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Proposal and Development of a BI Solution to Improve Supply Chain Performance

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Dedication

This thesis is dedicated to my parents, whose support and unconditional love have been guiding me all throughout this journey and more. Your encouragement and belief in me have given me the strength to overcome all challenges. You instilled in me values of perseverance and integrity that paved the way for my accomplishments. This achievement is as much yours as it is mine.

To my siblings, your camaraderie, humor, and understanding have been a constant source of joy and relief. You've inspired me to look up for the best and reminded me of the importance of family. This thesis reflects our relationship and shared strength.

Thank you, Mother, Father, and my siblings, for believing in me and supporting me unconditionally. This work is a tribute to your love and encouragement, which have been my guiding force.

- Feriel

Dedication

With the expression of my gratitude, I dedicate this modest work to those whom, no matter the words embraced, I could never fully express my sincere love.

To the man, my precious gift from God, who owes my success and respect, who suffered without letting me suffer, who never said no to my demands and spared no effort to make me happy, my dear and magnificent father.

To the woman, the reason for my joy, who, no matter what I say, I will never be able to thank her enough for her great love, sacrifices, and patience, who has always been by my side to encourage and support me throughout my life, my dear and wonderful mother.

To the dearest and closest people to my heart, for the love and joy they have continually surrounded me with, my adorable sisters.

To all my friends who have always been there for me, your unwavering support and encouragement have been invaluable. You've made this journey much easier and more enjoyable. This work is dedicated to you with heartfelt gratitude.

to my family members each one of them by their name, thank you for your unwavering support, encouragement and love. your presence and belief in me have been a constant source of strength and motivation.

- Meriem

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Abbreviations

BI: Business Intelligence

CSCMP: Council of Supply Chain Professionals

CSV: Comma-Separated Values

DSS: Decision Support System

ERP: Enterprise Resource Planning

ETL: Extraction-Transformation-Loading

IT: Information Technology

KPI: Key Performance Indicators

MD: Merinal Distribution

MDX: Multidimensional Expressions

MPP: Master Production Plan

OLAP: Online Analytical Processing System

RDBMS: Relational Database Management System

SC: Supply Chain

SCC: Supply Chain Coordination

SCD: Supply Chain Devision

SCE: Supply Chain Execution

SCM: Supply Chain Management

S&OP: Sales and Operations Planning

SCP: Supply Chain Planning

SSAS: SQL Server Analysis Service

SSDT: SQL Server Data Tools

SSMS: SQL Server Management Studio

SSIS: SQL Server Integration Service

UML: Unified Modelling Language

WPP: Weekly Production Plan

General Introduction

General Introduction

The pharmaceutical industry is a complex and dynamic sector, that is vital in ensuring the well-being of individuals in the world. It plays a crucial role in the global economy and public health and as a business, it involves the discovery, development and production of medications intended for use as treatments or preventatives of diseases.

The supply chain in the pharmaceutical business is a crucial component that ensures the timely delivery of drugs from manufacturers to patients. It encompasses a series of steps, each step must adhere to strict regulatory standards to maintain drug efficacy and patient safety.

Supply Chain Management is a critical component of modern business operations, encompassing the coordination and management of various activities involved in the production and delivery of goods and services. It plays a crucial part in the industry by directly impacting the availability, quality and affordability of essential medications. In order to achieve a an efficient SCM, coordination is an important factor since it guarantees the delivery of products on time, in the right quantities and at the right locations. It plays particularly a significant role in the pharmaceutical sector due to the complicated involvement of stakeholders with each other's, including manufacturers, distributors, wholesalers and healthcare providers on a larger scale. And also, between a company's supply chain departments such as production, stock management, procurement and distribution in terms of information sharing on a smaller scale.

The complexity of global supply chains has increased in the last decades, especially in the Big Data era. Leading to consistent need of real-time and developed data-driven tools to facilitate the management of supply chains. The Merinal Pharmaceutical company's supply chain division where we've held our internship, is faced with the problem of under usage of data leading to miscoordination between its department and poor supply chain management.

In this context, our project aims to develop a real-time business intelligence solution for Merinal Pharmaceutical in order to optimise its SCD performance. Our work was divided into three chapters presented as follows:

- **Chapter one:** this first chapter gives a presentation about Merinal Pharmaceutical, its internal organisation as well as the problem statement.

- **Chapter two:** the second chapter defines the theoretical and the technical concepts that will help us develop our BI solution as well as presenting some contributions from the literature of BI in the SC field.
- **Chapter three:** The third chapter presents the different steps that we took to build our solution and we gave an example of the useful results that can be extracted from the dashboard.

Chapter 1

The Practical Context

1.1 Introduction

The pharmaceutical industry in Algeria plays a crucial part in the industrial sector, by its contribution to healthcare, economic stability of the country and employment. Over the past years the sector has experienced a remarkable growth in its production rates by achieving more than 2.5 billion euros worth of medicines, with a 200-production unit covering 70 % of the country's generic needs, also the Algerian pharmaceutical market is expecting to achieve a revenue of 922.90 million of euros in 2024 . In order to reduce reliance on imports, increase production rates and reduce healthcare costs, the Algerian government has encouraged licencing deals with foreign pharmaceutical companies. The presence of several foreign investors in this domain has led to a high level of competition between local producers, in which each one of them aims to achieve higher levels of production and gain more profits by implementing better strategies and a more efficient management of their companies.

In this chapter we will give a presentation of the company where we have held our internship, by giving an overview of it's history and it's organizational structure, and then we will analyse it's current situation, define the problem statement and the proposed solution for it.

1.2 An overview of the company

Merinal Laboratories is one of the leading Algerian producers in the pharmaceutical industry. Specialized in generating dry form medications with a general formulation providing them in different shapes such as tablets, capsules and sachets.

1.2.1 Merinal Laboratories presentation

Merinal's laboratory has directed its development strategy to the production of generic medications since the emergence of its first innovative production unit, with an ability of producing up to 150 million boxes per year, and this by establishing procedures intended to control its production system, storage, maintenance, product distribution, batch recalls and clients' complaints. One of Merinal Laboratory goals is being present on a large national scale, by implementing a vast network of 26 strategically positioned distributors throughout the country. Ensuring a maximum accessibility to patient and healthcare services, as shown in the figure 1.1.

Figure 1.1: Different distributors of Merinal Laboratory.
[1]

Also, since 2007, Merinal has expended its presence into the international market, by realizing its first export operation into the Ivory Coast and currently it works with 12 other countries differing between African and Arabs such as Saudi Arabia and Iraq. In accordance with the constant need for pharmaceutical products, Merinal has a diversified range of generic medications covering 10 therapeutic categories with nearly 58 distinct presentations. Which are described in the following figure 1.2:

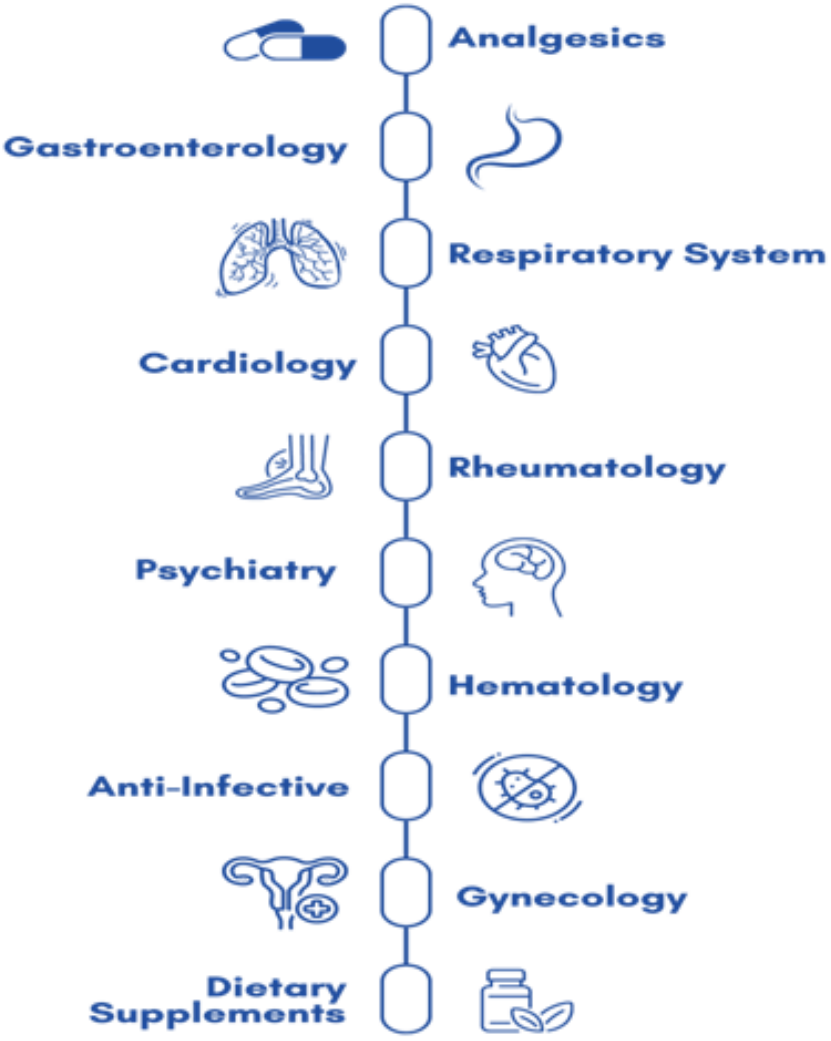


Figure 1.2: Therapeutic categories produced by Merinal.
[1]

1.2.2 The history of Merinal Laboratory

Similar to numerous global pharmaceutical companies, the origin of Merinal Laboratory dates back to the 1969, since then several changes have impacted the organization of the company, which are summarized in the table 1.1.

1969	MELLAH Pharmacy.
1997	Establishment of Merinal Company.
1999	Beginning of construction work for the production unit.
2002	Beginning of production activity under license.
2004	Launch of the first generic.
2007	Beginning of exports.
2012	Release of 30 million boxes onto the market.
2020	1000 employee committed to your health.
2022	20 years after, 70 million boxes released to the market.
2023	Inauguration of the new pharmaceutical complex.
2024	Introduction to the new Merinal Visual Identity.

Table 1.1: History of Merinal Laboratory.
[1]

1.3 The organizational structure of Merinal

The organisational chart reflects the activities held within the company; different departments work in synchronisation in order to achieve its goals. Being held under the authority of a chief executive officer, the following organizational chart (figure 1.3) reflects the different directors within Merinal Laboratory:

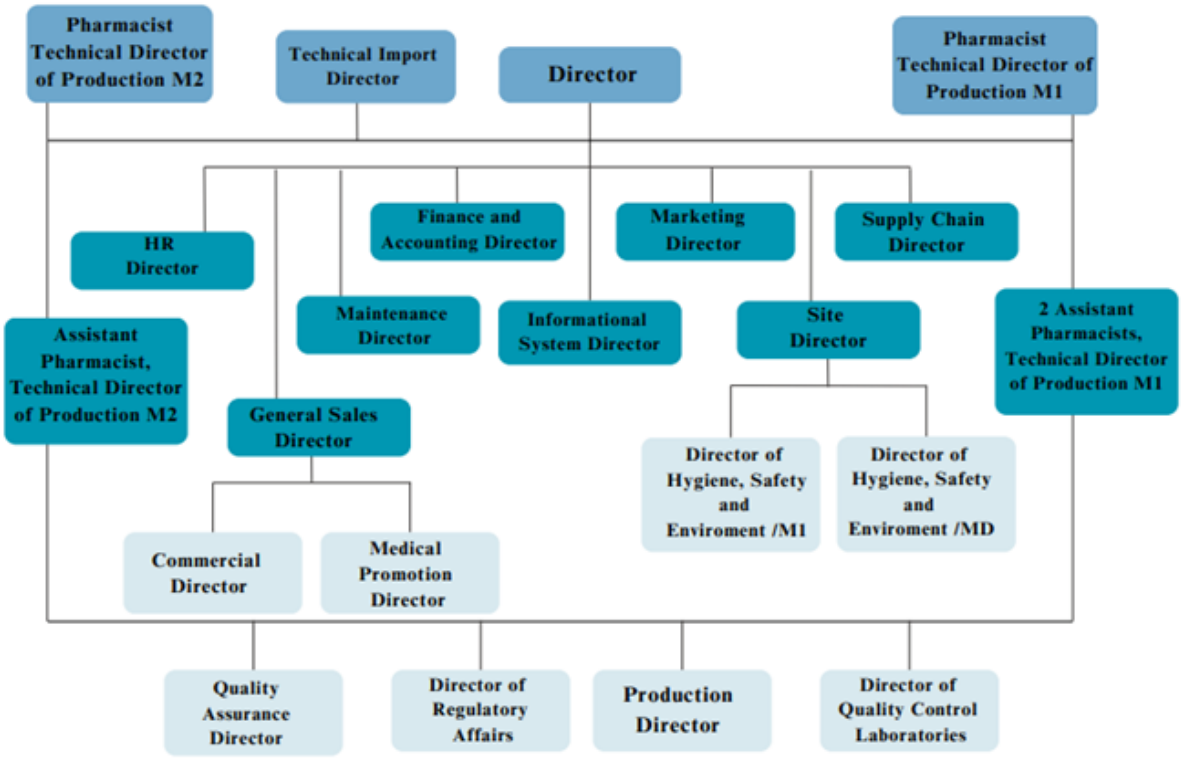


Figure 1.3: Merinal organisational chart.
[2]

The company dispose of 3 different sites to realise its distribution tasks, two are mainly located in the industrial zone of Oued Semar, and the third one in Khemis El Khechna presented in the following figure 1.4:

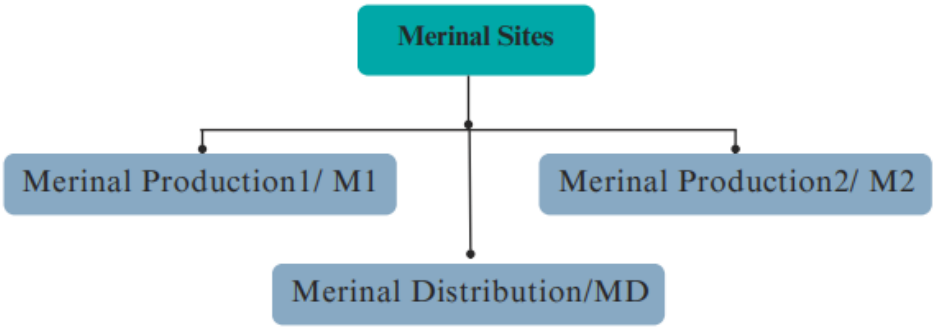


Figure 1.4: Sites of Merinal.
[1]

1.4 Supply Chain Division of Merinal

The supply chain division (SCD) of Merinal is the one responsible to ensure coordination among diverse departments and sub-departments, in order to guarantee an interrupted and effective flow of materials dedicated to the production and distribution of pharmaceuticals. This figure summarizes its organisation:

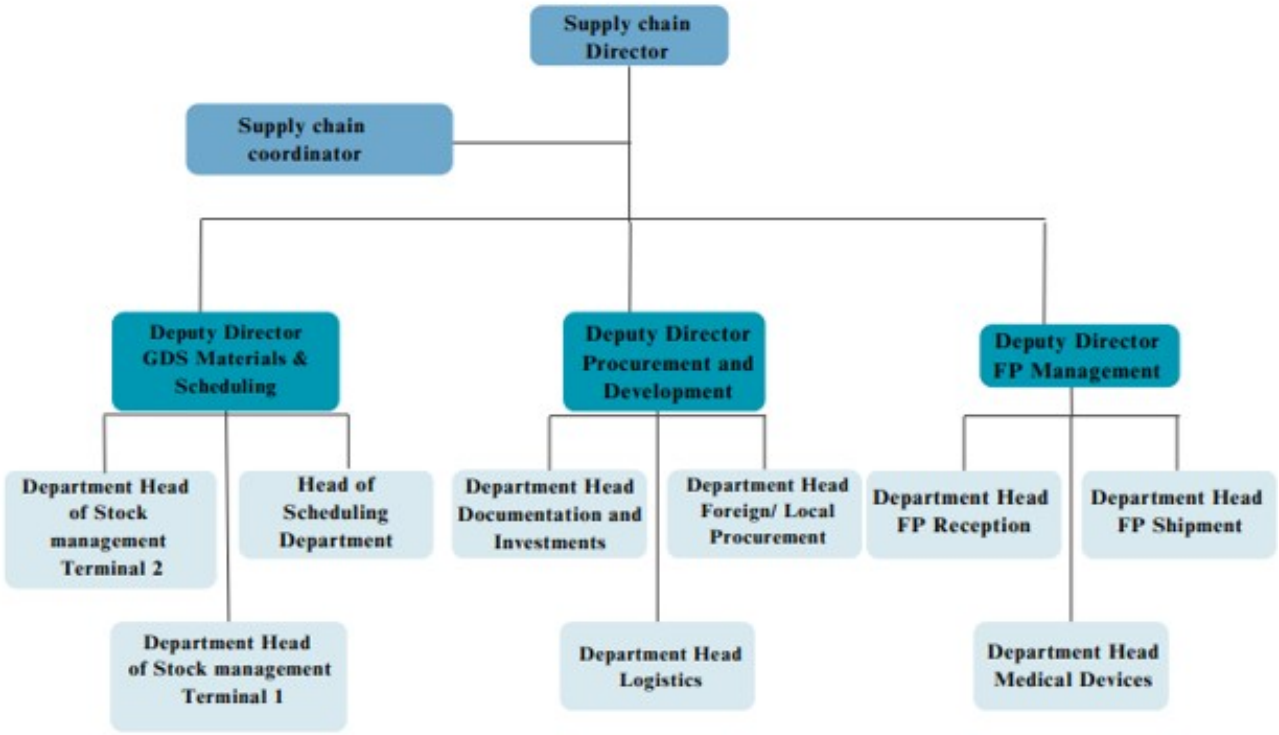


Figure 1.5: SCD Organisational chart .
[2]

Our solution is dedicated for the stock management and scheduling departments, their main responsibility is to manage raw materials and production planning:

- The stock management department: manages inventory levels of raw materials and makes sure of the availability of materials necessary for the production service.
- The scheduling department: the one in charge of scheduling and tracking fabrication orders and production department needs during the manufacturing process.

1.5 Problem identification

During our internship at Merinal, we've held discussions with the heads of stock management and scheduling departments concerning the overall performance of their supply chain. Both department heads highlighted issues managing the process of coordination between them. In order to analyse the current situation, and find the potential reasons of the faced problem, we have summarized the information flow of the SCD and employed two different approaches commonly used in process analytics which are the fishbone diagram and the 5W2H method to help us identify the root cause of these operational inefficiencies.

