Proposition and Development of a Business Intelligence Solution to Improve the Supply Chain Performance

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Abstract:

This research work aims to design and develop a Business Intelligence (BI) solution to improve the performance of Merinal Supply Chain Division.

The methodology used consists of an analysis of the supply chain requirements, followed by a literature review on supply chain management and Business Intelligence. A solution model was designed and implemented using tools such as Use-Case diagram, Microsoft SQL Server which included Data Warehouse design, ETL processes and OLAP cube followed by data visualization on Power BI.

The results show that the designed and developed BI solution can improve Merinal's supply chain performance by providing accurate and real-time information on transactions, inventory, quantities and delivery times.

The conclusions of the study indicate that Business Intelligence is a powerful tool for improving supply chain management and increasing customer satisfaction.

Keywords*: Business Intelligence, supply chain, supply chain management, performance, BI solution.*

1. Introduction:

The pharmaceutical industry is an important sector that ensures the well-being of individuals all around the world. The supply chain in this industry is critical for timely delivery of drugs with the right quantities from manufacturers to patients, adhering to strict regulatory standards for efficacy and safety, it is crucial for the industry, impacting the availability, quality, and affordability of essential medications. An effective Supply Chain Management requires coordination among various stakeholders, especially within the Supply Chain Division of the company, to ensure the right quantities gets delivered in time. The complexity of global supply chains has increased in recent decades, particularly with the rise of Big Data, necessitating real-time and data-driven tools for efficient management, and Business Intelligence makes one of the solutions for these problems, making one of the best decision-making tools for the heads of the Supply Chain division within a company allowing them to analyse data and get useful insights to make the best selections to improve and optimize their supply chain. The Merinal Pharmaceutical company's supply chain division faces the problem of underutilized data, leading to miscoordination and poor supply chain management, and this project aims to propose a Business Intelligence solution for Merinal to help them visualize the situation, and make better decisions for the overall performance of the company's supply chain. This project will be divided as follows:

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In the 1st section, we will mention the related previous work of Business Intelligence in Supply chain. In the 2nd section we will highlight the proposed solution's modelling and architecture and in the 3rd section we'll discuss the implementation of the solution and some of the observation that we were able to get from the final dashboards that we created.

2. Context:

2.1. Supply Chain definition:

Supply Chain is the combined flows of goods coordinated with their associated information from the origin point to the final destination [11]. 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 flow [12].

2.2. Business Intelligence definition:

Business Intelligence is 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 [2].

2.3. Merinal Laboratories:

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. Merinal Has directed its development strategy to 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. Their goal is to be present on a large national scale by implementing a vast network of 26 strategically positioned distributors throughout the country, ensuring maximum accessibility to patient and healthcare services.

3. Related Work:

Table 1: Table of previous related work of BI in Supply Chain

Reference	Tools/ techniques used	Contribution	limitations
[1]	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 product in their maturity life cycle level. The use of only quantitative forecasting for the interpretation of data.
[2]	Microsoft Power BI	Helps in forecasting future behaviour based on historical data related to past	Solution relayed only on one specific BI system.

		and current projects. Improves manually monitored processes. Provides a set of dashboards to visualise information of several projects.	The utilization of indicators obtained from the author's assessment. The use of synthetic data to increase the data set.
[3]	Microsoft Power BI Action design method (ADR)	Identifying which KPI's are showing or causing a low performance in the SC. Offers real time tracking and updates of KPI's 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 the BI tools, proposing for the future research to use multiple data sources and more advanced BI tools for more comprehensive dashboards.
[4]	Microsoft Power BI Data collection techniques Qualitative research methods.	The paper highlights the importance of using advanced analytics and visualisation tools in order to improve decision making and enhance the 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 finding.	The focus on a single case study, which leads to the limitations of the proposed model in terms of the obtained results, and its transferability to other companies. Data limitation which can have an impact on the depth of the analysis conducted by the model.
[5]	ERP. Microsoft Power BI.	The proposed model helped the company in reducing its total levels of inventory, which conducted to a remarkable cost savings. Improved the efficiency of inventory management by combining the use of ERP database and Power BI tools to visualise data and improve the 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 of continuous updates for the model in order to respond for the user's needs.
[6]	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.	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

