UNIVERSITY OF ECONOMICS AND LAW

FACULTY OF INFORMATION SYSTEMS

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FINAL PROJECT REPORT

DATA ANALYTICS IN BUSINESS

PRODUCTION DEPARTMENT – ADVENTURE WORKS CYCLES

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Group 6

Commitment

We hereby guarantee that the subject "Business Intelligence Solution for Adventure Work Cycles' Production model" was conducted publicly, based on contributions and efforts of the team members' self-researching, reading and translating documents, synthesized and performed.

The details and study results in the subject are truthful and absolutely do not copy or use the results of any similar research topic. Any support in implementing the report has been appreciated. The information is specifically sourced and annotated.

The group would bear full responsibility for not being honest and clear in the process in the use of information./.

Ho Chi Minh City, May 2021

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List of Acronyms

BI	Business Intelligence
BPMN	Business Process Modelling and Notation
DB	Database
DM	Data Mart
DW	Data Warehouse
ETL	Extract - Transform - Load
IT	Information Technology
KPI	Key Performance Indicator
MDX	Multidimensional Expressions
OLAP	Online Analytical Processing
ROI	Return On Investment
SQL	Structured Query Language
SSAS	SQL Server Analysis Services
SSIS	SQL Server Integration Services
XML	Extensible Markup Language

Chapter 1 - Introduction

1.1 Reason for the project

In the competitive and fiercely competitive environment nowadays, the extraction of knowledge from business data such as product buying trends, production cycles, customer behavior... to help managers planning the right business strategies is one of the most important factors to help businesses survive and thrive. However, the extraction of knowledge sources is not easy particularly in the current life, data is increasing larger and larger. In addition, it comes from many different sources leading to the heterogeneous and it is not all data is valuable, some of data is not needed and even if it jams information.... All those reasons interfere with the knowledge gathering process.

To solve that problem, a Business Intelligence (BI) solution appears to be the key to help businesses to take all advantages of their data. BI solution analyzes and evaluates to create reports and charts by extracting information from the existing data of the enterprise, helping administrators to quickly analyze and find a reasonable strategy and more accurate predictions in the future. In addition, BI tools also help administrators to grasp the real situation of the company, organize, operate and monitor business activities smoothly and effectively, minimizing costs, time, risk and increase revenue and profit for business.

Therefore, the application of a BI solution in the organization, storing and exploiting enterprise data is very necessary, deciding the survival of the business. And in this project, we will focus on designing and building the data warehouse, extracting useful data and visualizing knowledge to meet specific business requirements for production operations of Adventure Works Company.

1.2 Objectives

1.2.1 General objectives

The process of data analysis uses analytical and logical reasoning to gain information from the data. The main purpose of data analysis is to find meaning in data so that the derived knowledge can be used to make informed decisions.

- Define The Business Impact

An important aspect before starting any analytics project is defining how the model will impact the workflow and decision-making processes of the business. To achieve maximum return on the investment in analytics, the results of the initiative must lead to advantageous changes in business operations.

- Connect Business Objectives to The Data

Connecting the business objectives to the input data usually requires considerable time and effort. The data scientist must interview subject-matter experts within the company to determine the objectives of the project, the resources available (people, data, and technology), the precise definitions of terms to be used, the projected costs and benefits of the project, and the projected return on investment (ROI).

- Clarify Your Objective

Take sufficient time and care to clarify the purpose of your data analytics initiative. If you don’t get your objective right, your whole project can be a waste of time and money. A team of our data scientists recently spent more than eight hours on the phone with several business and technical people who work at the home office of one of our clients. This provider of outpatient medical services needed to predict the rate at which subscribers were likely to be referred out of their network.

1.2.2 Specific objectives

- Research on overview of model for decision support and BI system.
- Research and use of a detailed SQL Server Business Intelligence solution set.
- Study of performance measurement index Productivity Key Performance Indicators.

- Research and analyze requirements in the financial reporting system and the meaning of each report.
- Designing and constructing DW, implementing ETL.
- Designing a method of analyzing business results, supporting business decision-making based on Microsoft's SQL Server Business Intelligence solution, integrating data blocks with Excel, Power BI, MDX language, Time Series, Tableau.
- Research Microsoft AdventureWorks database integrated with business processes.

1.3 Research objects

Adventure works 2014 Database.

The relevant reports are provided by the instructor.

Professional production process.

Microsoft SQL Server 2019 application.

KPI performance evaluation solution.

SQL Server Analysis services

SQL Server Integration Services

Tableau

Power BI

Excels

Multidimensional Expressions

Online Analytical Processing

1.4 Scope

Research AdventureWorks Database 2014, focus on Production department.

Analyze business requirements, build BI strategy for business.

Build data warehouse supporting information of Production department.

Data integration with ETL process.

Data analytics with SSAS, MDX and OLAP techniques, set KPIs related to specific outcomes or objectives of Production department.

Data visualization by building dashboards using Tableau, Power BI and Microsoft Excel.

1.5 Value and desired outcome

The value and desired outcome of the project is to optimize production costs, manufacturing strategy, inventory, production line and product quality. With the fact that Adventure Works Cycles currently supports end-users representing 10% of its user population. Adventure Works Cycles' goal is to increase revenue by 40% by 2022. The company weighs the potential costs of increased BI usage against the business value and ROI we receive. Thus, the company has a clear view of its measured, accountable, and defensible success.