1.5.1 Information Flow

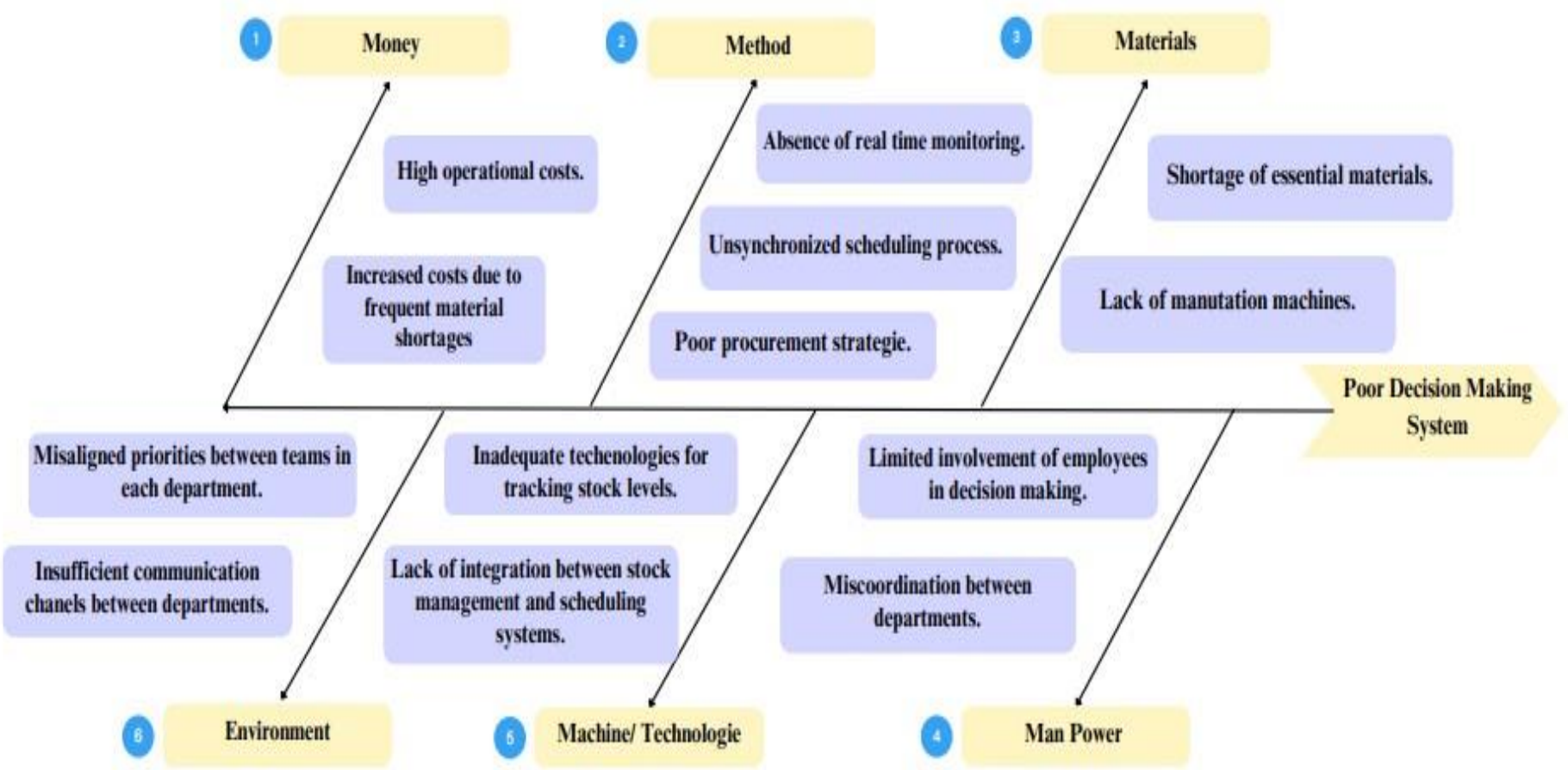
The information flow between the concerned parties of the company goes as follows :

1. After holding a committee to establish the yearly SOP (Sales and Operations Planning) to identify the annual production goals, the MPP (Master Production Plan) will be formulated, This plan will then be used to develop the Monthly Production Plan (MPP), which in turn will guide the creation of the Weekly Production Plan (WPP).

2. The scheduling department receives the WPP by email, and stock management department receives a roadmap for all the necessary materials to issue the manufacturing order from SageX3.

3. Information about the received and consumed materials as well as produced final products, will be updated by data entry on Excel Sheet and on Sage X3 daily.

1.5.2 The Fish-bone diagram


1
Money
2
Method
3
Materials
High operational costs.
Absence of real time monitoring.
Shortage of essential materials.
Increased costs due to frequent material shortages
Unsynchronized scheduling process.
Lack of manutation machines.
Poor procurement strategie.
Poor Decision Making System
Misaligned priorities between teams in each department.
Inadequate techenologies for tracking stock levels.
Limited involvement of employees in decision making.
Insufficient communication chanels between departments.
Lack of integration between stock management and scheduling systems.
Miscoordination between departments.
6
Environment
5
Machine/ Technologie
4
Man Power

This fish-bone or the cause and effect diagram is a tool that helps in modelling the possible root causes of the problem , it is presented in the figure 1.6. After discussing the found results, we have reached the following conclusions:

	Potential issues	**Eliminated issues**
Issue	• Absence of real-time monitoring. • Inadequate technologies for tracking stock levels. • Lack of integration between scheduling and stock management departments	• Money. • Environment. • Manpower. • Materials. • Unsynchronized scheduling process.
Reason	Reliance on data storage in Excel sheets and Sage-x3.	The necessary policies and systems are available to identify and prevent any of these issues.

Table 1.2: Obtained results from the fish-bone diagram

According to the obtained results of the fishbone diagram, and to have a better understanding of the current situation as well as the factors resulting in it. We have used the 5W2H method.

1.5.3 The 5W2H method

The 5W2H method is a simple yet a powerful tool used in problem solving, it helps in understanding the problem from different perspectives by asking the right questions depending on the faced situation. The following table summarizes the different questions that we have conducted to gather pertinent details:

Who	The heads of stock management and scheduling departments.
What	increased operational inefficiencies and frequent shortages of essential production materials quantities.
Where	In stock management and scheduling departments.
How	Through the frequent miscoordination between the scheduling and stock management departments concerning quantities needed to fulfil production orders.
How much	A significant amount of materials required for production orders require multiple procurement attempts to provide the needed quantities.
Why	Lack of data analysis, real time monitoring and a mutual visualization and decision-making system.

Table 1.3: The 5W2H approach.

1.6 Problem statement

Following the in-depth analysis of the potential root causes of the current problem at Merinal. We have concluded that currently the company lacks an adequate system for real-time monitoring of its stock levels. Specifically, when GDS department issues the availability of the necessary materials without prior confirmation of their inventory levels, leading the scheduling department to confirm production orders, provoking delays and manufacturing inefficiencies in the production service.

In this context, our objective is to develop a Business Intelligence (BI) solution dedicated to the stock management and scheduling departments at Merinal. This solution aims to enhance coordination between the various departments, optimize stock management, ensure continuity in the production processes and provide useful insights for scheduling and stock management departments. We propose to create a dashboard that allows for real-time supervision and monitoring of stock levels, thereby providing an effective and efficient decision-making tool. Our solution will also offer forecasts of quantities to be produced and consumed. Finally, these forecasts will be used to optimize procurement and improve the overall performance of the supply chain.

1.7 Conclusion

This chapter has helped us in presenting the company where we've held our internship and understand the way in which it operates. By giving an overview of its evolution history, and its overall organisational structure. It has also presented the fish-bone diagram and the 5W2H method that we have used to analyse the company's current situation, define the problem statement, and presenting the proposed solution.

In the next chapter we will discuss the theoretical aspects and concepts of our solution which will include supply chain, Business Intelligence and the relationship between them .

Chapter 2

State of the Art

2.1 Introduction

After defining the problem statement in the previous chapter, we will now discuss the theoretical aspects and concepts that will help us in implementing our solution.

the present chapter is divided into three sections. In the first one, we will define supply chain and supply chain management in order to show the difference between the two terms, then, we will define the different actors, types, and components that can be held within the SC; after that, we will highlight the importance of coordination in SC and more specifically between inventory and manufacturing services. In the second section, we will define the concept of business intelligence, and explain the different steps to take in order to develop a BI solution and the tools that can be used. Lastly, in the third section, we will discuss the relationship between Business Intelligence and Supply Chain and cite some studies that have been realised in this field.

2.2 Supply Chain Concepts

2.2.1 Supply Chain

In the literature, we can find a large number of definitions about supply chain, since it has been examined and established from multiple perspectives. According to Beamon,B [3]:

> ”Supply chain is a structured manufacturing process where in raw materials are transformed into finished goods, then delivred to the end customer.”

Ayers,J.B has defined it as[4]:

> ”The life cycle processes comprising physical, information, financial and knowledge flows whose purpose is to satisfy the end-user requirements with products and services from multiple linked suppliers.”

the council of supply chain professionals described it as [5] :

> ”the material and informational interchanges in the logistical process stretching from acquisition of raw materials to delivery of finished products to the end user. All vendors, service providers and customers are links in the supply chain.”

in other words, we can say that supply chain is the combined flows of goods coordinated with their associated information from the origin point to the final destination[6] . alternatively, it encompasses all the activities associated with the flow and transformation of goods from the raw materials stage, through to the end user, as well as the associated information flows [7].

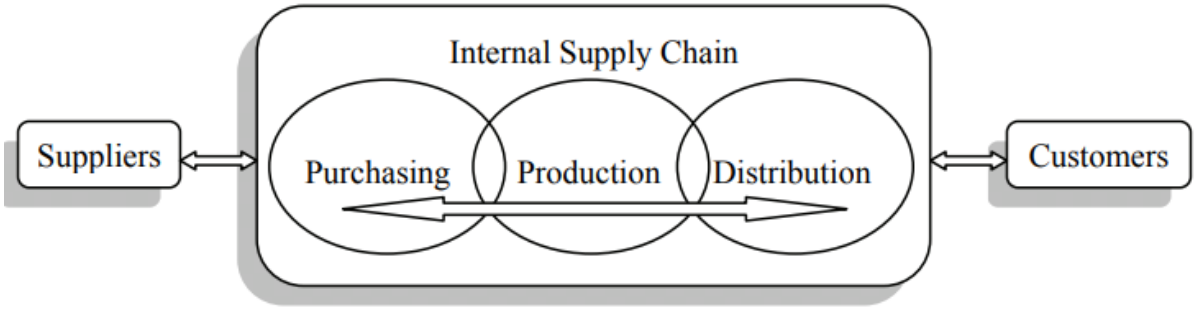


Figure 2.1: Schema of a company’s SC.
[8]

2.2.2 The Main Actors in the Supply Chain

Several key players contribute to the movement of goods or services from raw materials to the end user. According to Chopra and Meindl[9] , the supply chain includes suppliers, manufacturers, distributors, retailers, and customers. The customers being the main focus of the chain, since the primary purpose of the existence of any supply chain is to satisfy customer needs, in the process generating profit for itself. And in order to get more details about each one of them, here is their definition in accordance with the CSCMP[5]:

1. **Supplier:** An individual or an organization who supplies goods or services to the company. This is also sometimes referred to as a "vendor". In some settings—where a company provides goods through a distribution network—network members may be referred to as suppliers.

2. **Manufacturers:** companies or entities involved in transforming goods from raw materials to the end product.

3. **Distributors/Wholesalers:** A business and industry which acts as a third-party local representative and distribution point for a manufacturing firm. These firms may perform some light assembly or kitting of goods, but generally provides a buffer for finished goods. Distributors typically purchase the goods in quantity from the manufacturer and ship to customers in smaller quantities.

4. **Retailers:**An individual or organization which purchases products from a manufacturer or distributor and resells them to the ultimate consumer. This group includes a wide range of businesses from door to door and corner stores to global companies.

5. **Customer:** in distribution a customer is the trading partner or reseller, and in direct-to-consumer he is the end customer or user.

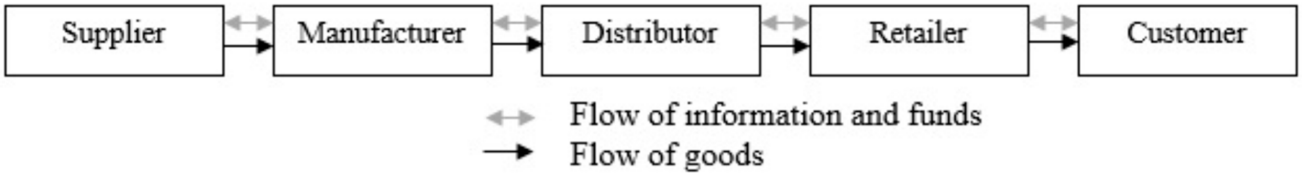


Figure 2.2: The Basic Supply Chain.
[9]

2.2.3 The Degrees of Supply Chain

Supply chain complexity can differ from one another depending on the number of organizations involved in the activity. Mentzer et.al has divided this complexity into three different degrees noting that the final consumer is considered part of the chain and any organization can be part of numerous supply chains[10] :

1. **Direct Supply Chain:** It consists of an inter play between the company, its supplier and customer, where flows of information traverse both upstream and downstream products, services and finances.

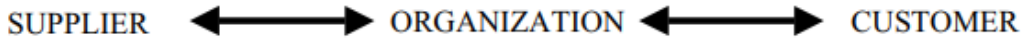


Figure 2.3: The Direct Supply Chain.
[10]

2. **Extended Supply Chain:** Adding to the immediate suppliers and customers extended supply chain includes also the suppliers of immediate suppliers and customers of the immediate customers.

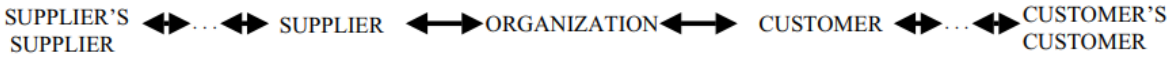


Figure 2.4: The Extended Supply Chain.
[10]

3. **Ultimate Supply Chain:** This one represents the ultimate encompasses the totality of organizations engaged in the spectrum of the upstream and downstream operations entailing the multi-faced exchange of goods, services, financial transactions and informational flows.

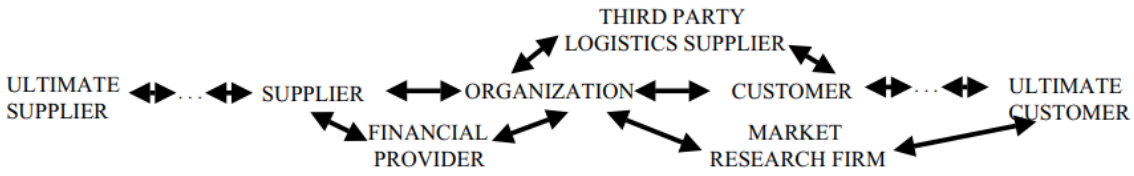


Figure 2.5: The Ultimate Supply Chain.
[10]

2.2.4 Components of a Supply Chain

In order to fulfil the client demand and provide the needed product, supply chain manages its life cycle within a specific process which the CSCMP has defined it as "a series of time-based activities that are linked to complete a specific output" . These activities can change depending on the complexity of the product, but the main ones according to the CSCMP are defined as [5]:

1. **Procurement/Purchasing:** The activities associated with acquiring products or services. The range of activities can vary widely between organizations to include all of parts of the functions of procurement planning, purchasing, inventory control, traffic, receiving, incoming inspection, and salvage operations.

2. **Manufacturing/Processing:** The segment which is associated with the production of product using formulas and manufacturing recipes. It can be contrasted with discrete manufacturing which is concerned with bills of materials and routing.

3. **Inventory Management:** The process of ensuring the availability of products through inventory administration.

4. **Distribution:** The activities associated with moving materials from source to destination, can be associated with movement t from a manufacturer or distributor to customers, retailers or other secondary warehousing / distribution points.

5. **Reverse Logistics:** A specialized segment of logistics focusing on the movement and management of products and resources after the sale and after delivery to the customer. Includes product returns for repair and/or credit.

2.2.5 Supply Chain Management

Since the satisfaction of the customer plays a crucial part in the success of a supply chain, an effective management of its components is necessary, which leads as to the concept of supply chain management. From its introduction in the 1980s, supply chain management has undergone significant changes and extensions. Sweeney has defined it as [11]:

> " the systemic, strategic coordination of the traditional business function and tactics across these business functions within a particular company and across business within the supply chain, for the purpose of improving the long-term performance of the individual companies and the supply chain as a whole."

Simchi-Levi believes that [12]:

> "Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements."

According to the CSCMP, researchers define SCM as [5]:

> "It encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. "

In accordance with these definitions,we conclude that supply chain management is the integration of all the mentioned activities through improved supply chain relationships, to achieve sustainable competitive advantage [7] .

2.2.6 Supply Chain Coordination

Inter-entities coordination refers to distinct entities collaborating together in purpose of achieving aligned goals and decision-making to optimize the overall performance of the supply chain. In fact, coordination is an essential part in the conceptual model of a supply chain.[13] it is defined as:

"the act of making arrangement for a purpose and making separate entities work in alignment."[14]

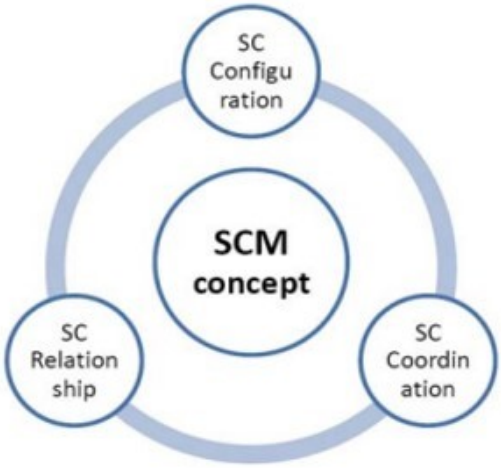


Figure 2.6: Conceptual Model of SCM.
[13]

Supply Chain Coordination (SSC) can involve the coordination from the supplier to the end customer on a large scale, and also it can involve the coordination between a supply chain's inter-members in terms of their inter-dependencies such as: order, procurement, inventory management, production, design and development, prediction and distribution. SCC helps in increasing sales, organize inventories, shortening lead times and improve the performance of the supply chain [15]. In order to achieve a successful coordination, the first step is to identify which members of the SC should coordinate, which actions and activities requires coordination and what are the reasons for it [15]. It also can be categorized in three different types which are: simple information exchange, formulated information communication and modelled collaboration. In other terms, SCC is about information sharing, updating and collaborative work between SC members.

2.2.7 Manufacturing and inventory management coordination

Coordinating the supply chain can be one of the most difficult tasks in supply chain management[15], specially between manufacturing and inventory management departments in terms

of information sharing that can be defined as distributing useful Information for systems, firms, people or organizational units[16]. Since manufacturing is about using resources to create new products with added value, inventory's management purpose is to ensure an uninterrupted materials flow to maintain production without provoking overstocking or under-stocking. A lack of coordination arises mostly when decision makers possess uncompleted or lack for real time information [14]. Which means that, effective information systems should be implemented to help sharing important insights such as: inventory levels, products quantities, demand forecasting ext.

The influence of information sharing on supply chain effectiveness has grown considerably in the last periods, due to its advancement in information technology [16] . Numerous solutions have been developed for achieving successful coordination and information sharing such as Business Intelligence.