		Identifies the key success factors for implementing a BI solution aligned with the user's needs.	interpretation.
[7]	Microsoft Power BI. Streamlit. Python.	The developed framework helped in optimizing inventory levels and enhanced ressources utilization. Provides a real time monitoring of data, to adjust inventory and supply chain operations according to timely fluctuations. Helps in team work, by providing sharable reports and insights of the company information's.	Some missing data in the company's system can influence on 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.
[8]	Microsoft Power BI. Kimball's ETL.	Offers detailed view on the metrics such as revenue, customer details and real time updates. Helps in identifying the crucial KPI's influencing the effectiveness of the SC. Propose 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 of significant data ressources in order to implement such advanced data tools.
[9]	ERP. Microsoft Power BI.	Helped in reducing lead time for inventory planning process. Identified unnecessary tasks included in inventory management and improved it with the developed solution. Offred 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.
[10]	Microsoft Power BI. RStudio. Spoon Pentaho Data Integration (ETL tool).	Offers better control of inventory levels by reducing overstocks and shortages in the analyses period. The developed BI solution has improved the overall productivity of health service by reducing the likelihood of inventory shortages.	Lack of historical data impacts the accuracy of forecasts the 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 of trained users to make sure of successful use and Deployment of the system.

4. Business Intelligence solution for Merinal's Supply Chain division:

Merinal's Supply Chain Division lacks a real-time data tracking and visualization solution that which can allow them to utilize their existing data to create a decision-making tool off of it. In this section, we will

build a BI solution for mentionned division using the available data. We first describe the problem statement then we present the modelling and architecture of the BI solution and finally implement the solution to get insightful dashboards for Stock management and Scheduling departments as well as the Supply Chain Division.

4.1. Problem Statement:

During our internship at Merinal, and after discussing the overall performance of their Supply Chain with the heads of Scheduling and Stock Management departments, they both highlighted issues managing the process of coordination between them. And after following an in-depth analysis of the root causes of the current problem using the Fish-bone diagram and the 5W2H approach, we have concluded that the company lacks an adequate system for real-time monitoring of its stock levels. Specifically, when the Stock Management department issues the availability of the necessary materials without prior confirmation of their inventory levels, leading the Scheduling department to confirm Manufacturing orders, provoking delays and manufacturing inefficiencies in the production service. We have reached the conclusion that Merinal's Supply Chain division needs a real-time Business Intelligence solution that will allow them to utilize their data to create a decision-making tool.

