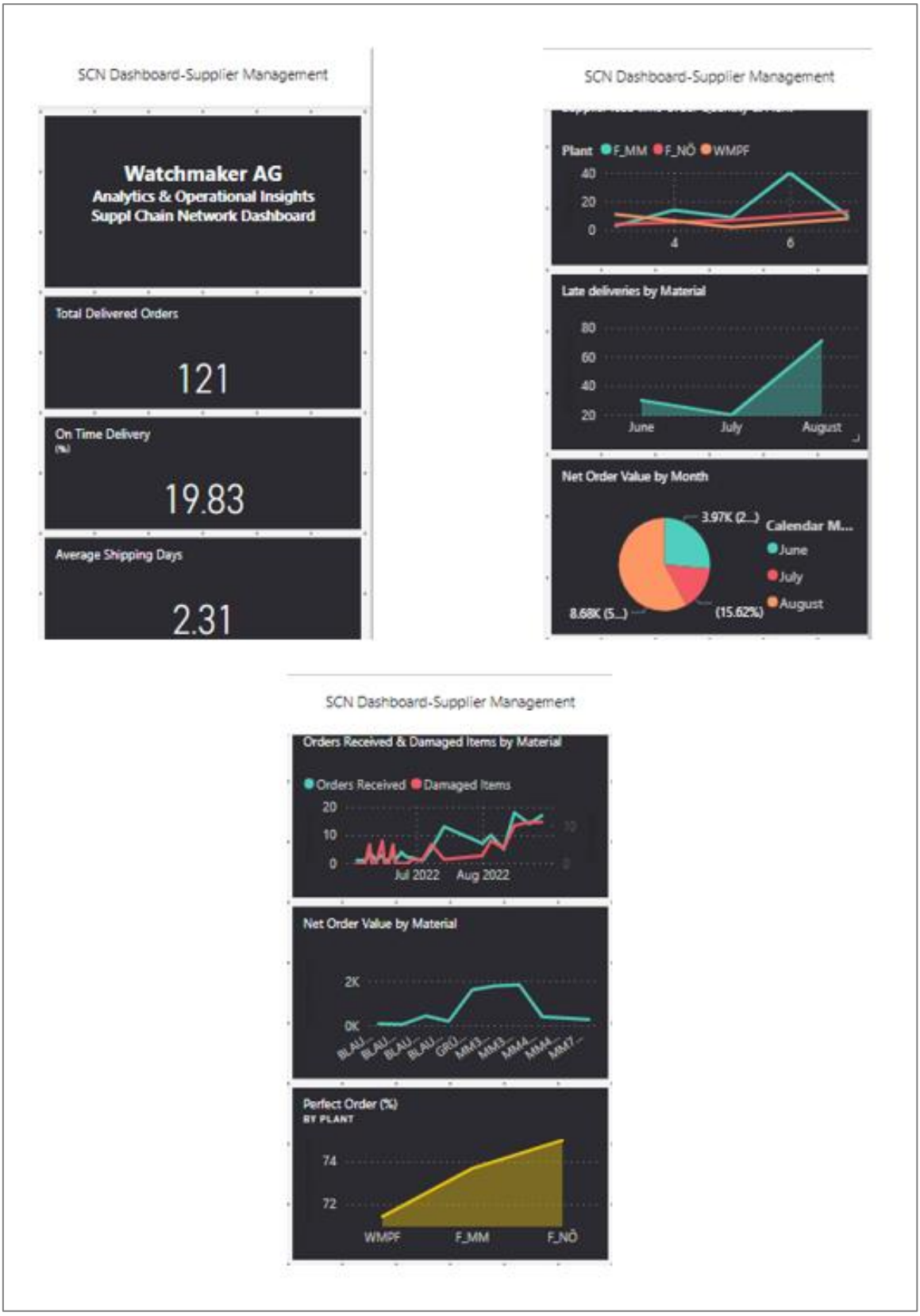


Figure 15. Mobile Layout Dashboard

6.3 Publish & Collaborate

Once the Power BI developer navigate to ‘My Workspace’ in Power BI Service and share the specified report/ dashboard through email within the organization Power BI Service allow the Company’s colleagues to easily access the datasets, dashboards, and reports. By enabling the coworkers to work together on the same dashboards and reports, Power BI streamlines the collaboration and enhances the result. Additionally, the underlying data is unaffected while the dashboards developer and his colleagues study the data and modify it.

On the other hand, these dashboards can be also shared with the supplier or any other external users to discuss the results. This can be done by two options:

- Once the relationship between the company and its supplier is in a well trust-based collaboration environment. Watchmaker AG managers can publish this dashboard by simply sharing it and determine the user permissions on what they can see and what not. Thus, managers oversee the external users (suppliers) as an internal one within the organization.
- However, due to security and privacy policies, some managers prefer to restrict their suppliers and share the results only by exporting interactive dashboards as PowerPoint slides (or pdf file), with no permission to access all features and view datasets.

In the last section, will be presented a brief summary on the whole project and will be discussed the related customer and supplier collaborations issues regarding the implemented monitoring system.

7. Discussion &Conclusions

In this thesis, a low-cost monitoring system using power BI was created and was applied to a case-example company, created appositely, called ‘Watchmaker AG’.

Based on BI concepts in SCM, the following discussed measures were calculated using Power BI (DAX) bringing data from SAP HANA database through SAP S/4 HANA. For this, a data mart conceptual model and ETL process was applied by elaborating all requirement analysis, conceptual designs, and logical designs. The analysis of the dashboard obtained (and extensively described in the results chapter) allows ‘Watchmaker AG’ to have a clear idea about its supplier behavior.

By analyzing the supplier performance, supplier lead time, and shipping days averages, it seems that the supplier is supporting the company in a professional way. However, some measures like on-time delivery and perfect order (measured through the free-damage orders) must be discussed to be improved in the coming shipping batches. Hence, actions must be done from ‘Watchmaker AG’ managers to investigate whether this damaged orders and late deliveries depend on the supplier’s shipping agency or any other factor.

To create the dashboard, were used only 3 months of data because the main goal was to prove that is possible to create a low-cost monitoring system with the collaboration of the supplier. For a full analysis, a supplier must share at least one year of shipping records to evaluate each quarter and month of the year. The model built in this thesis is already settled for the upcoming month’s datasets.

The usual problems in SCC can be minimized through the use of several enablers. In this thesis, the share of data guaranteed the accuracy and availability of the information through the whole analysis process, based on the use of modern technology infrastructure. Subsequently, the collaboration process, necessary for a working monitoring system, also involved people (human) as a connecting factor by accepting and believing the need to interact with the vendors forming a trust-based collaborative culture.

Additionally, the barriers that have to be removed for a successful SCC were investigated. Despite the sensitive information and poor system connectivity, the well-known, in SCC, barriers: humans, lack of trust, organizational silos, ineffective tools, and inadequate alliance management, can form as main obstacles for any serious intention to collaborate in SC.

In Conclusion, this master thesis showed that is possible, for a company, to create its own, on budget, supply chain monitoring system accompanied by some limitations depending on the supplier willingness. This suggest that there is a window to improve the collaboration between the parts.

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