2.3 Business Intelligence

2.3.1 Business Intelligence definition

> "The term business intelligence dates back to 1958 –introduced by Hans Peter Luhn an early pioneer in Information Sciences. In spite of this early vision, business intelligence did not evolve into a mainstream technology component until only very recently." [17]

Its a set of computer-based techniques that allow us to leverage data-driven decisions and employ the operational data collected of a company to incorporate robust analysis, from the different databases and sources that the company is utilizing [18]. The goal is to get a software solution that helps planners and decision makers within said company, asses their achievements in comparison to their goals using the Key Performance Indicators (KPIs), as well as help refine their approach to decision-making and optimize it based on the strategic and operational goals of the organization as well as their chosen KPIs. As Swain Scheps defined (BI) in his book: "BI is any activity, tool, or process used to obtain the best information to support the process of making decisions." [19]

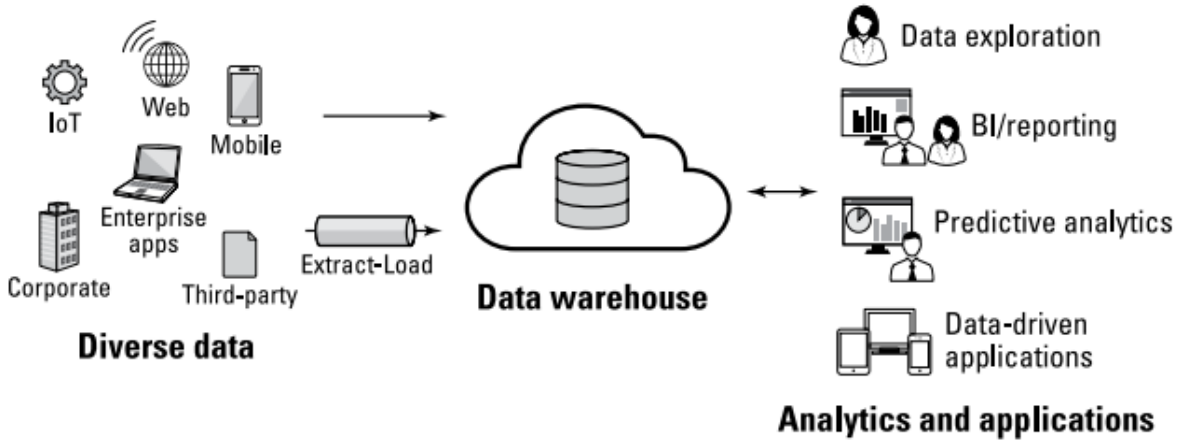


Figure 2.7: Business Intelligence Schema.
[20]

The Journal of Knowledge Management, Economics and Information Technology also defined Business Intelligence as a technology that provides historical, current, and predictive views of business operations. Common functions of business intelligence technologies are reporting, online analytical processing, analytics, data mining, business performance management, bench marking, text mining, and predictive analytics. Business intelligence aims to support better business decision-making. Thus, a BI system can be called a decision support system (DSS). [21]

Drew Bently said that Business intelligence (BI) can be described as:"a set of techniques and tools for the acquisition and transformation of raw data into meaningful and useful information for business analysis purposes". [22] In more depth, BI is a solution that is based on taking pre-selected measures and axes of analysis and using them to create functions that can be used for decision-making. While the measure are the points that the decision-making parties wish to asses, the axes represent the points that the measures are going to be segmented by and analysed on, for example:

> "Analysing Sales by a product date of production", or "Analysing the Reach of a marketing campaign by age of targeted audience". The "sales" and "reach of a marketing campaign" represents the measures that our decision-making parties wish to analyse, and the "product date of production" a well as the "age of targeted audience" represent the axes that we wish to analyse our measures by."

In conclusion, Business Intelligence is a data-driven enterprise solution that facilitates decision-making for strategic and operational parties of an organization, by using different functions to provide historical, current and predictive views of key operations in its different field of application within the company (Sales, Revenues, Marketing, Supply Chain, Resources etc.).

2.3.2 The Architecture of a Business Intelligence solution

As any other software system, a BI solution has a specific architecture that defines the logic and the process that it takes to achieve an affective decision support system (DSS). It has three main phases:

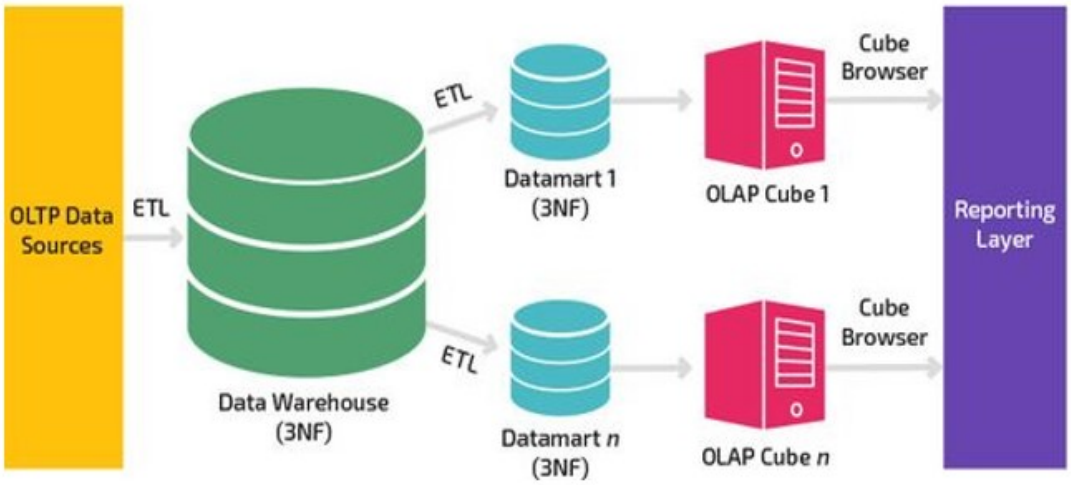


Figure 2.8: business intelligence architecture.
[23]

1. **Phase 1: Creation of the Data Warehouse**

According to Inmon Data Warehouses are 'subject-oriented', integrated, time-varying, non-volatile data collections used primarily in organizational decision-making [24] . It is also a centralized storage location for large volumes of structured and unstructured data generated by the business processes. A data warehouse serves not only a central location that is easily accessible but also as the go to place for reliable and consistent data about the business [19].

If we wanted to work with a smaller range of data, we can introduce the concept of data marts which is a specialized and focused subset of data warehouses, used to achieve the analytical needs of a specific and focused business unit. It draws data from fewer data sources comparing to the data warehouses and it might include internal operational systems, a central data warehouse and external data [25].

(a) **Modelling the Data Warehouse:** In the realm of Data Warehousing, dimensional modelling makes a crucial part in order to structure data and provide an efficient way to analyse it. It helps representing data in a way that is easily understood by users. This multidimensional approach in the data warehouse is based on dimensions and measures[26].

(b) **Fact Table Concept:** According to Kimball et.al [27]. fact table is the primary table in dimensional modelling, it contains the numerical measurements of the business like how much? How many? and are attributes of facts in the background of dimensions. Also, the information inside this table doesn't have to be at the finest level of detail, it could be summarised data such as the total phone calls made by a customer.[28] Fact tables are the central focus of a dimensional model, and it should contain at least two foreign keys in order to connect it with the other dimension tables.

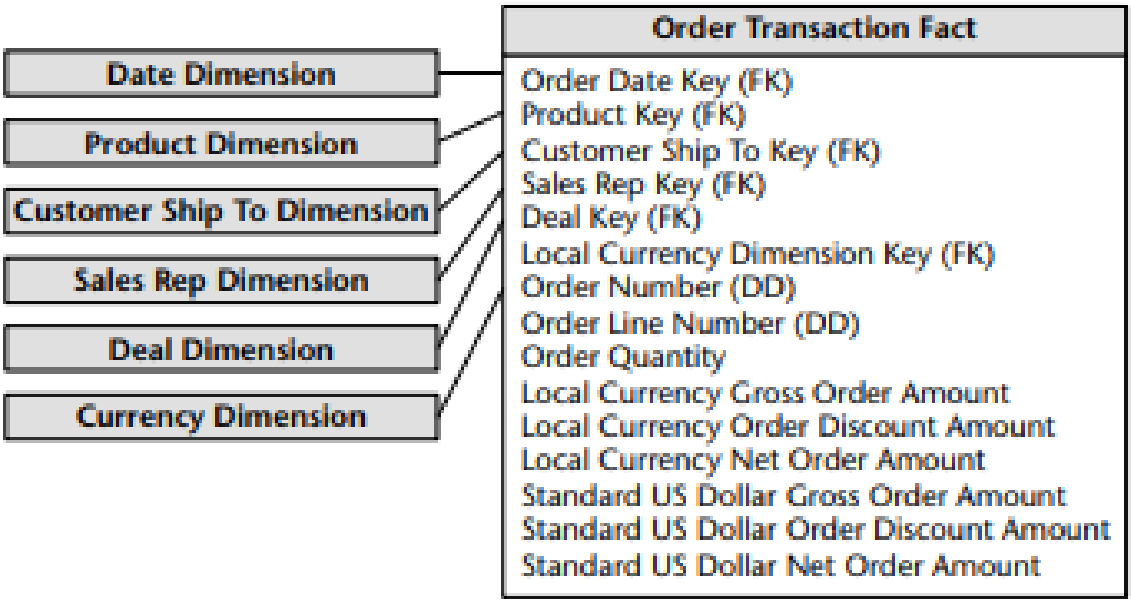


Figure 2.9: Schema of a Fact Table for Order Transaction.
[27]

(c) **Dimension Table Concept:** Dimension tables are integral companions to the fact table they contain textual descriptors of the business they represent descriptive, non-numeric data, like what? where? why? who? etc. It contains columns or attributes that describe the rows in the dimension table. Each dimension is defined by its single primary key which is designated by the PK notation. The dimensions attributes serve as the primary source of query constraints, grouping and reports label.[27] For a better understanding an example of a dimension table is represented in the figure 2.10:

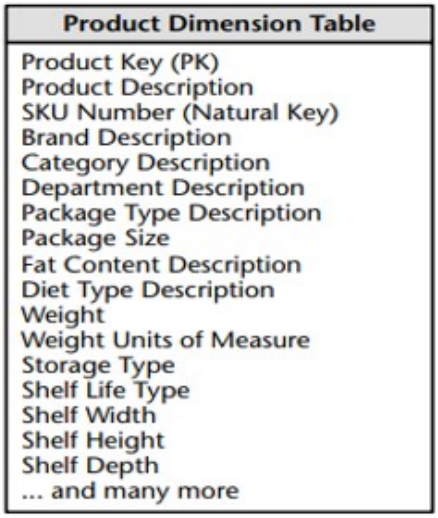


Figure 2.10: example of Dimension Table
[27]

(d) **Types of Multidimensional Models:** Multidimensional modelling helps in structuring data in order to make it organized and performant for the queries of the user. By dividing the data into fact and dimension tables as mentioned above, multidimensional modelling has two major forms known as the snowflake schema and the star schema:

i. **Star Schema:** It is called the star schema simply because the fact table is maintained in the middle of the dimension tables, these tables are connected to each other forming a star like structure, making it better for simple queries and aggregations in terms of performance. The figure 2.11 illustrates an example of the star schema:

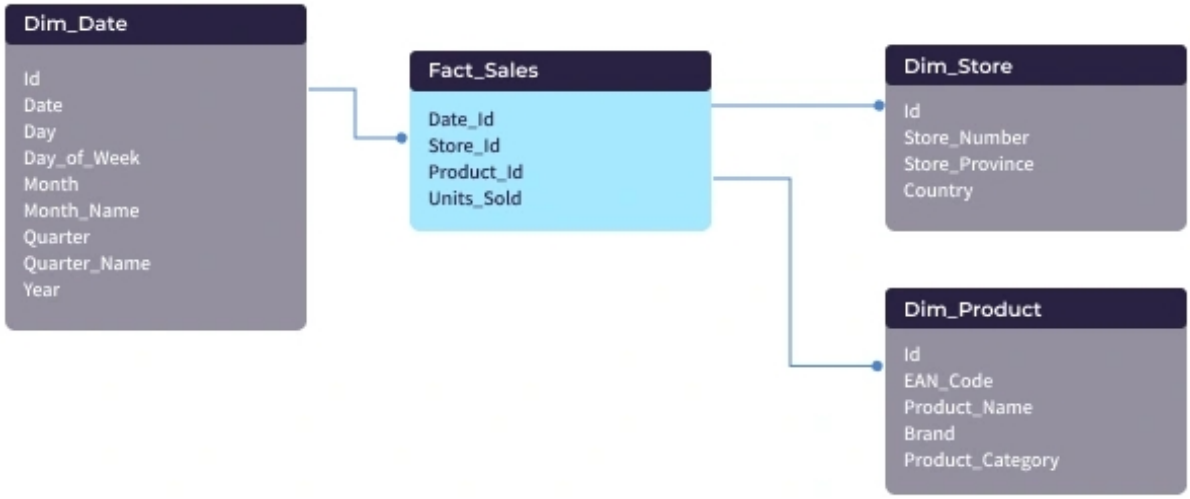


Figure 2.11: Star Schema Example
[29]

ii. **Snowflake schema:** is a more complex model, consisting of a centralized fact table connected to multiple dimension tables in a hierarchical manner forming a pattern of a snowflake and the figure 2.12 gives us an overview of this diagram:

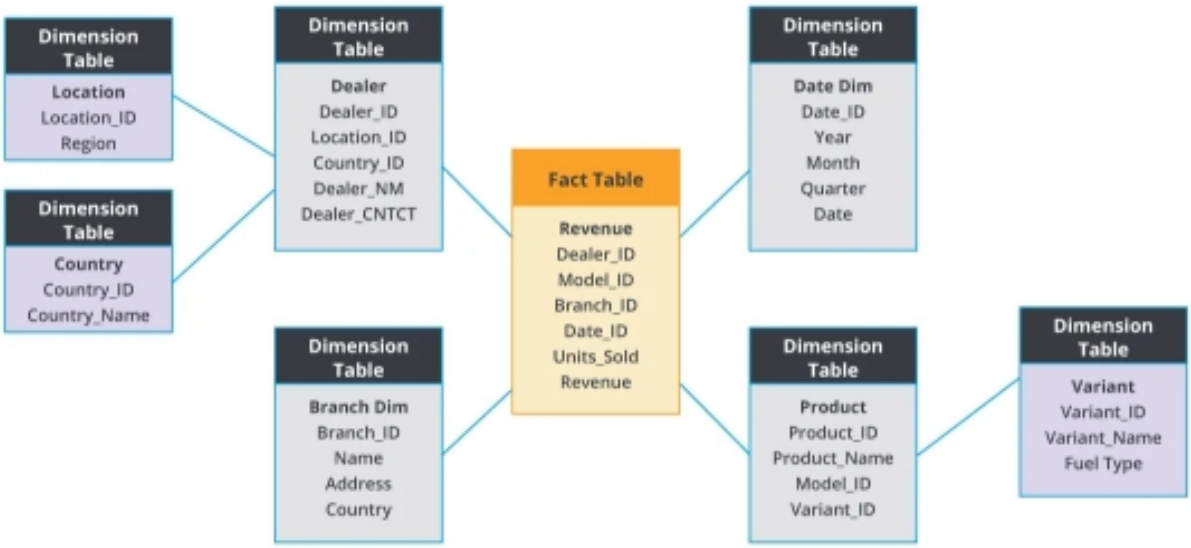


Figure 2.12: Snowflake Schema Example
[30]

2. **Phase 02: Extraction, Transformation, Loading (ETL)**

Definition: An ETL System represents the movement of data and its transactional process of extraction from multiple sources, transforming it into dimensional fact tables

and loading it into a data warehouse environment.

Extraction-Transformation-Loading (ETL) processes describe (a) the identification and extraction of (relevant) data from various operational sources, (b) the transformations needed to cleanse and customize this data, and finally, (c) the loading of the data into a data warehouse [31]. The data warehouse is the core of the BI system. It is a database built for the purpose of data analysis and reporting [32].

(a) **Extract:** It is the initial stage that consists of retrieving data from various sources that can be diverse, ranging from relational databases to flat file. It is used to create a connection to the source, while identifying the needed data and extracting it.[25]

(b) **Transform:** When extracting the data, its initial state can have a lot of inconsistencies in format, structure or data types. This is when the transformation part of the ETL process comes into place. Depending on the intended use of data in the target system, the transformation usually include:

   i. **Cleaning:** Correcting mistakes, deleting duplicates and handling missing values.

   ii. **Standardization:** Making sure the formatting is correct when it comes to date format and units.

   iii. **Deriving new fields:** Combining different data to create new metrics, indicators or attributes.

   iv. **Filtering:** Removing unwanted data based on specific criteria

   v. **Aggregation:** Applying specific functions on data to summarize it (sum, count, average, max and min etc.).

(c) **Load:** It is the final stage of ETL, it consists of loading the data warehouse by ensuring the efficient and accurate loading, avoiding potential errors during the process. [25]

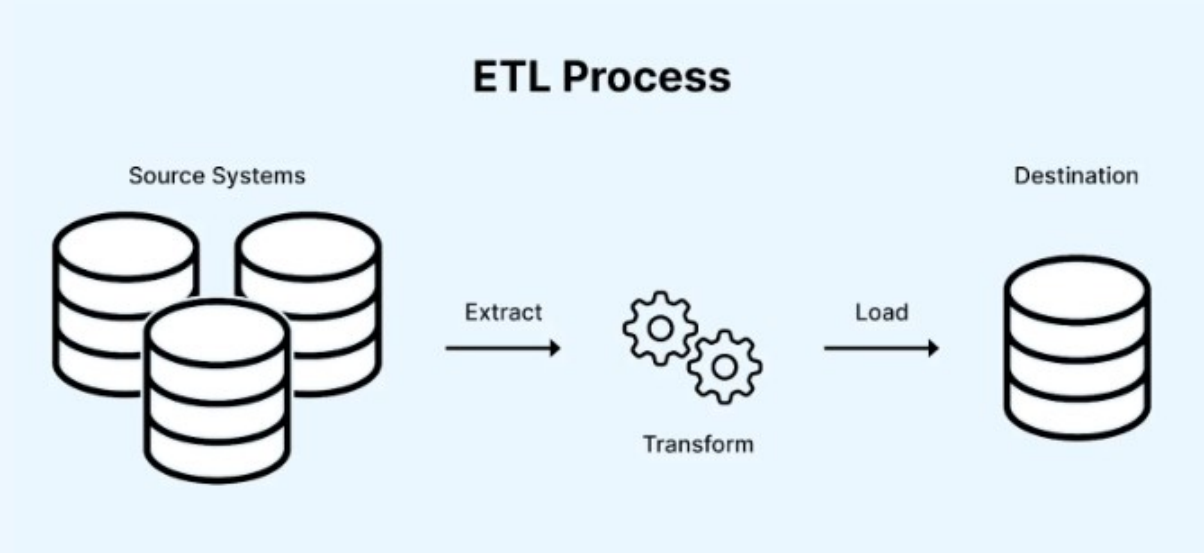


Figure 2.13: ETL Process
[33]

3. **Phase 03: OLAP cubes**

OLAP is a data structure that provides multidimensional cubes from data and provides useful information for decision makers. While designing an OLAP system, the most important factor is reporting requirements. Compared to Online Transactional Processing (OLTP), OLAP provides faster reports because it reshapes data in cube structures rather than the traditional relational structure based on tables [32].

The OLAP (Online Analytical Processing) system is a type of data analysis system that is designed to support complex analytical and decision-making tasks. Based on the search results provided they found out that OLAP systems are characterized by their ability to perform multidimensional analysis on large datasets, often used in data warehousing and business intelligence applications [32][34].