4.2. Solution modelling and Architecture:

4.2.1. Solution modelling using the Use-Case Diagram:

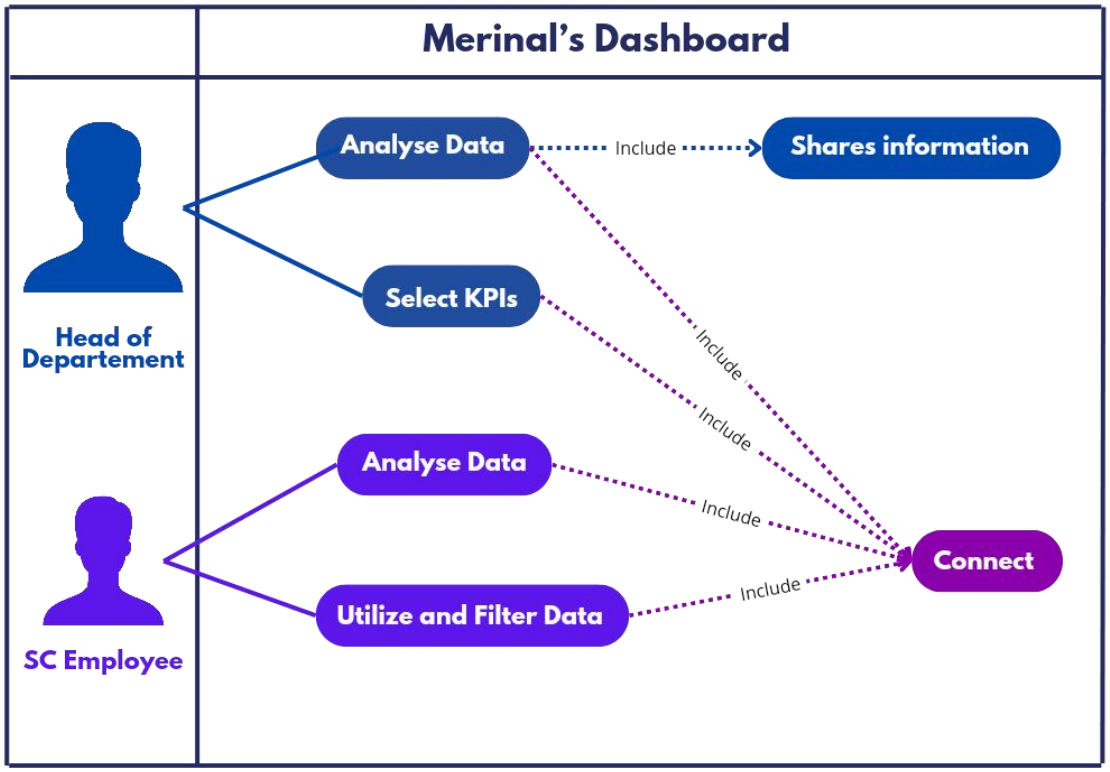

Figure 1: Use case Diagram of the solution

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

- Heads of departments
- Supply Chain division employees

The Head of Department selects and adds KPIs and customizes the visuals to tailor the information to their needs, analyse it and derive insights.

The SC Employee can analyse data, utilize and filter it for specific insights, extract it from various sources, and model it for better interpretation.

4.2.2. The used data:

The data that we were allowed to use and had access to from Merinal's Supply Chain division is presented as follows:

- **Reception file:** It contains 3 years of data in Excel sheets about received goods and for each article, from different sites and suppliers.
- **Consumption file:** It contains 3 years of data in Excel sheets about each consumed article for each manufacturing order.
- **Manufacturing Order file:** It contains 3 years of data in Excel sheets about each manufacturing order for each of the 5 final products.

We have the data of 5 final products with each of their components from raw to packing materials, which constitutes a total 59 articles. The 5 final products that we worked with are: **XYDOL 400Mg, DOLYC 500 Mg, DOLYC 1G, SULPIRIDE, BYZOLEX Mg.**

4.2.3. Solution Architecture:

In order to create an insightful BI solution, we had to choose the correct measures to use from the available data, and the measures we chose were as follows:

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.
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.

Table 2: Measure and Indicators

The fact and dimension tables we chose for our BI solution are presented in the following tables:

Table 3: Fact tables architecture

Fact Table	**Measures**	**Data Type**	**Dimensions**
Fact Reception	Received_Quantities Invoiced_Quantities	numeric(18, 3) numeric(18, 3)	DimProduct DimSupplier DimSite DimTime
Fact Consumption	Consumed_Quantities	numeric(18, 3)	DimProduct DimManufacturing Declaration DimTemps
Fact Manufacturing Declaration	Quantity_produced	numeric(18, 3)	DimProduct DimManufacturing Declaration DimTemps
Fact Supply to Manufacturing Time	Manufacturing_Date Consumption_Date	date date	DimProduct DimManufacturing Declaration DimTemps

Table 4: Dimension tables architecture

Dimension	**Content**	**Data Type**

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

Time dimension has a specific architecture that should be created using an SQL Query in SSMS, which will create the dimension, define its columns and upload it with the necessary data (Dates from 2020 to 2023).