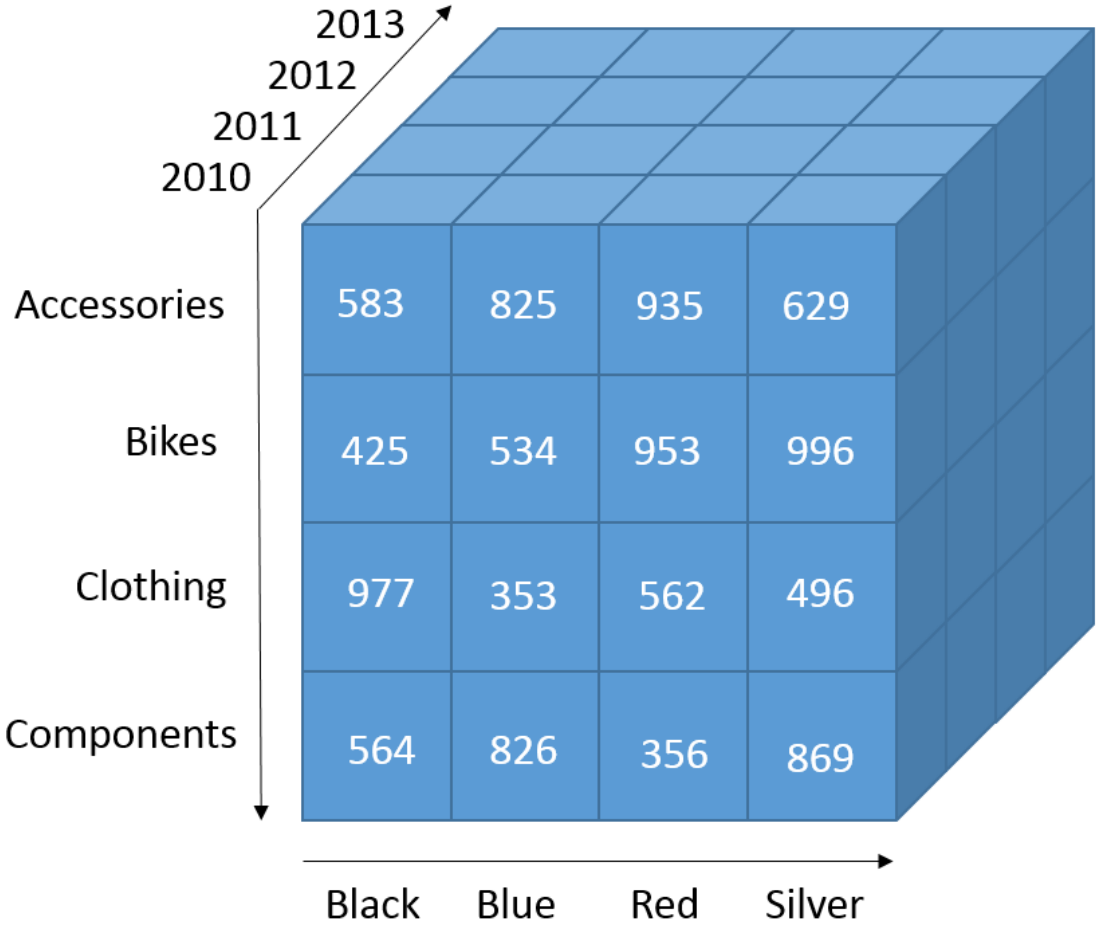


Figure 2.14: OLAP Cube Representation Example
[35]

The key features of OLAP systems include:

(a) **Columnar data storage:** OLAP systems often use column-oriented NoSQL databases to store and manage large volumes of data, which is more efficient for analytical queries compared to traditional row-oriented databases.[34].

(b) **Multidimensional data modelling:** OLAP systems organize data into multidimensional ”cubes” that allow users to analyse data from different perspectives, such as by time, product, geography,etc[19][22][31].

(c) **Analytical operations:** OLAP systems provide advanced analytical operations like slicing, dicing, drilling down, and rolling up data to enable interactive and exploratory data analysis[34].

(d) **Real-time analytics:** Some OLAP systems, known as Hybrid Transactional and Analytical Processing (HTAP) systems, aim to support both transactional and analytical processing in real-time to provide fresh data for decision-making[31].

4. **Phase 04: Visualisation**

Data visualization is a crucial component of business intelligence (BI) that involves the graphical representation of data to facilitate understanding and decision-making [17][19] [22].

It allows decision-makers to quickly identify patterns, trends, and insights from complex data sets, enabling them to make fast, reliable, and fact-based decisions [17][19]. Effective data visualization techniques, such as interactive dashboards and reports, are essential for technological companies operating in fast-moving business environments, as they provide a systematic organizational intelligence to support risk-related decision-making [17][19].The application of business intelligence and data visualization techniques has been shown to be beneficial in various domains, such as bridge health monitoring, where it can support investment planning and decision-making processes in the public works sector [19].

(a) **Definition of Dashboards:**

A dashboard is a tool that is commonly used for visualisation in a BI solution. It helps users whom in most cases are decision makers across different industries to answer questions as what, why, when and how did an action happened, using KPI's or other important business metrics by displaying various types of visuals such as tables, graphs, and charts to make friendly manageable insights of the data.[36] The figure 2.15. illustrates an example of a dashboard:

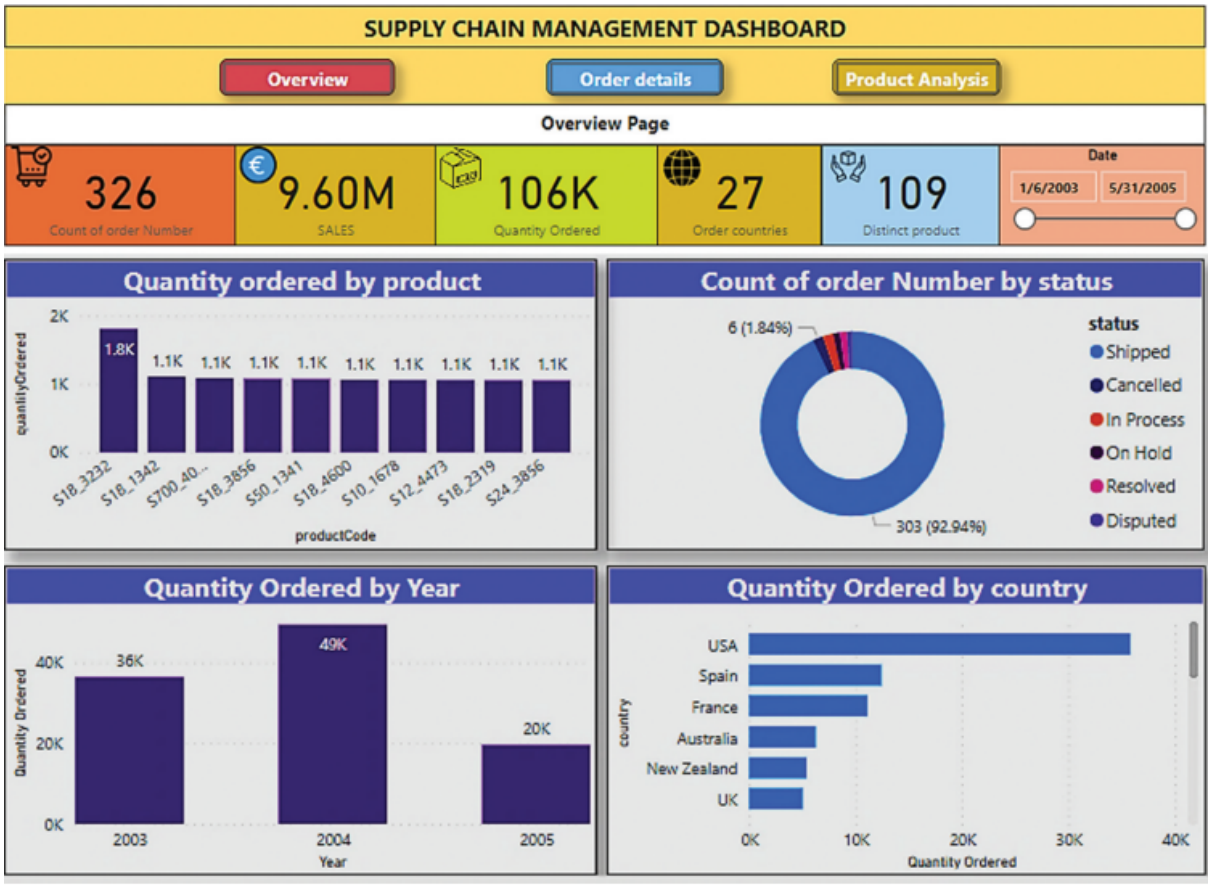


Figure 2.15: Example of a SCM Dashboard.
[37]

2.4 Business Intelligence in Supply Chain Management

In the previous parts of the chapter, we have given an overview of the concept of supply chain management, and then we have defined the business intelligence technique by explaining the different steps of implementing it. In this part we are going to highlight the relationship between SCM and BI by showing the importance of data analysis for decision making.

2.4.1 Information flow within a supply chain

Since customers always look for good quality products delivered to them at the right time and in the right place, modern companies need to enhance their efficiency in order to align it with customers' demands while minimizing the duration and costs associated with the production process. As mentioned in the previous part, supply chain provides information from the supplier to the clients such as information about orders, inventory management, account payable or point

of sale transactions, and it all needs to be processed for those in positions of authority like supervisors, experts and employees in order to improve their ability for better and fast decision making.

Therefore, for an effective SC information flow, each company works with different types of software and each one is dedicated for a specific purpose along the process. We can divide them into three main categories: the first ones are software's for strategy planning (SCP) like the APS (advanced planning system), the seconds are dedicated for supply chain execution (SCE) like WMS (warehouse management system) and TMS (transport management system) and the third category are the ERP (enterprise resource planning) and it integrates all the functions of the company.[38]

These software's are generating a huge amount of data that we call nowadays Big Data, and it needs to be analysed in order to make decisions based on them, and help the company to effectively gain profits according to it. So, in that concept, the BI is approached to help supply chain analyse its data and then transform it into simple and understandable real time insights to improve its performance.

2.4.2 The impact of using BI in Supply chain management

Business intelligence can lead into great impact in the overall supply chain performance, as Chen et al said:" consider business intelligence and analytics as an important area of study and research to solve data-related problems in companies". [39]

There are several examples that can gives us a better understanding of how BI improved SCM. Invoking the case of Walmart the largest retailer in the world, the company has implemented a BI system to provide real time visibility of its inventory levels, order status and delivery times helping it in reducing stock-outs, optimizing inventory levels and identifying areas of improvement in the supply chain operations. Also, BI has helped the Coca Cola company to optimize its production and distribution processes, reduce waste and improve its delivery systems by providing it with analytics and predictive modelling to analyse its SC data[40].

2.4.3 BI techniques used in similar cases

In order to highlight the contributions of Business Intelligence use cases in supply chain, we have summarized some studies that have been conducted to enhance supply chain performance using the business intelligence techniques in the following table:

Table 2.1: Summary of References, Tools/Techniques Used, Contributions, and Limitations

Reference	Tools/techniques	Contribution	Results
[40]	Visual Studio C++ software, Power BI software, Holt-Winters method, Holt's method, Brown's method, Moving average method	A combined use of software to extract optimal forecasting and monitor the accuracy of the obtained sales forecasts. Offers better calculations of demand forecasts and data connections for a clear display via dashboards. Helps reduce forecasting errors and levels of stock.	The proposed framework only concerns products in their maturity life cycle level. The use of only quantitative forecasting for the interpretation of data.
[41]	Microsoft Power BI	Helps in forecasting future behavior based on historical data related to past and current projects. Improves manually monitored processes. Provides a set of dashboards to visualize information of several projects.	Solution relied only on one specific BI system. The utilization of indicators obtained from the author's assessment. The use of synthetic data to increase the data set.

Continued on next page

[37]	Microsoft Power BI. Action design method (ADR)	Identifying which KPIs are showing or causing low performance in the SC. Offers real-time tracking and updates of KPIs related to decision-making. Enhances control over data types and enables sophisticated transformations of traditional text import features.	The solution is utilized only in the case of small businesses. The article highlights the limitations of the proposed model in terms of used BI tools, proposing future research to use multiple data sources and more advanced BI tools for more comprehensive dashboards.
[42]	Microsoft Power BI. Data collection techniques. Qualitative research methods	The paper highlights the importance of using advanced analytics and visualization tools to improve decision making and enhance overall SC performance by allowing companies to view their data in real time. The use of qualitative research methodology helps in providing a more understandable analysis of the SC performance measurement model adding depth and context to the findings.	The focus on a single case study, which leads to limitations of the proposed model in terms of the obtained results, and its transferability to other companies. Data limitation which can impact the depth of the analysis conducted by the model.

Continued on next page

[43]	ERP. Microsoft Power BI	The proposed model helped the company in reducing its total levels of inventory, leading to remarkable cost savings. Improved the efficiency of inventory management by combining the use of ERP database and Power BI tools to visualize data and improve decision-making processes.	The absence of some important data within the database causing the use of manual methods to collect it. The difficulty in integrating ERP with Power BI without the use of intermediate tools such as Excel. The need for continuous updates for the model to respond to the user's needs.
[44]	Microsoft Power BI. Excel. Analysis for Excel	The paper has demonstrated the effectiveness of implementing BI tools to improve performance, reporting, and decision-making within the case company. Highlights the gap concerning the underuse of data in the case company. Identifies the key success factors for implementing a BI solution aligned with the user's needs.	The application of the study in one specific country can influence the reliability or the applicability of the obtained results for other countries or cases. Time constraint impacting the data collection process, analysis, and interpretation.

Continued on next page

[45]	Microsoft Power BI. Streamlit. Python	The developed framework helped in optimizing inventory levels and enhanced resource utilization. Provides real-time monitoring of data to adjust inventory and supply chain operations according to timely fluctuations. Helps in teamwork by providing shareable reports and insights of the company's information.	Some missing data in the company's system can influence the proposed forecasting model. Cost constraints for the framework implementation might limit the organization to fully gain profits from the developed solution. Integration difficulty of other sources of data into the system.
[46]	Microsoft Power BI. Kimball's ETL	Offers a detailed view on the metrics such as revenue, customer details, and real-time updates. Helps in identifying the crucial KPIs influencing the effectiveness of the SC. Proposes a data structure to simplify the integration of different sources to the dashboard.	Delays in data processing due to the large size of data sets can influence the performance of the system. The need for significant data resources to implement such advanced data tools.

Continued on next page

[47]	ERP. Microsoft Power BI	Helped in reducing lead time for the inventory planning process. Identified unnecessary tasks included in inventory management and improved it with the developed solution. Offered real-time insights about inventory levels, vendor analysis, and inventory value for inventory planning officers.	Reliance on monthly data export into Excel sheets leading to delays in data processing and data accuracy. Difficulties faced while connecting Power BI software with the ERP database.
[48]	Microsoft Power BI. RStudio. Spoon Pentaho Data Integration (ETL tool)	Offers better control of inventory levels by reducing overstocks and shortages in the analysis period. The developed BI solution has improved the overall productivity of health services by reducing the likelihood of inventory shortages.	Lack of historical data impacts the accuracy of forecasts and given insights. The use of advanced algorithms can make the decision-making process complicated for decision-makers who are not familiar with it. The need for trained users to ensure successful use and deployment of the system.

2.5 Conclusion

in this chapter we have defined the key concepts of supply chain and supply chain management to differentiate between the two terms. we also highlighted the importance of coordination. Then, in the second part we have explained what does Business Intelligence means, its architecture and its different tools. finally, we discussed the relationship between the two concepts and cited some studies in this field.

In the next chapter we will present the different steps we have taken to implement our proposed solution.

Chapter 3

Conception and development of BI Solution for the Merinal company

3.1 Introduction

In the previous chapter, we have reached the conclusion that Merinal SCD lacks for a real-time Business Intelligence (BI) solution that would allow them to utilize their existing data to create a decision-making tool. In this chapter, we will present the three phases that we took to build our solution, its modeling, architecture and implementation. At the end of the chapter, our BI solution will provide tailor made dashboards for both scheduling and stock management departments as well as the Supply Chain division by leveraging real-time data access, ensuring that the decision-making process is agile and accurate. Also we will give an example of the results that could be extracted from the dashboard.

3.2 Solution Modelling

In this phase, we will be modeling how the end user will interact with our solution and explain it ensure a good construction of the solution.

3.2.1 The Use-Case Diagram

Definition: It is a Unified Modelling Language (UML) diagram that enables us to describe the possible usage and future scenarios (use cases) that a system is developed for, by expressing what a system should be doing, and what functionality each user in the system will be using. We can use this diagram to address the following questions: [49]

1. What is being described?
2. Who interacts with the system?
3. What actions can the actors perform?

The use case diagram for Merinal's BI dashboard solution shows the interactions between employees within the company and the dashboard.

Each one of these actors performs a specific function to utilize and manage the dashboard:

1. **Heads of departments:** interacts with the dashboard by selecting and adding KPIs and customizing the visual display to tailor the information according to their needs, analyse it and derive useful insights.

2. **Supply Chain division employees:** is able to analyse data, utilize and filter data for specific insights, extract data from various sources, and models the data for better interpretation.

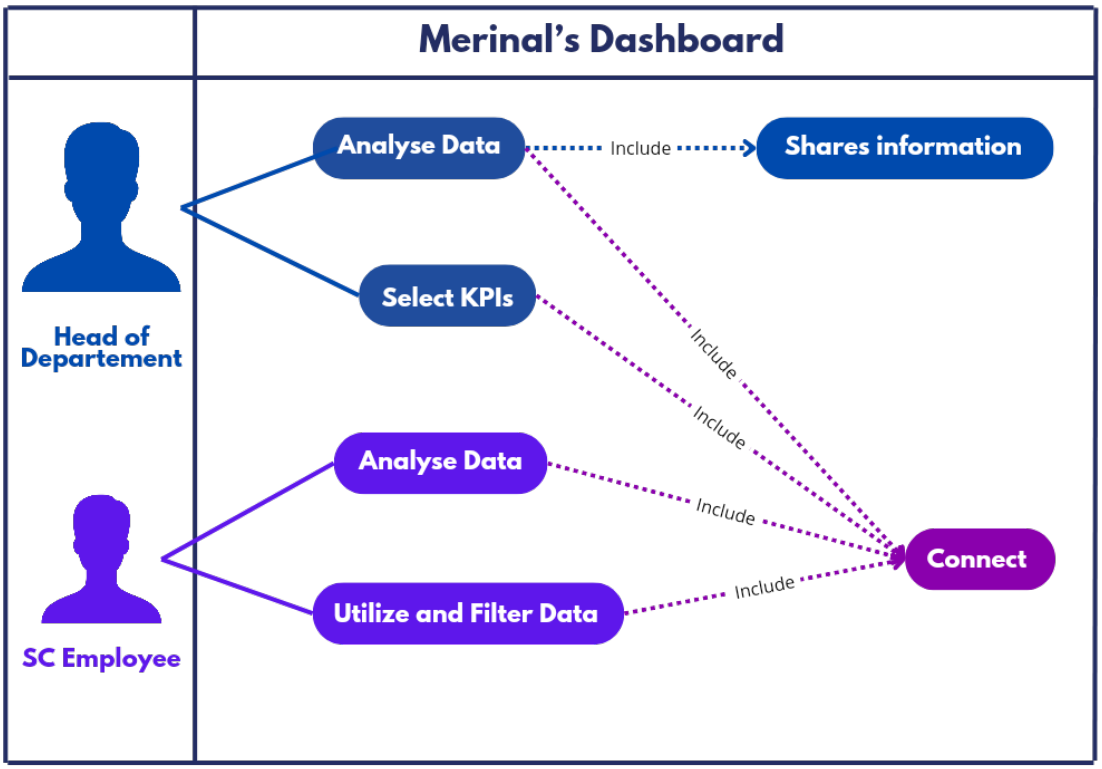


Figure 3.1: Use case Diagram of the dashboard

3.3 Solution Architecture

3.3.1 The used Tools

1. **Microsoft SQL Server 2014:**Microsoft SQL Server 2014 is a powerful relational database management system (RDBMS), which means it is a system that organizes files of data in two dimensional arrays (rows and columns) of data elements, with the capability of combining these elements in order to form and create a variety of relations giving us a significant flexibility in data usage [50] . This RDBMS caters to a wide range of users. Whether it's a developer, data analyst, or IT professional, SQL Server 2014 offers feature-rich editions that facilitate learning, development, and deployment [51] . It can accommodate a small number of users and scale up to and expand to serve the largest corporations due to its capacity to deal with terabytes of data [52] . This is where the Data Warehouse will be and these are some of the essential tools within this ecosystem:

2. **SQL Server Management Studio (SSMS):**SQL Server Management Studio (SSMS) is an easy-to-use, comprehensive graphical user interface (GUI) tool for managing SQL Server instances. It allows you to perform tasks such as database design, querying, administration, and performance tuning[53] . It features tools for working with developing database solutions and it constitutes the tool that accomplishes the passing of SQL commands and functions to SQL Server[52].

3. **SQL Server Data Tools (SSDT) for Visual Studio 2014:**SQL Server Data Tools (SSDT) is an integrated development environment (IDE) that enables database developers and administrators to create, manage, and deploy database projects. It integrates seamlessly with Visual Studio[53]. SSDT Visual Studio contains the two most important Services in Business Intelligence: **Analysis Services and Integration Services** .

4. **SQL Server Analysis Services (SSAS):**SQL Server Analysis Service (SSAS) is a multidimensional and tabular data modelling platform. It allows you to create OLAP cubes that are built on top of a data base that have specific design of Fact and Dimensions Tables containing precise data each one with a chosen data type, in order to create a business intelligence solution[54][55]. and they are presented as follows:

   (a) **Fact Tables:**Contains transactional data and measures.

(b) **Dimension Tables:**Describe business entities (e.g., customers, products) that will represent the measures and be used for granulation

(c) **Cubes:**Aggregates data for analysis depending on the need and goal of the Business Intelligence solution to be built.

(d) **MDX (Multidimensional Expressions):Query language for SSAS.**

5. **SQL Server Integration Services (SSIS):**SQL Server Integration Service (SSIS) is an ETL (Extract, Transform, Load) tool used for data integration and workflow automation[54]. It is needed for Data Warehousing and its operations: Extraction of data from different sources, Transformation of said data and its Loading[56]. Without the data cleansing and data movement that SSIS provide the rest of SQL Server BI products won't operate. It facilitates by the creation of specifically designed ETL process and workflow the integration of data from various sources that the enterprise might have (CRM, ERP, Excel etc.), to an already designed Data Warehouse.

6. **Python:** a versatile programming language, is increasingly used in BI scenarios. Its libraries (e.g., pandas, matplotlib) enable data manipulation, analysis, and visualization.[57]

7. **Power BI:**Power BI is a suite of Business analytics tools made by Microsoft, to analyse data by connecting to various data sources, creating interactive reports, sharing insights and providing a holistic view for business users with the most important metrics in real-time to monitor the health of their business at every point in time, all in one place and available in different devices.[51][58]

3.3.2 The used Data

In order to build of Business Intelligence solution for Merinal's SCD, we need to collect Data according to their specific needs, the Data available and the Data we've had access to. and also choose the useful key performance indicators (KPI) that will contribute to the optimization of their coordination and decision making system.
The data that we were able to collect and allowed to use, was divided into three main datasets:

1. **Reception file:**This file contains data about the received goods of each article from different sited and suppliers.

No de repection	Fournisseur	Raison Sociale	Date reception	Article	Designation	Qte rcp UOM	Unite reception	Qte facturee	No de commande	Site reception	Date Reception
MPR01/2004RCI0	MCL01	Centre logistiqu	28/04/2020	APMAL	ALU SULPIRID	20000	ML	0		MEX01	20200428
MCL01/2006REC0	100039	PRINTMED	24/06/2020	APMAL	ALU SULPIRID	20010	ML	20010	MCL01/1909CDE0	MCL01	24062020
MPR01/2009RCI0	MCL01	Centre logistiqu	09/09/2020	APMAL	ALU SULPIRID	20000	ML	0		MCL01	20200909
MCL01/2101REC0	100039	PRINTMED	30/01/2021	APMAL	ALU SULPIRID	68250	ML	68250	MCL01/2102CDE0	MCL01	20210130
MCL01/2107REC0	100039	PRINTMED	13/07/2021	APMAL	ALU SULPIRID	36150	ML	36150	MCL01/2102CDE0	MCL01	20210713
MCL01/2111REC0	100039	PRINTMED	29/11/2021	APMAL	ALU SULPIRID	37440	ML	37440	MCL01/2107CDE0	MEX01	20211129
MCL01/2211REC0	100039	PRINTMED	15/11/2022	APMAL	ALU SULPIRID	13160	ML	13160	MPR01/2211CDEC	MEX01	20221115

Figure 3.2: Screenshot of the Reception CSV file

2. **Consumption file:** The file contains data about each consumed article for each manufacturing order.

Numéro suivi	Article	Nomenclature	Quantité consommé	Date imputation	No O.F.	Date suivi	DATE
[illegible]	[illegible]	[illegible]	10707	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	10728	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	10717	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7426	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7249	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7360	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7360	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7212	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7678	[illegible]	[illegible]	[illegible]	[illegible]

Figure 3.3: Screenshot of the Consumption CSV files.

3. **Manufacturing Order file:** It contains data about each manufacturing order for each of the 5 final products.

Numero suivi	Article	Qte realis	Date imputation	No O.F.	Date suivi	DATE
[illegible]	[illegible]	43202	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	48266	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	48771	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	48862	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	48678	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	48171	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	49772	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	48585	[illegible]	[illegible]	[illegible]	[illegible]

Figure 3.4: Screenshot of the Manufacturing Orders CSV file

These files contained three years' worth of data (from 2021 to 2023) of 59 Articles categorized into:

- **Active Ingredients**
- **Excipients**

- **Packaging Materials I: Direct contact with the final products.**
- **Packaging Materials II: Indirect contact with final products.**
- **Semi Final Products**
- **Final Products**

Globally, we collected a set of 5 final products, with all of their components. These final products are considered from the top performing products in the company and they are produced all year long:

- **XYDOL 400MGs.**
- **DOLYC 500MG.**
- **DOLYC 1G.**
- **SULPIRIDE.**
- **BYZOLEX 5MG.**

3.3.3 The Measures and Performance Indicators

The following table shows the measures and performance indicators that we have implemented in our dashboard:

Table 3.1: Measures and Indicators

Measures and Indicators	**Explanation**
Received Quantities	This measure represents all the quantities that the warehouse of Merinal receives. From Suppliers, other sites, as well as the materials received by Manufacturing department: Excess Raw Materials, Finished and Semi-Finished Goods.
	Continued on next page

Table 3.1 – continued from previous page

Measures and Indicators	Explanation
Invoiced Quantities	This measure represents the quantities of the materials delivered by suppliers and were invoiced. They only represent the Raw Materials as well as the Packaging of the medical products.
Consumed Quantities	This measure represents the consumed quantities of all different types of materials.
Produced Quantities	This measure represents the quantities that were produced for each final product.
Date of Consumption	This date represents the earliest day of the consumption of raw materials of a manufacturing order.
Date of Production	This date represents the date where the production started of each manufacturing order.
Stock Turnover	Stock turnover is a key performance indicator for the stock management department, enabling them to measure the frequency at which inventory is consumed over a specific period.

3.3.4 Fact Tables:

The following table summarizes the fact tables used in our solution with it measures, data types, dimensions and its explanation:

Table 3.2: Fact Tables and Measures

Fact Table	Measures	Data Type	Dimensions	Explanation
Fact Reception	Received Quantities, Invoiced Quantities	Numeric (18, 3), Numeric (18, 3)	DimProduct, DimSupplier, DimSite, DimTime	Received and invoiced quantities are one of the most important metrics in Stock Management where they can give so many indicators that enables a better analysis of stock levels. The best analysis approach would be to analyse both these quantities by product, supplier, site and time in order to get the best insights and granulation for the concerned parties (Stock management department and the Supply Chain division) and to get the best out of the available data.
Fact Consumption	Consumed Quantities	Numeric (18, 3)	DimProduct, DimManufacturing Declaration, DimTemps	The consumption of products is very important for both scheduling and stock management departments, it helps them stay in track of consumption rates and with planning manufacturing orders. They have to be analysed based on different axes: by products, by time and by manufacturing order.

Continued on next page

Table 3.2 – continued from previous page

Fact Table	Measures	Data Type	Dimensions	Explanation
Fact Manufacturing Declaration	Quantity produced	Numeric (18, 3)	DimProduct, DimManufacturing Declaration, DimTemps	The production rate is an essential part of the Supply Chain, and tracking it would give an immense added-value to its process, whether it's scheduling Manufacturing orders or tracking the demand on Raw and Packaging materials. This should be by product, by time and manufacturing declaration.
Fact Supply to Manufacturing Time	Manufacturing Date, Consumption Date	Date, Date	DimProduct, DimManufacturing Declaration, DimTemps	One of the key elements to a successful supply chain management is to maintain a short delivery time, and this applies even inside the company, where the time to supply to Manufacturing plays a major role in the success of customers satisfaction and the availability in the market. So, the tracking of metrics such as the consumption and manufacturing date can contribute to a better control of the Supply time, hence the insurance of a smooth manufacturing process. The axes of analysis should be: by product, by time, and by manufacturing order.

3.3.5 Dimension Tables

Dimension tables represent the analysis axes for different measures of the fact tables related to them. It should contain two parts:

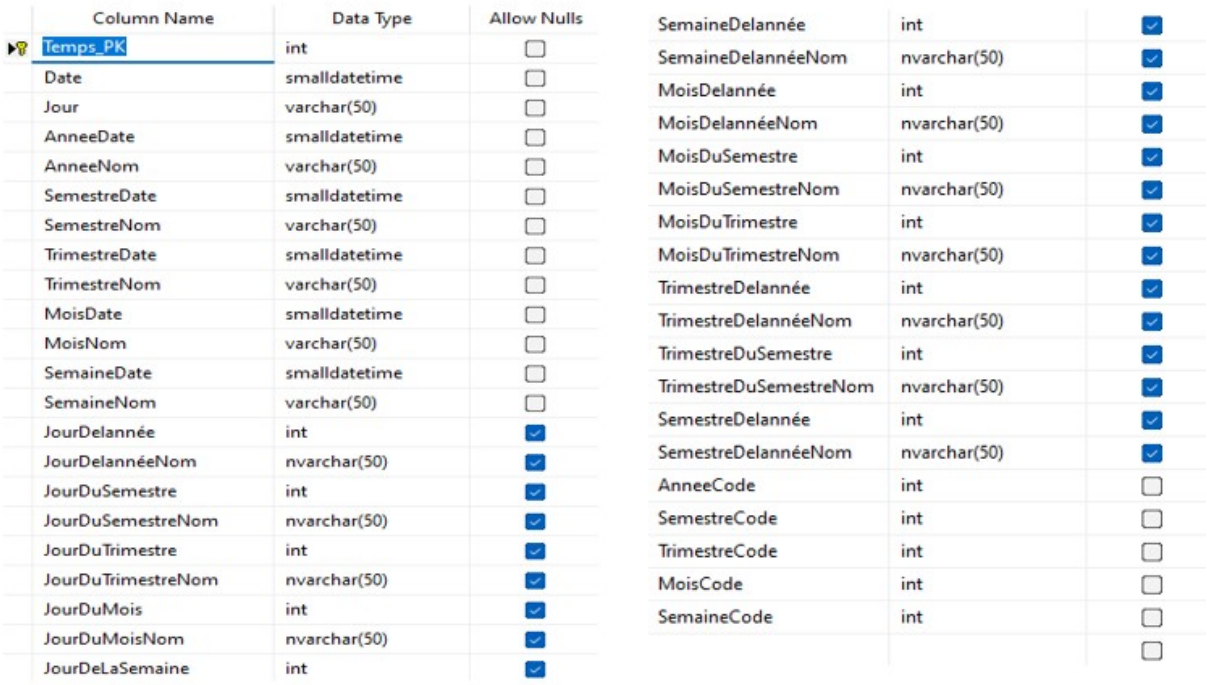
1. **Primary Keys:** they are the link to the Fact tables.
2. **Dimension element:** these are the granulation elements that each measure would be analysed upon.

Table 3.3: Dimensions and Data Types

Dimension	**Content**	**Data Type**
Dim Product	Product_PK	int
	Product_Code	varchar (10)
	Product_Designation	varchar (50)
	Product_Type	varchar (10)
Dim Manufacturing Order	Manufacturing_order_PK	int
	Manufacturing_order_number	varchar (60)
Dim Site	Site_PK	int
	Site_code	varchar (20)
Dim Supplier	Supplier_PK	int
	Supplier_code	varchar (20)
	Business_name	varchar (50)

3.3.6 Time Dimension

The creation of the Time Dimension is different than other dimensions, because it contains a specific form and a variety of columns with different purposes and data types, it would be time consuming to create it directly on SSMS, so would be easier and more optimal to create it with a SQL Query. Its architecture should be as follows:



Column Name	Data Type	Allow Nulls
Temps_PK	int	☐
Date	smalldatetime	☐
Jour	varchar(50)	☐
AnneeDate	smalldatetime	☐
AnneeNom	varchar(50)	☐
SemestreDate	smalldatetime	☐
SemestreNom	varchar(50)	☐
TrimestreDate	smalldatetime	☐
TrimestreNom	varchar(50)	☐
MoisDate	smalldatetime	☐
MoisNom	varchar(50)	☐
SemaineDate	smalldatetime	☐
SemaineNom	varchar(50)	☐
JourDelannée	int	☑
JourDelannéeNom	nvarchar(50)	☑
JourDuSemestre	int	☑
JourDuSemestreNom	nvarchar(50)	☑
JourDuTrimestre	int	☑
JourDuTrimestreNom	nvarchar(50)	☑
JourDuMois	int	☑
JourDuMoisNom	nvarchar(50)	☑
JourDeLaSemaine	int	☑

SemaineDelannée	int	☑
SemaineDelannéeNom	nvarchar(50)	☑
MoisDelannée	int	☑
MoisDelannéeNom	nvarchar(50)	☑
MoisDuSemestre	int	☑
MoisDuSemestreNom	nvarchar(50)	☑
MoisDuTrimestre	int	☑
MoisDuTrimestreNom	nvarchar(50)	☑
TrimestreDelannée	int	☑
TrimestreDelannéeNom	nvarchar(50)	☑
TrimestreDuSemestre	int	☑
TrimestreDuSemestreNom	nvarchar(50)	☑
SemestreDelannée	int	☑
SemestreDelannéeNom	nvarchar(50)	☑
AnneeCode	int	☐
SemestreCode	int	☐
TrimestreCode	int	☐
MoisCode	int	☐
SemaineCode	int	☐
		☐

Figure 3.5: Screenshots of Time Dimension Design

3.4 Solution Implementation

After creating the database, designing all fact and dimension tables in object explorer, the next step is to design the data warehouse and connect each fact table to the dimensions assigned to it in the database diagrams.

3.4.1 Datawarehouse Diagram

Our data warehouse is designed as shown in the following figure3.6:

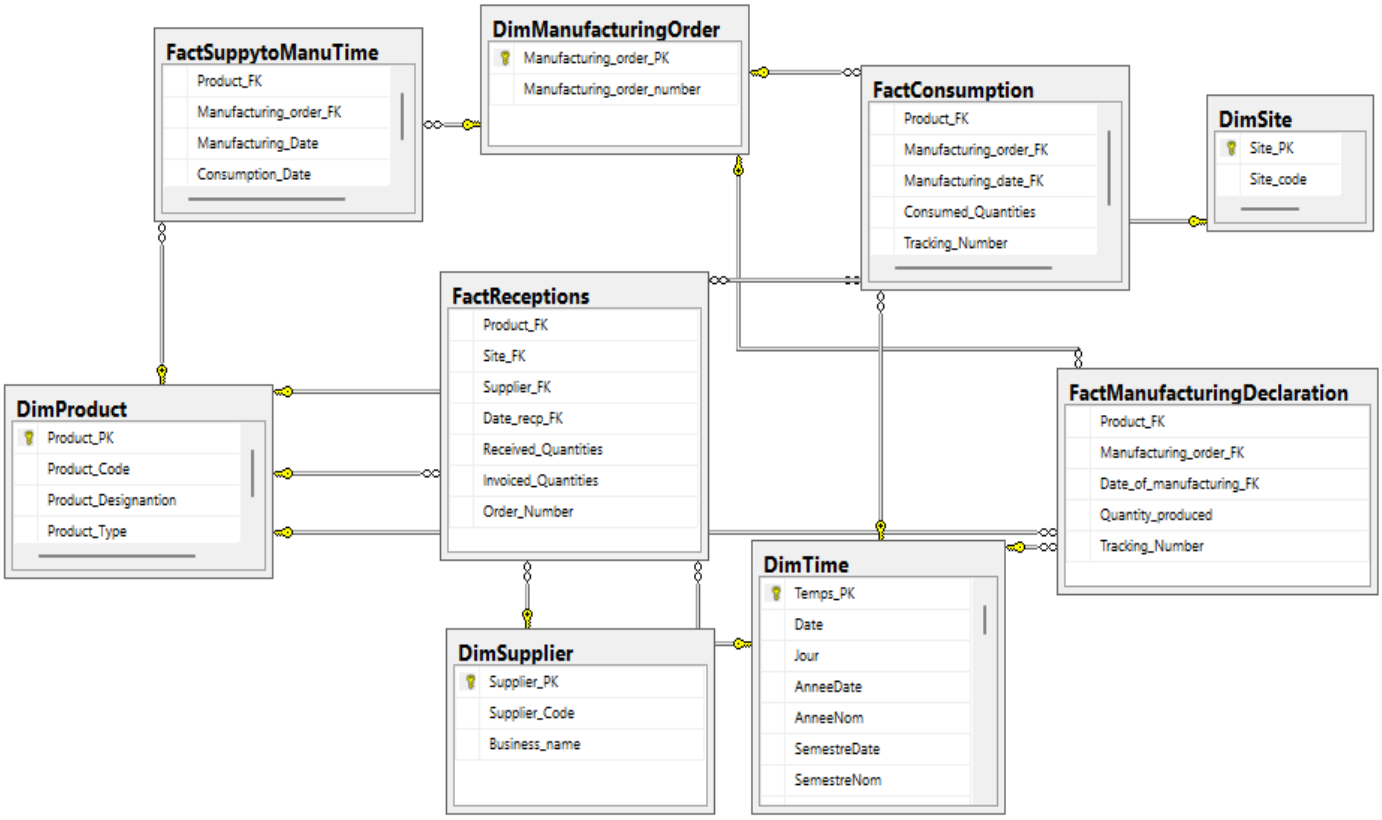


Figure 3.6: The Data warehouse Design of Merinal

3.4.2 The ETL Process

Now that the data warehouse is created, the next step would be to extract, transform and load the data. We would start this process with dimension tables followed by fact tables.