4.3. Solution Implementation:

To implement the BI solution, we created MERINAL Data warehouse in SSMS using the fact and dimension tables previously defined and designing it by creating relations between fact and dimension tables using Primary and Foreign keys, chich results in the following data warehouse design:

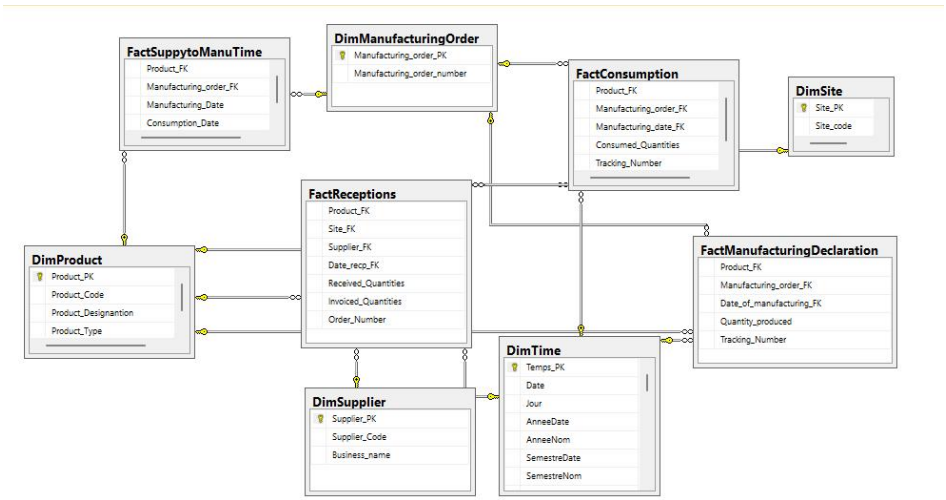

Figure 2: Merinal Data Warehouse Diagram

Now that the data warehouse is created, the next step is to start the ETL process. We extracted data from the files to upload them in the fact and dimension tables. After that, we automated the ETL process to ensure that the data is always up-to-date and in real-time. The ETL packages will run every 3 hours, everyday guaranteeing that all data entries are uploaded.

The following step is the creation of OLAP cubes ensuring the ability of visualization of data from different perspective as well as its granularity. We define the fact tables and dimension tables, and the Order by of each attribute to ensure the logical organization of data, then we define the hierarchies which will allow us to filter the data in a concise manner ensuring an optimized analysis and user experience. With the cube created, the data is prepared for use in developing dashboards that provide insightful visualizations.

Using Power BI, we created dashboards for:

- Scheduling Department
- Stock Management Department
- Supply Chain Division

5. Results:

Each dashboard contains the necessary data for its intended users, they contain graphs and charts which will allow them to visualize the present data as well as the forecasting of the necessary data, in addition to that, we have put on specific filters providing granularity, giving them a decision-making tool that presents