1. **Dimension Tables ETL Process:**The ETL process of dimension tables is simple due to the simplicity of data. It is established only by a Data flow task containing a source file and a destination file. The source file is a flat CSV file containing the necessary data of the dimension to be loaded into the data warehouse. 3.7

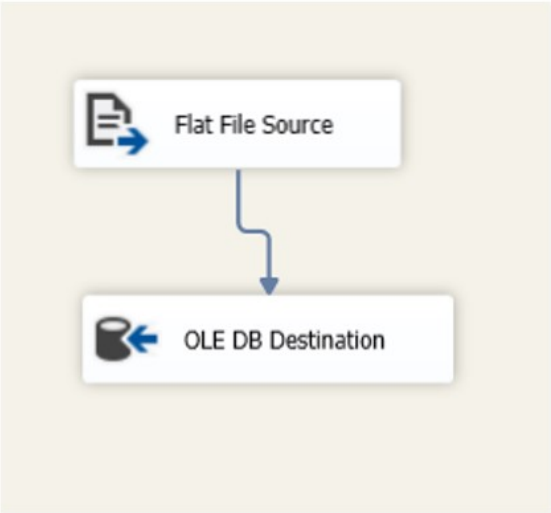


Figure 3.7: ETL Process of a dimension table with SSIS

2. **Fact tables ETL process:**For fact tables, we will upload data from Merinal source files: Reception, Consumption, Manufacturing- declaration, each table will be associated with its specific source file, except for Supply to Manufacturing fact table, that needs to extract data from both Consumption and Manufacturing declaration files.
   For this case the ETL process will go through a “Foreach Loop Container” that contains a “Data Flow task. 3.8

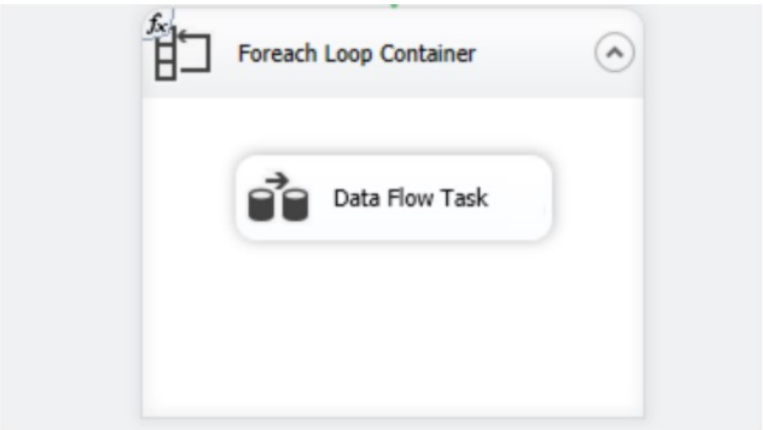


Figure 3.8: The Foreach Loop Container

The Data Flow task for fact tables should contain a source file, research task for each dimension table and a destination file. The research should be based on codes that exist in the dimension tables and the source file to allow the match between the data in order to upload the Foreign Key of each dimension to allow the connection between fact tables and their associated dimensions. 3.9

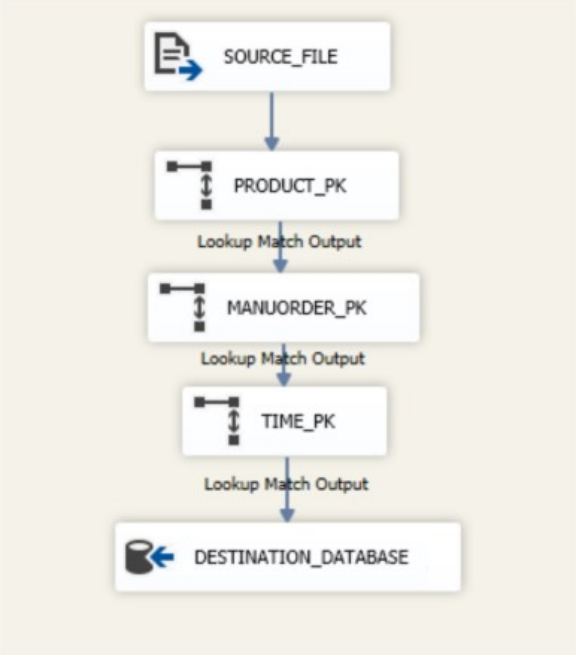


Figure 3.9: Data Flow Task in Fact Tables ETL process

We have to make sure that the Flat File Source connection has similar data types for each column as the database (Flat File Connection Manager Editor –Advanced) and change the data type if necessary as shown in the figure n3.10

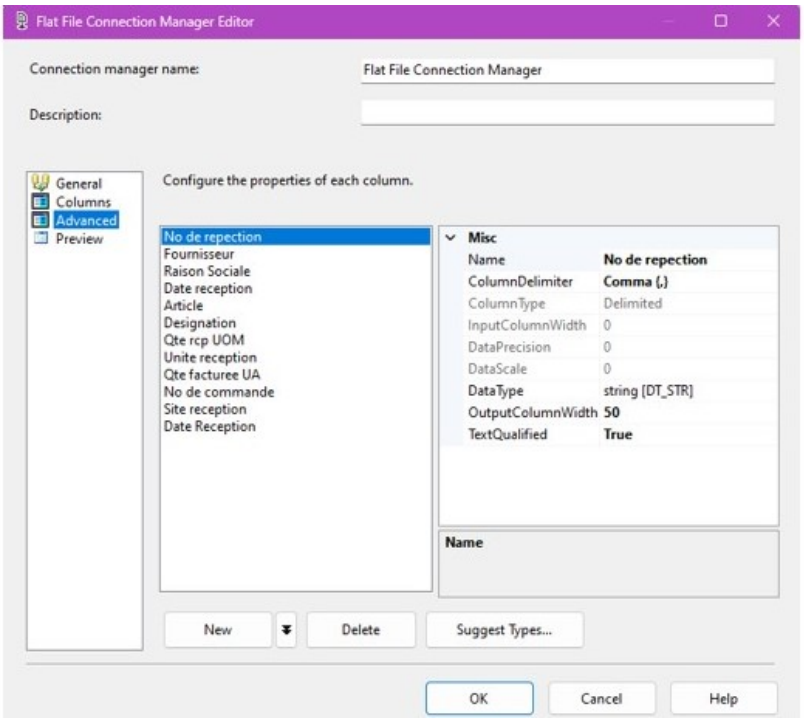


Figure 3.10: Flat File Connection Manager Editor

This process is applicable for all Fact tables, we only need to change parameters and add a research task for some tables.

For the Supply to manufacturing Fact table, before we proceed with the ETL process in SSIS, we have to go through one more step.

Since we didn't have a specific source file where we can upload the data from, we should use both Manufacturing declaration and Consumption files to extract the consumption and manufacturing dates. this can't be done directly because the Manufacturing declaration file contains only data about the final products, whereas Consumption file contains data about all the raw and packaging materials that constitute those final products. This leads to having multiple consumption dates for one Manufacturing order in the consumption file, especially if the raw and packaging materials are consumed on different dates due to the production process being long. In order to filter the data and

take the earliest date of consumption per Manufacturing order, we scripted a Python code to extract data from both files, filter them based on the earliest date per manufacturing order and uploading them in a third file that contains the manufacturing order number, date of consumption and date of manufacturing. (code in Appendix A).

3. **ETL Automation:**To automate the ETL process we have to create an integration service catalogue in SSMS, deploy the SSIS package and put the SQL Server Agent in running mode. After that, we create a new Job in SQL Server Agent, give it a name and move to Steps, this would link the SSIS package under SQL Server Agent. And To ensure continuous real-time data upload, we have to Schedule the Job with a 3 hours recurrence interval throughout each day.

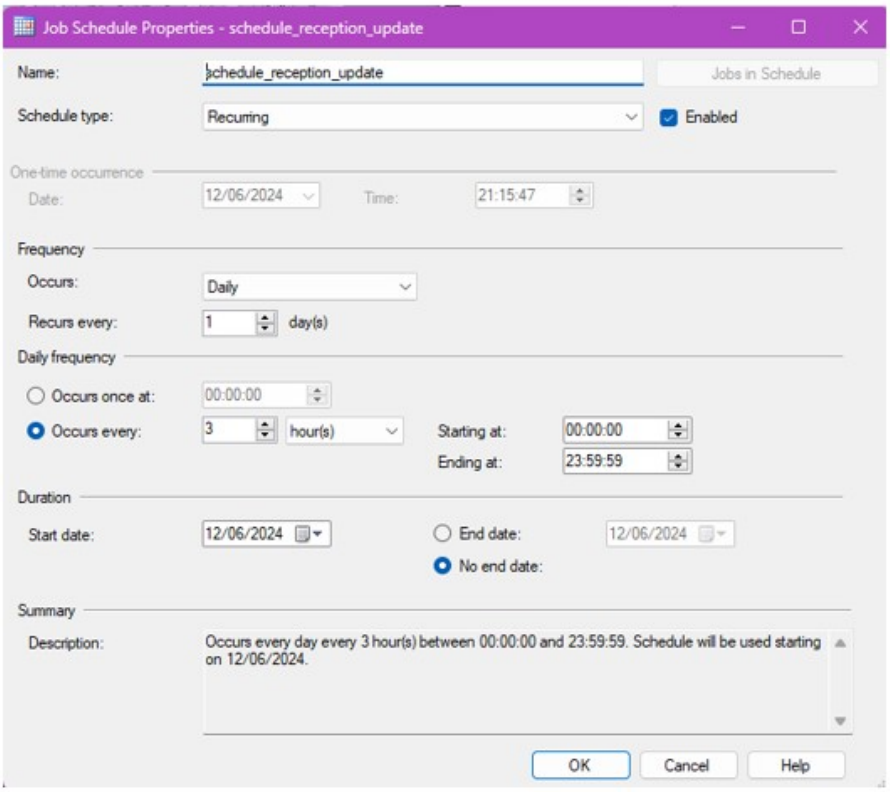


Figure 3.11: Job Schedule configuration

Our package will run every 3 hours every day, guaranteeing that all data entries are uploaded.

3.4.3 Olap Cubes

After uploading the Data Warehouse, we need to create the cube to analyse our data from different perspectives and define its granularity, by defining the fact tables, dimension tables, properties and hierarchies. The following figure shows the olap cube for Merinal's Data warehouse.

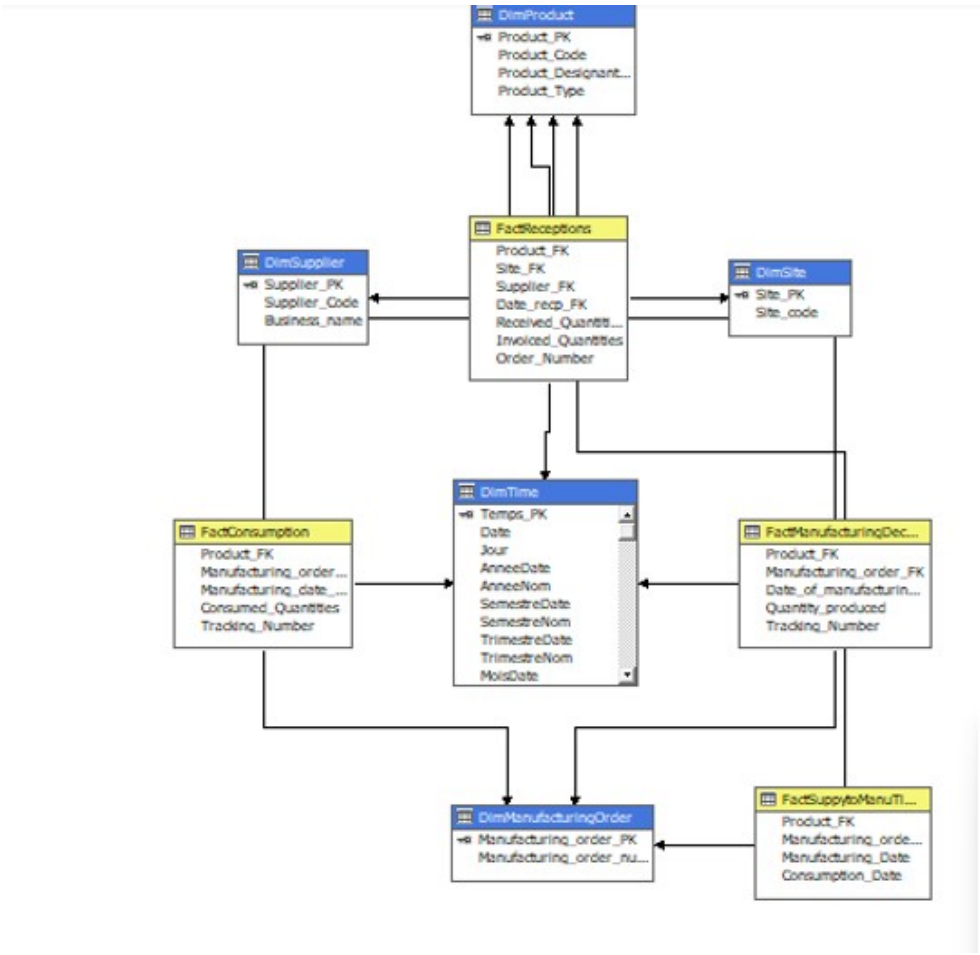


Figure 3.12: OLAP Cube for Merinal Data Warehouse

In properties, we should define the Order by for Key attributes to establish a structured and logical organization of data, ensuring efficient querying and retrieval processes. The Product, Site, Supplier and Manufacturing Order Dimensions are ordered by: Name. Whereas the Time dimension is ordered by: Key.

The hierarchies should be made based on how the data ought to be organized, in order to filter it in a logical and concise manner that will ensure an optimized analysis and user experience.

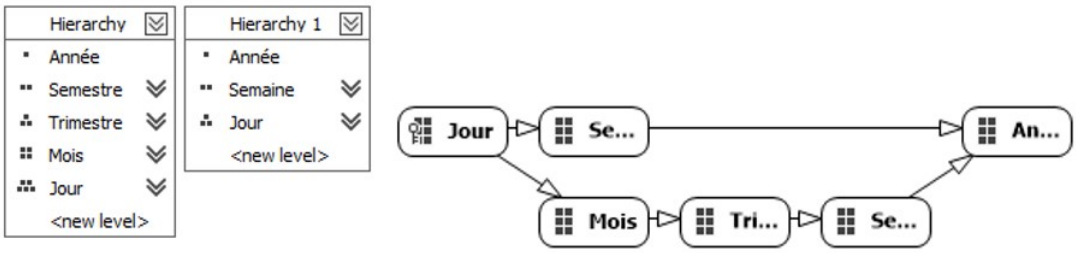


Figure 3.13: DimTime Structure and Attribute relationships

Figure 3.14: DimProduct Structure and Attribute relationships

With the cube now created, the data is prepared for use in developing dashboards that provide insightful visualizations. These dashboards will enable the scheduling and stock management department and the head of the Supply Chain division to monitor key metrics, identify trends, and make informed decisions based on real-time data analysis.

3.5 Data Visualization

Our data has undergone the ETL and OLAP cubes process, ensuring its accuracy and organization. To fully harness the potential of this prepared data, it is essential to translate it into a format that enables clear comprehension and facilitates insightful analysis. This is where Power BI plays a crucial role.

3.5.1 Dashboard construction

Our Dashboard will contain 3 main parts, each interface is dedicated to specific users in:

- Stock Management department.

- Scheduling department.
- Supply Chain Division.

available in Desktop and Mobile versions (See Appendix), to make the Dashboard accessible at all times and places.

1. **Stock management department**

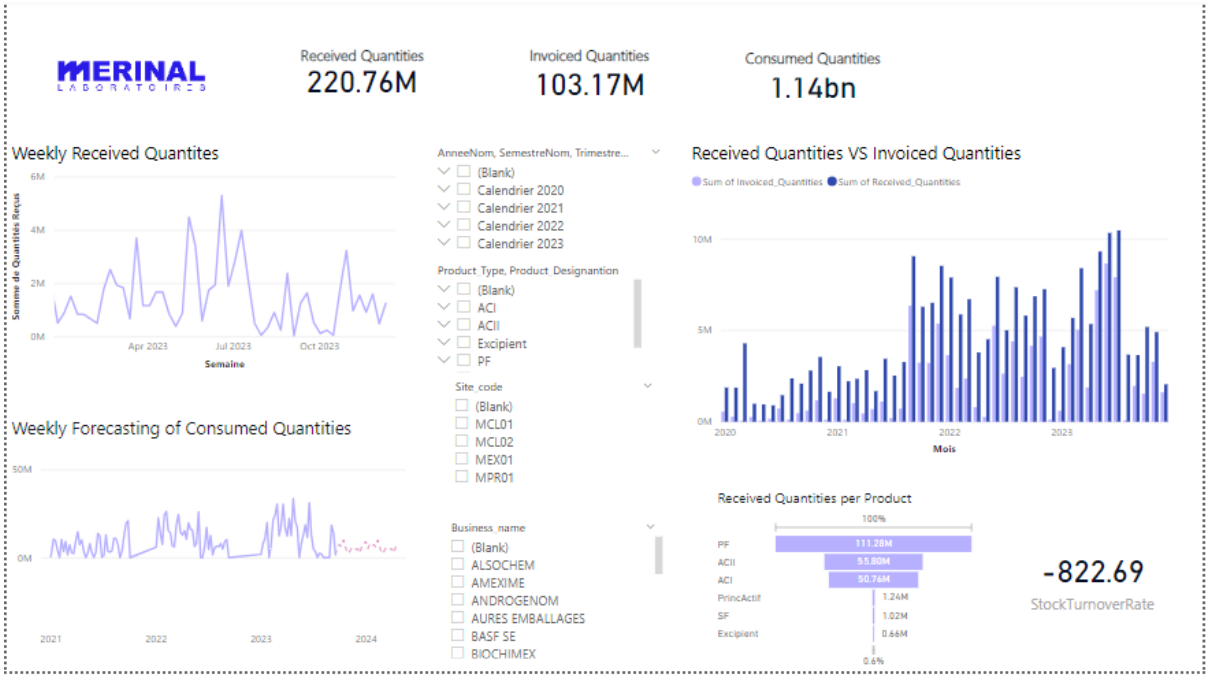


Figure 3.15: Stock management Dashboard-Desktop Version-

Cards are there to have the total of all different quantities reunited in one place instead of multiple Excel tables and sheets, in addition, there's a card for stock turnover rate which will allow the best analysis of each of the products in stock to provide useful insights.

The graphs that we made for the stock management department are weekly Received Quantities and Forecasting Consumed Quantities. These will allow them to visualize existing data of both received and consumed quantities and forecast consumption which will help them avoid under-stocking raw and packaging materials.

The clustered column chart represents a comparison between invoiced and received quantities. This chart will allow stock management to examine the received quantities and how much the missing products rate over time.

The funnel in this case will help visualize the received quantities by product type, it is a very useful visualization tool that will help compare stock rate of each product type, and know the percentage of each product type in each site.

Also, Filtering the data is a crucial part of the Dashboard, without it, it wouldn't be as useful, so we made sure to put all the possible filters to ensure the best granularity and the easy access to all data.

The tables are an additional visualization tool that is there to allow the user to check the raw format of data of each product in one table. In addition to that, they can even track the rapidity of their response to the needs of production by the table of Time To supply by manufacturing order number, it contains the dates of consumption and the date of manufacturing, with these they can analyse their performance when it comes to meeting the needs of each manufacturing order(See Apendix B).

2. **Scheduling department**

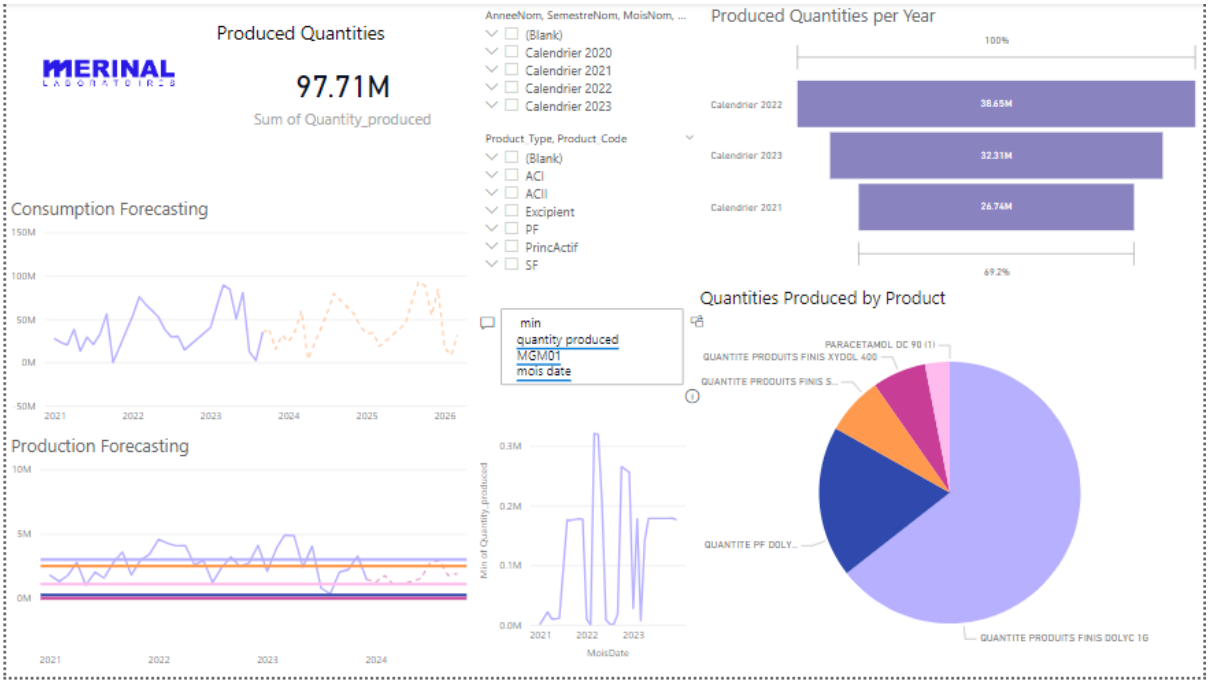


Figure 3.16: Scheduling Department Dashboard -Desktop Version-

Cards are there to have the total of produced quantities reunited in one place instead of multiple Excel tables and sheets. It is there to have a summarization of the quantities produced. Forecasting graphs are for consumption and production quantities, this would

immensely help the scheduling department in predicting potential consumption and production quantities which will keep them ahead and notified of the real-time and future quantities leading in a synchronisation between scheduling and stock management departments avoiding any manufacturing orders staying unfulfilled because of the lack of some materials. In addition to that, the produced quantities graph has indicator lines for each of the 5 products representing the goal quantities to be produced per year. This will lead to a better track of the quantities produced and to be produced to meet the annual goals.

The funnel is a representation of production quantities for each year, allowing the best comparison between the current and previous year. The pie chart represents the quantities produced by the final product to compare all of them and classify them based on performance and quantities.

The Q and A is a useful tool, especially for a quick and precise question, for example: (min quantities-produced, MGM25 month May 2023 it would give you a direct result whether it's a number or a graph.)

The tables are an additional visualization tool that is there to allow the user to check the raw format of data of each product in one table.(See Appendix B).

3. **Supply Chain Division**

The Supply Chain Division Dashboard is a summarization of the important insights collected from both stock management and scheduling department, it contains the key performance indicators of each of the departments in the cards as well as the forecasting graphs that represent both the real-time and future insights about the consumed and produced quantities.

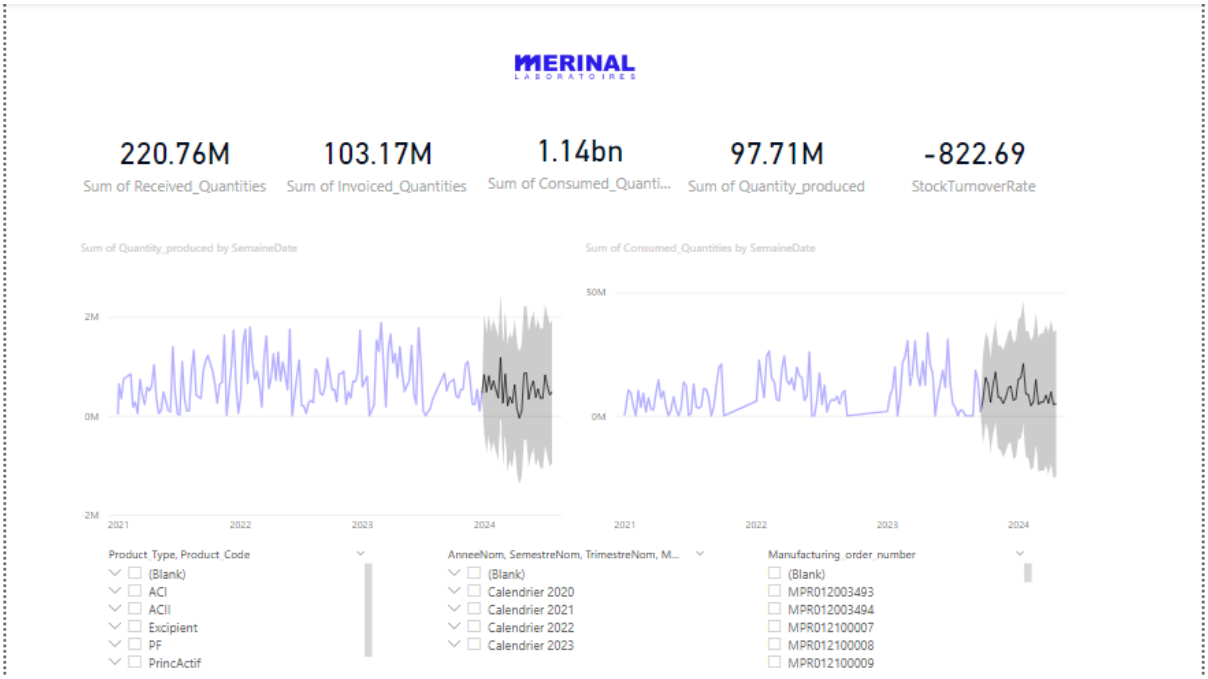


Figure 3.17: Supply Chain Division Dashboard -Desktop Version-

After creating the dashboard and showing its final form, several insightful patterns and trends emerged. we were able to identify significant remarks that highlighted key aspects of Merinal's production operations. One such noteworthy observation is that the quantities produced were different from what was expected in the graph of production forecasting in the scheduling department's dashboard.

We can see that the production quantities for DOLYC 1G exceeded two times the production goal (approximately 10 million) for the three previous years. This can lead to operational issues in stock and warehouse management, particularly concerning space utilization, product expiration date management, and associated costs. Also, if the annual sales didn't reach the produced quantities it could have decreased the stock turnover rate. On the other hand, there might be a potential explanation to the huge excess in production. In 2021 and 2022, there were still high rates of COVID-19 cases, and knowing that DOLYC 1G is headache and fever medicine, it might have resulted in the over-consumption of this medicine leading to its overproduction. In figure 3.18

Same goes with DOLYC 500MG, that has witnessed an immense production rate compared to the goal which was approximately 250 000. In figure 3.19

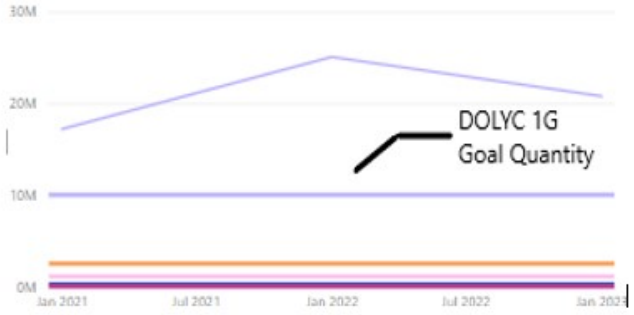


Figure 3.18: Graph of DOLYC 1g production quantities over 3 years

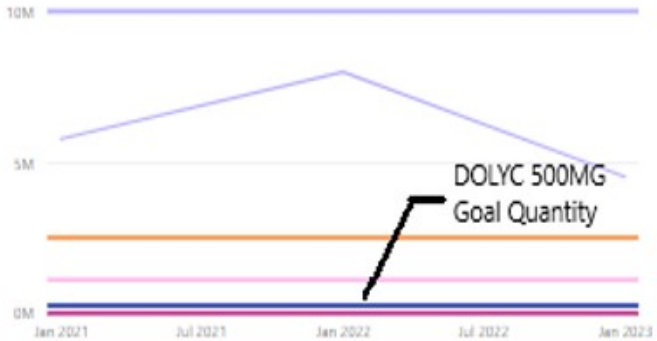


Figure 3.19: Graph of DOLYC 500MG production quantities over 3 years

3.6 Conclusion

In this chapter, we have created the modelling of our Business Intelligence solution by describing the interactions of the user with the dashboard using UML (Use case diagram), mentioning Merinal's information flow, then we explained the solution architecture and its implementation steps which are the data warehouse diagram, the ETL process, OLAP cube and the dashboard creation. Finally, we mentioned an example of the useful results that could be extracted from the visualisation of data in the dashboard which will help evaluate the Supply Chain Division's situation.

General Conclusion

General Conclusion

In this project, our goal was to create a BI solution for Merinal supply chain division, to optimize and increase the coordination between the scheduling and stock management department, by providing useful insights through tailored dashboards.

We started with describing the company's organization and understanding the information flow between each department within the SC division in order to analyse and understand the process between each department within the division to identify and define the problem statement.

Then we defined the key notions of supply chain as well as Business Intelligence, and mentioned the relationship between the two concepts by citing some recent articles with their contributions in the implementation of business intelligence in SCM, which demonstrated the effectiveness of using it in SC and how much it can improve and optimize its processes. All that by creating tailor made solutions to the companies 'problems and limitations, and providing useful dashboards which contain significant insights that can give a resourceful analysis for decision makers.

Lastly, we started our solution implementation by modelling it using the Use-Case diagram to show how the actors are going to interact with the developed dashboard. Then we defined the used tool and designed a solution architecture to ensure an optimal use of the available data. Finally, we built the solution using Microsoft SQL Server by creating the data warehouse, a suitable ETL process and OLAP cubes for a good analysis, then we designed tailor made dashboards for both scheduling and stock management departments as well as the supply chain division using Power BI. This solution has helped them in visualising measures related to stock and quantity management and forecasts related to them.

Concerning the perspectives of our work and in order to improve and expand this Bl solution into a more useful and insightful dashboard, we recommend for Merinal to consider the data entry of more detailed information that has demonstrated to be useful, such as the time of consumption, the time of production, material order dates from suppliers and production duration. These would lead to a more detailed insights that will allow deeper analysis leading to a better

understanding of the overall supply chain allowing for a better evaluation of the process. We also suggest the use of the other available data, which we were not allowed to access as data concerning their finance, to analyse more relevant KPIs such as warehousing cost, Supply chain cycle time, return rate, warehouse utilization rate and many more.

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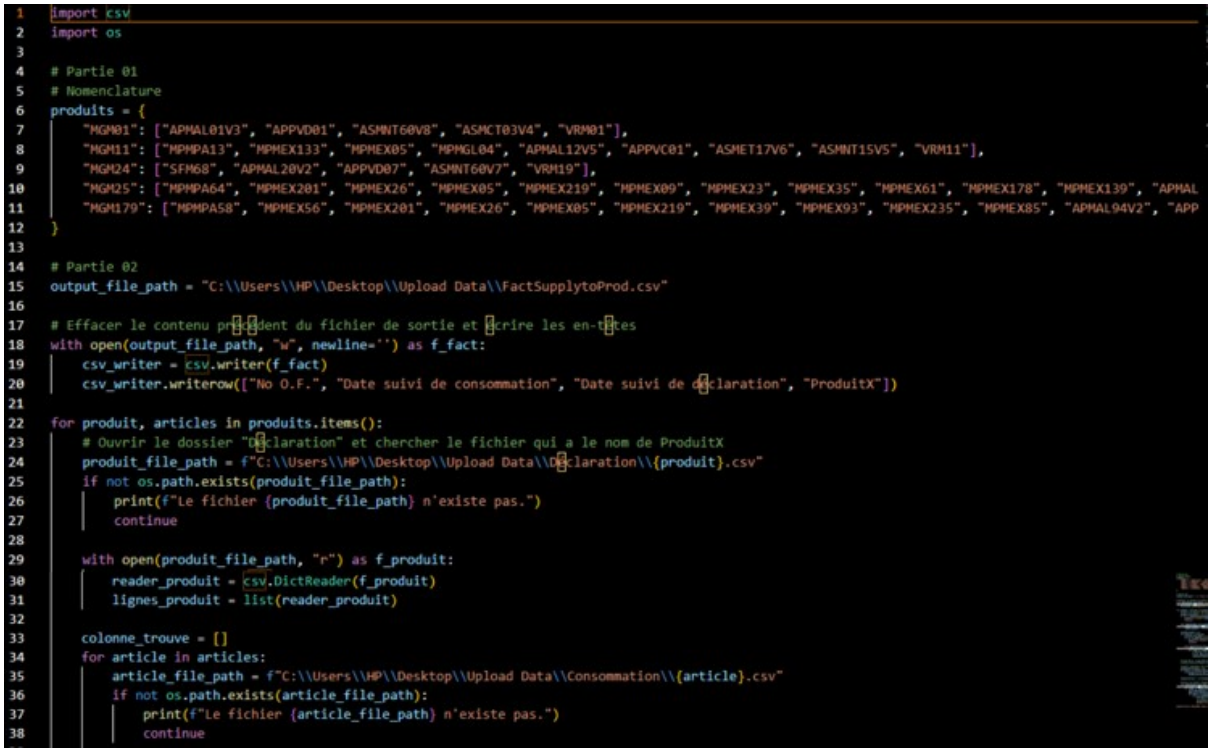
Appendix

Appendix A

Python Code Creating the file of Supply to manufacturing Time upload



```python
import csv
import os

# Partie 01
# Nomenclature
produits = {
    "MGM01": ["APMAL01V3", "APPVD01", "ASMNT60V8", "ASMCT03V4", "VRM01"],
    "MGM11": ["MPMPA13", "MPMEX133", "MPMEX05", "MPMGL04", "APMAL12V5", "APPVC01", "ASMET17V6", "ASMNT15V5", "VRM11"],
    "MGM24": ["SFM68", "APMAL20V2", "APPVD07", "ASMNT60V7", "VRM19"],
    "MGM25": ["MPMPA64", "MPMEX201", "MPMEX26", "MPMEX05", "MPMEX219", "MPMEX09", "MPMEX23", "MPMEX35", "MPMEX61", "MPMEX178", "MPMEX139", "APMAL
    "MGM179": ["MPMPA58", "MPMEX56", "MPMEX201", "MPMEX26", "MPMEX05", "MPMEX219", "MPMEX39", "MPMEX93", "MPMEX235", "MPMEX85", "APMAL94V2", "APP
}

# Partie 02
output_file_path = "C:\\Users\\HP\\Desktop\\Upload Data\\FactSupplytoProd.csv"

# Effacer le contenu précédent du fichier de sortie et écrire les en-têtes
with open(output_file_path, "w", newline='') as f_fact:
    csv_writer = csv.writer(f_fact)
    csv_writer.writerow(["No O.F.", "Date suivi de consommation", "Date suivi de déclaration", "ProduitX"])

for produit, articles in produits.items():
    # Ouvrir le dossier "Déclaration" et chercher le fichier qui a le nom de ProduitX
    produit_file_path = f"C:\\Users\\HP\\Desktop\\Upload Data\\Déclaration\\{produit}.csv"
    if not os.path.exists(produit_file_path):
        print(f"Le fichier {produit_file_path} n'existe pas.")
        continue

    with open(produit_file_path, "r") as f_produit:
        reader_produit = csv.DictReader(f_produit)
        lignes_produit = list(reader_produit)

    colonne_trouve = []
    for article in articles:
        article_file_path = f"C:\\Users\\HP\\Desktop\\Upload Data\\Consommation\\{article}.csv"
        if not os.path.exists(article_file_path):
            print(f"Le fichier {article_file_path} n'existe pas.")
            continue
```

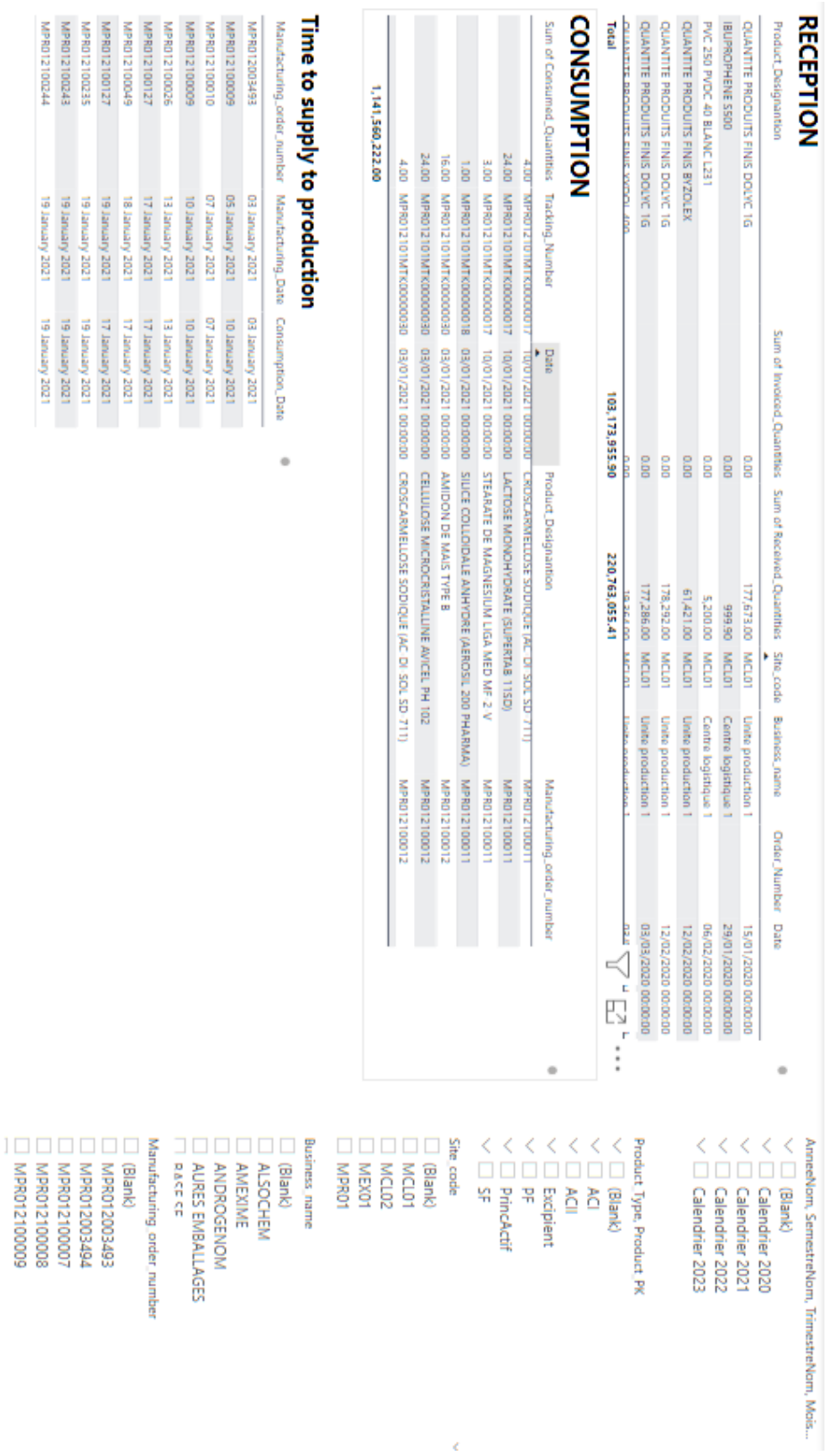
```
        continue

    with open(produit_file_path, "r") as f_produit:
        reader_produit = csv.DictReader(f_produit)
        lignes_produit = list(reader_produit)

    colonne_trouve = []
    for article in articles:
        article_file_path = f"C:\\Users\\HP\\Desktop\\Upload Data\\Consommation\\{article}.csv"
        if not os.path.exists(article_file_path):
            print(f"Le fichier {article_file_path} n'existe pas.")
            continue

        with open(article_file_path, "r") as f_article:
            reader_article = csv.DictReader(f_article)
            for ligne in reader_article:
                # Chercher la colonne "No O.F." ainsi que "Date suivi" correspondante à chaque ligne.
                no_of, date_suivi_conso = ligne["No O.F."], ligne["Date suivi"]
                colonne_trouve.append({"no_of": no_of, "date_suivi_conso": date_suivi_conso, "produit": produit})

    # Trier de A à Z par "No O.F." les deux colonnes
    colonne_trouve.sort(key=lambda x: x["no_of"])

    # Garder uniquement les entrées avec les dates les plus anciennes pour chaque "No O.F."
    unique_entries_dict = {}
    for entry in colonne_trouve:
        if entry["no_of"] not in unique_entries_dict or entry["date_suivi_conso"] < unique_entries_dict[entry["no_of"]]["date_suivi_conso"]:
            unique_entries_dict[entry["no_of"]] = entry

    unique_entries = list(unique_entries_dict.values())
```

```
    # Trier de A à Z par "No O.F." les deux colonnes
    colonne_trouve.sort(key=lambda x: x["no_of"])

    # Garder uniquement les entrées avec les dates les plus anciennes pour chaque "No O.F."
    unique_entries_dict = {}
    for entry in colonne_trouve:
        if entry["no_of"] not in unique_entries_dict or entry["date_suivi_conso"] < unique_entries_dict[entry["no_of"]]["date_suivi_conso"]:
            unique_entries_dict[entry["no_of"]] = entry

    unique_entries = list(unique_entries_dict.values())

    # Ouvrir le fichier "ProduitX", chercher la colonne "No O.F." et le mettre dans la colonne "No O.F." du fichier "FactSupplytoProd"
    with open(output_file_path, "a", newline='') as f_fact:
        csv_writer = csv.writer(f_fact)
        for ligne in lignes_produit:
            no_of_declaration = ligne["No O.F."]  # Utiliser le nom de la colonne pour extraire la valeur
            date_suivi_declaration = ligne["Date suivi"]  # Utiliser le nom de la colonne pour extraire la valeur
            for entry in unique_entries:
                if no_of_declaration == entry["no_of"]:
                    # Prendre les colonnes "Date suivi" de consommation et de déclaration correspondantes au "No O.F." et les mettre dans le fich
                    csv_writer.writerow([no_of_declaration, entry["date_suivi_conso"], date_suivi_declaration, entry["produit"]])
                    print(f"Ecrit: No O.F.: {no_of_declaration}, Date suivi de consommation: {entry['date_suivi_conso']}, Date suivi de déclarati

print("FIN DU TRAITEMENT POUR TOUS LES PRODUITS")
```