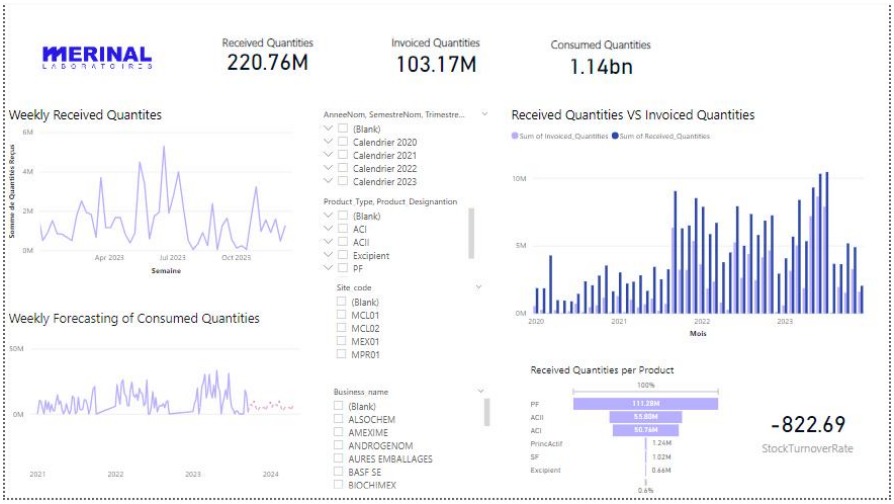

Figure 3 Stock Management Department

real-time visualization.

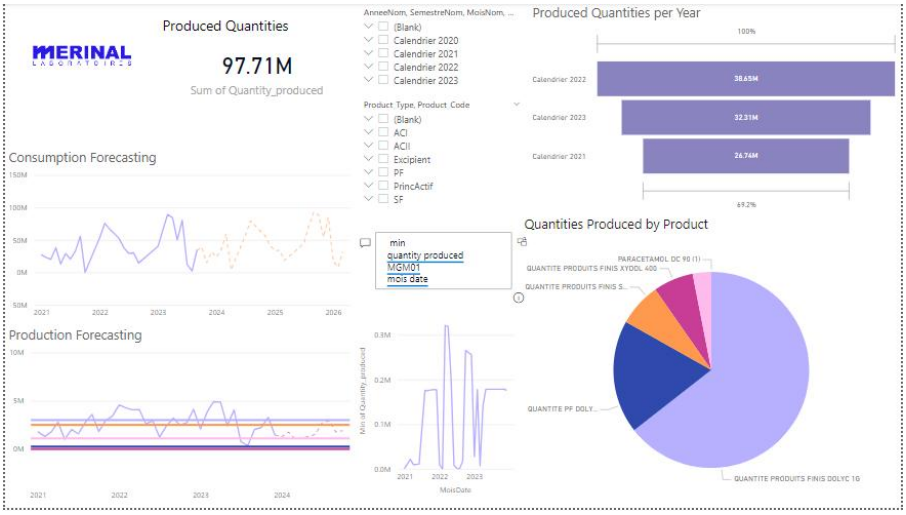

Figure 4: Scheduling Department Dashboard

Figure 5: Supply Chain Division Dashboard

From these dashboards, we could see that there's an excess in production for both DOLYC 1G and 500Mg in the previous three years (2021 to 2023) compared to the production goals. The excess in production of any product can lead to operational issues in sock and warehouse management, specifically when it comes to space utilization, product expiration dates and associated costs. But there can be a potential explanation to this phenomenon, in 2021 and 2022, there were high rates of COVID-19 cases, and knowing that DOLYC is a headache and fever medicine, it might have resulted in the over consumption of this medicine, which lead to its over production.

6. Conclusion:

In our project, we developed a BI solution for Merinal's supply chain division to enhance coordination between scheduling and stock management through customized dashboards. Initially, we analysed the company's structure and information flow within the supply chain division to identify and define the problem. Then explored key supply chain and Business Intelligence concepts, demonstrating the benefits of BI in optimizing supply chain processes with tailored solutions and insightful dashboards for decision-making. We analysed the company's supply chain division to identify and define the problem.

The implementation involved modelling with Use-Case diagrams, defining tools, and designing a solution architecture. We built the solution, creating a data warehouse, ETL processes, and OLAP cubes, followed by designing dashboards in Power BI for scheduling, stock management, and the overall supply chain division. These dashboards provided valuable insights into stock and quantity management and forecasts.

For future improvements, we recommend Merinal to incorporate more detailed data such as consumption times, production times, order dates, and production duration for deeper insights. Additionally, accessing financial data could enable analysis of more relevant KPIs like warehousing cost, supply chain cycle time, return rate, and warehouse utilization rate, further enhancing the dashboard's usefulness and the overall evaluation of supply chain processes.

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