Appendix B

Additional tables for each dashboard -desktop version-

1. Stock Management additional tables



RECEPTION

Product_Designantion	Sum of Invoiced_Quantities	Sum of Received_Quantities	Site_code	Business_name	Order_Number	Date
QUANTITE PRODUITS FINIS DOLYC 1G	0.00	177,673.00	MCL01	Unite production 1		15/01/2020 00:00:00
IBUPROPHENE 5500	0.00	999.90	MCL01	Centre logistique 1		29/01/2020 00:00:00
PVC 250 PVDC 40 BLANC L231	0.00	5,200.00	MCL01	Centre logistique 1		06/02/2020 00:00:00
QUANTITE PRODUITS FINIS BYZOLEX	0.00	61,421.00	MCL01	Unite production 1		12/02/2020 00:00:00
QUANTITE PRODUITS FINIS DOLYC 1G	0.00	178,292.00	MCL01	Unite production 1		12/02/2020 00:00:00
QUANTITE PRODUITS FINIS DOLYC 1G	0.00	177,286.00	MCL01	Unite production 1		03/03/2020 00:00:00
QUANTITE PRODUITS FINIS VYDOL 400	0.00	19,264.00	MCL01	Unite production 1	024	
Total	**103,173,955.90**	**220,763,055.41**				

CONSUMPTION

Sum of Consumed_Quantities	Tracking_Number	Date	Product_Designantion	Manufacturing_order_number
4.00	MPR012101MTK000000017	10/01/2021 00:00:00	CROSCARMELLOSE SODIQUE (AC DI SOL SD 711)	MPR012100011
24.00	MPR012101MTK000000017	10/01/2021 00:00:00	LACTOSE MONOHYDRATE (SUPERTAB 11SD)	MPR012100011
3.00	MPR012101MTK000000017	10/01/2021 00:00:00	STEARATE DE MAGNESIUM LIGA MED MF 2 V	MPR012100011
1.00	MPR012101MTK000000018	03/01/2021 00:00:00	SILICE COLLOIDALE ANHYDRE (AEROSIL 200 PHARMA)	MPR012100011
16.00	MPR012101MTK000000030	03/01/2021 00:00:00	AMIDON DE MAIS TYPE B	MPR012100012
24.00	MPR012101MTK000000030	03/01/2021 00:00:00	CELLULOSE MICROCRISTALLINE AVICEL PH 102	MPR012100012
4.00	MPR012101MTK000000030	03/01/2021 00:00:00	CROSCARMELLOSE SODIQUE (AC DI SOL SD 711)	MPR012100012
1,141,560,222.00				

Time to supply to production

Manufacturing_order_number	Manufacturing_Date	Consumption_Date
MPR012003493	03 January 2021	03 January 2021
MPR012100009	05 January 2021	10 January 2021
MPR012100010	07 January 2021	07 January 2021
MPR012100009	10 January 2021	10 January 2021
MPR012100026	13 January 2021	13 January 2021
MPR012100127	17 January 2021	17 January 2021
MPR012100049	18 January 2021	17 January 2021
MPR012100127	19 January 2021	17 January 2021
MPR012100235	19 January 2021	19 January 2021
MPR012100243	19 January 2021	19 January 2021
MPR012100244	19 January 2021	19 January 2021

AnneeNorm, SemestreNorm, TrimestreNorm, Mois...

- (Blank)
- Calendrier 2020
- Calendrier 2021
- Calendrier 2022
- Calendrier 2023

Product Type, Product Pk

- (Blank)
- ACI
- ACII
- Excipient
- PF
- PrincActif
- SF

Site code

- (Blank)
- MCL01
- MCL02
- MEX01
- MPR01

Business_name

- (Blank)
- ALSOCHEM
- AMEXIME
- ANDROGENOM
- AURES EMBALLAGES
- BASSE CE

Manufacturing_order_number

- (Blank)
- MPR012003493
- MPR012003494
- MPR012100007
- MPR012100008
- MPR012100009

2. Scheduling Department additional tables

PRODUCTION

Product_Designation	Tracking_Number	Manufacturing_order_number	Sum of Quantity_produced	Date
QUANTITE PRODUITS FINIS DOLYC 1G	MPR012101MTK000000001	MPR012003493	43,581.00	03/01/2021 00:00:00
QUANTITE PRODUITS FINIS DOLYC 1G	MPR012101MTK000000002	MPR012003493	96.00	03/01/2021 00:00:00
QUANTITE PRODUITS FINIS DOLYC 1G	MPR012101MTK000000020	MPR012100009	274,000.00	05/01/2021 00:00:00
QUANTITE PRODUITS FINIS DOLYC 1G	MPR012101MTK000000133	MPR012100010	356,160.00	07/01/2021 00:00:00
QUANTITE PRODUITS FINIS DOLYC 1G	MPR012101MTK000000135	MPR012100009	13,939.00	10/01/2021 00:00:00
QUANTITE PF DOLYC 500	MPR012101MTK000000221	MPR012100026	177,695.00	13/01/2021 00:00:00
QUANTITE PF DOLYC 500	MPR012101MTK000000300	MPR012100127	166,400.00	17/01/2021 00:00:00
QUANTITE PRODUITS FINIS DOLYC 1G	MPR012101MTK000000301	MPR012100049	356,304.00	18/01/2021 00:00:00
QUANTITE PF DOLYC 500	MPR012101MTK000000347	MPR012100127	1,400.00	19/01/2021 00:00:00
QUANTITE PRODUITS FINIS SULPIRIDE	MPR012101MTK000000344	MPR012100235	43,202.00	19/01/2021 00:00:00
QUANTITE PRODUITS FINIS XYDOL 400	MPR012101MTK000000346	MPR012100243	19,105.00	19/01/2021 00:00:00
QUANTITE PRODUITS FINIS XYDOL 400	MPR012101MTK000000348	MPR012100244	18,957.00	19/01/2021 00:00:00
QUANTITE PRODUITS FINIS XYDOL 400	MPR012101MTK000000351	MPR012100245	19,369.00	19/01/2021 00:00:00
QUANTITE PRODUITS FINIS SULPIRIDE	MPR012101MTK000000415	MPR012100236	48,266.00	20/01/2021 00:00:00
QUANTITE PRODUITS FINIS XYDOL 400	MPR012101MTK000000353	MPR012100246	19,314.00	20/01/2021 00:00:00
Total			**97,706,142.00**	

CONSUMPTION

Sum of Consumed_Quantities	Tracking_Number	Date	Product_Designation	Manufacturing_order_number
1.00	MPR012101MTK000000016	03/01/2021 00:00:00	STEARATE DE MAGNESIUM LIGA MED MF 2-V	MPR012100017
25.00	MPR012101MTK000000016	03/01/2021 00:00:00	SULPIRIDE	MPR012100017
16.00	MPR012101MTK000000017	10/01/2021 00:00:00	AMIDON DE MAIS TYPE B	MPR012100011
24.00	MPR012101MTK000000017	10/01/2021 00:00:00	CELLULOSE MICROCRISTALLINE AVICEL PH 102	MPR012100011
4.00	MPR012101MTK000000017	10/01/2021 00:00:00	CROSCARMELLOSE SODIQUE (AC DI SOL SD 711)	MPR012100011
24.00	MPR012101MTK000000017	10/01/2021 00:00:00	LACTOSE MONOHYDRATE (SUPERTAB 11SD)	MPR012100011
3.00	MPR012101MTK000000017	10/01/2021 00:00:00	STEARATE DE MAGNESIUM LIGA MED MF 2-V	MPR012100011
1.00	MPR012101MTK000000018	03/01/2021 00:00:00	SILICE COLLOIDALE ANHYDRE (AEROSIL 200 PHARMA)	MPR012100011
16.00	MPR012101MTK000000030	03/01/2021 00:00:00	AMIDON DE MAIS TYPE B	MPR012100012
24.00	MPR012101MTK000000030	03/01/2021 00:00:00	CELLULOSE MICROCRISTALLINE AVICEL PH 102	MPR012100012
4.00	MPR012101MTK000000030	03/01/2021 00:00:00	CROSCARMELLOSE SODIQUE (AC DI SOL SD 711)	MPR012100012
24.00	MPR012101MTK000000030	03/01/2021 00:00:00	LACTOSE MONOHYDRATE (SUPERTAB 11SD)	MPR012100012
1.00	MPR012101MTK000000030	03/01/2021 00:00:00	SILICE COLLOIDALE ANHYDRE (AEROSIL 200 PHARMA)	MPR012100012
3.00	MPR012101MTK000000030	03/01/2021 00:00:00	STEARATE DE MAGNESIUM LIGA MED MF 2-V	MPR012100012
1.00	MPR012101MTK000000032	03/01/2021 00:00:00	STEARATE DE MAGNESIUM LIGA MED MF 2-V	MPR012100018
1,141,560,222.00				

AnneeNorm, SemestreNorm, TrimestreNorm, M...

- (Blank)
- Calendrier 2020
- Calendrier 2021
- Calendrier 2022
- Calendrier 2023

Product_Type, Product Pk

- (Blank)
- ACI
- ACII
- Excipient
- PF
- PrincActif
- SF

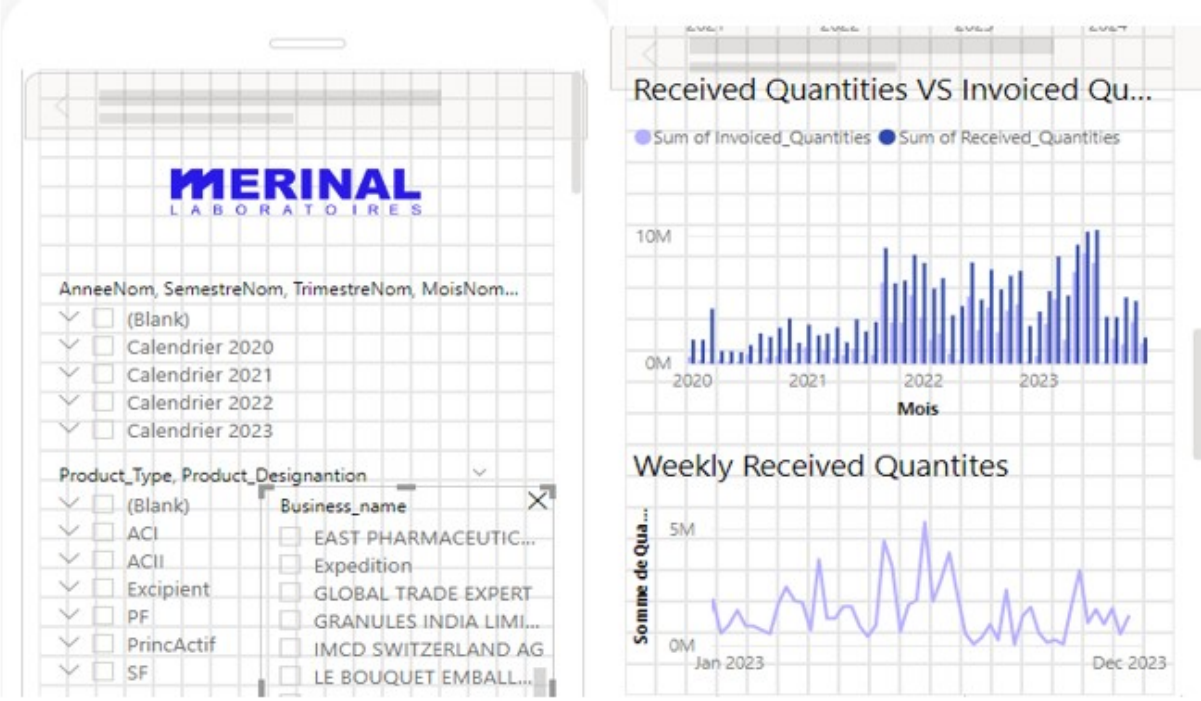
Manufacturing_order_number

- (Blank)
- MPR012003493
- MPR012003494
- MPR012100007
- MPR012100008
- MPR012100009

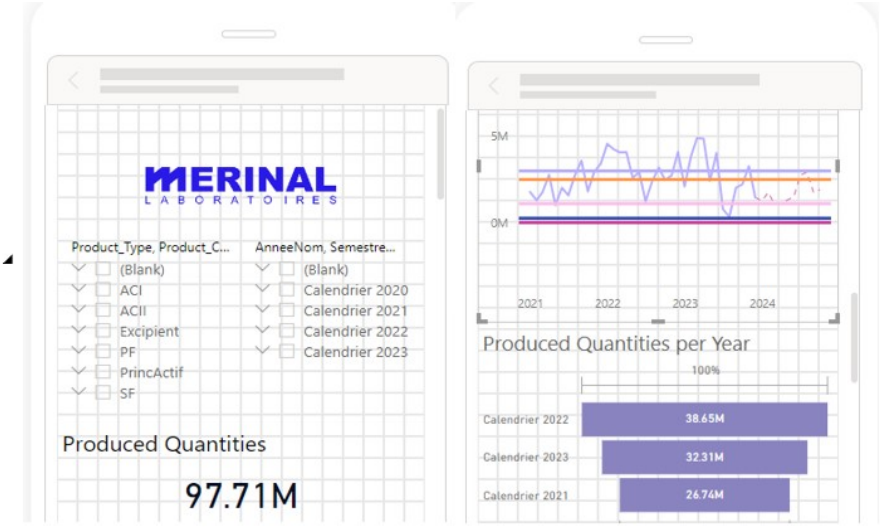
Appendix C

Mobile Versions of the dashboard

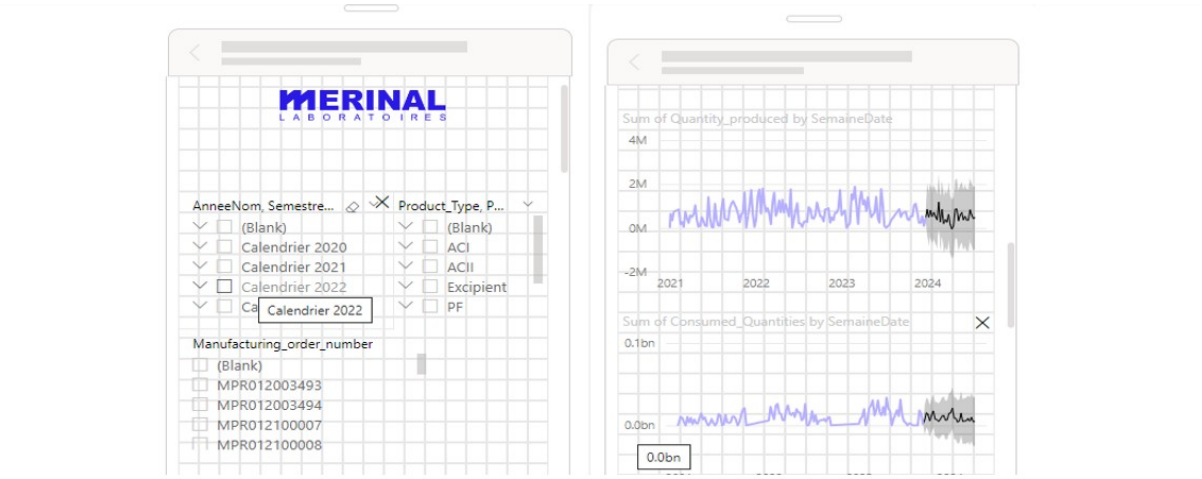
1. **for Stock management**



2. **for Scheduling Department**



3. **for Supply Chain Division**



Abstract:

This study describes the design and implementation of a business intelligence (BI) solution for Merinal's pharmaceutical supply chain, specifically targeting the scheduling and stock management departments. The aim is to enhance transparency and decision-making within the scheduling and stock management processes. The development of this solution comprised several key stages: data collection from, data warehousing for centralized storage, data transformation and data visualization. The objective is to create an efficient dashboard for the Scheduling and Stock management departments within Merinal's pharmaceuticals to help decision-makers get useful insights and optimize the overall performance of their supply chain.

Key words: Business Intelligence (BI) - Supply Chain - Stock Management - Performance Dashboard - Data Warehouse - ETL – OLAP- Power BI- Microsoft SQL Server.

Résumé:

Cette étude décrit la conception et la mise en œuvre d'une solution de Business Intelligence (BI) pour la chaîne d'approvisionnement pharmaceutique de Merinal, ciblant spécifiquement les départements de planification et de gestion des stocks. L'objectif est d'améliorer la transparence et la prise de décision dans les processus de planification et de gestion des stocks. Le développement de cette solution a compris plusieurs étapes clés : la collecte de données, l'entreposage des données pour un stockage centralisé, la transformation des données et la visualisation des données. L'objectif est de créer un tableau de bord efficace pour les départements de planification et de gestion des stocks de Merinal Pharmaceuticals afin d'aider les décideurs à obtenir des informations utiles et à optimiser la performance globale de leur chaîne d'approvisionnement.

Mots clés : Business Intelligence (BI) - Chaîne d'approvisionnement - Gestion des stocks - Tableau de bord de performance - Entrepôt de données - ETL - OLAP - Power BI - Microsoft SQL Server.

ملخص:

تصف هذه الدراسة تصميم وتنفيذ حل ذكاء الأعمال (BI) لسلسلة التوريد الصيدلانية لشركةMerinal ، مع التركيز بشكل خاص على أقسام الجدولة وإدارة المخزون. الهدف هو تعزيز الشـــفافية واتخاذ القرارات داخل عمليات الجدولة وإدارة المخزون. تضـــمن تطوير هذا الحل عدة مراحل رئيســـية: جمع البيانات، تخزين البيانات في مســـتودع بيانات مركزي، تحويل البيانات وتصـــوير البيانات. الهدف هو إنشـــاء لوحة معلومات فعالة لأقسام الجدولة وإدارة المخزون داخل شركة Merinal للصناعات الدوائية لمساعدة صانعي القرار في الحصول على رؤى مفيدة وتحسين الأداء العام لسلسلة التوريد الخاصة بهم

الكلمـات الرئيسـية: ذكـاء الأعمـال - سلسـلة التوريـد - إدارة المخـزون - لوحـة معلومـات الأداء - مسـتودع البيانـات - ETL . OLAP - Power BI - Microsoft SQL Server –