1.6 Structure of project

In this chapter, we presented the background for the report, our reason, scope, and goals of the report.

In chapter 2, we give an introduction to Business Intelligence and discuss definitions, characteristics, and architecture. We also give the reader some information of the concepts involved in data warehousing.

Chapter 3 discusses the concepts of business processes and states what distinguishing features that represents business processes. In this chapter we also point out different kinds of business requirements that need to be studied related to the topic.

Chapter 4 illustrates a building data warehouse and integration data process. The data is extracted, transformed and loaded into our by using SSIS method.

Chapter 5 we describe a few processes around data analysis work with SSAS and MDX technique.

Chapter 6 portrays our visualization artefacts created for this thesis. The visualizations are done using Excel, Tableau and Power BI tools. The chapter shows visualizations for many different cases, each of which have distinct characteristics when it comes to data mining.

Chapter 7 is the conclusion where we evaluate our findings and discuss the future work.

Chapter 2 - Theoretical Basic

2.1 Overview

2.1.1 What is BI?

BI (Business Intelligence) is a set of processes, architectures, and technologies that convert raw data into meaningful information that drives profitable business actions. It is a suite of software and services to transform data into actionable intelligence and knowledge.

BI has a direct impact on an organization's strategic, tactical and operational business decisions. BI supports fact-based decision making using historical data rather than assumptions and gut feeling.

BI tools perform data analysis and create reports, summaries, dashboards, maps, graphs, and charts to provide users with detailed intelligence about the nature of the business.

2.1.2 BI Architecture

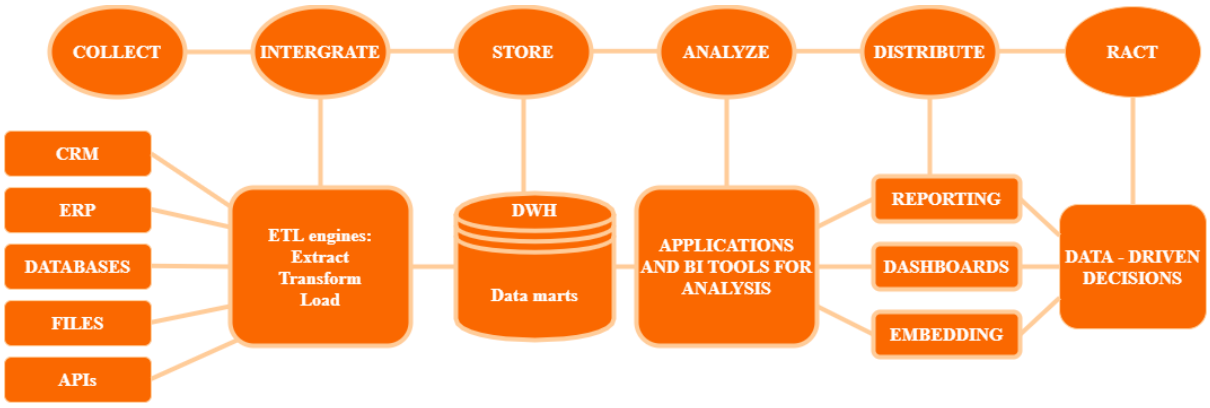


Figure 2-1. BI Architecture

***Collection of data*:** Collecting data, cleansing it, combining it, and aggregating it in a data warehouse or a data lake.

Data integration: Integrating extraction, transformation, and loading (ETL) data

Storage of data: Storing data in the data warehouse

Data analysis: Analyzing using Business Intelligence tools and analytical models.

Distribution of data: Distribution of insights, reports, dashboards, and analyses using portals and mobile BI.

Reaction based on insights: Reaction by the organization's directors: the decision-making process.

2.1.3 Advantage of BI in enterprises

- Understanding customers and tuning the company's offering accordingly

BI tools enable companies to process customer data from multiple sources and create a 360-degree customer profile. They are empowered to tune their offering accordingly and deliver top-notch products and services.

- Boosting sales and marketing activities

With BI solutions, companies take a closer look at multidimensional retail data to forecast customer needs and define sales and marketing activities to meet the demand.

- Optimizing back-end operations

A BI solution can analyze data to advance a company's internal business processes.

- Keeping a close eye on the competition

Benchmarking delivers practical insights on how to outperform competitors. A competitive analysis allows continuously improving a company's performance.

- Revenue increase and cost reduction

Businesses effectively employing BI software earn more by analyzing customers and their demands, boosting marketing and sales activities, optimizing business-supporting operations, and benchmarking.

2.1.4 BI Strategy for Business

A business intelligence strategy is a blueprint for deciding how we will use data in our company. We need a strategy because merely choosing the right technology and implementing a software platform is not enough to realize a return on investment. To create a strategy, we must determine three things. How will we deploy the software platform? How will you manage the data for analysis? And how will we enable people to make informed, data-driven decisions?

Now we go into detail about one of the stages of our implementation plan – documenting a BI strategy:

Step 1. Create the vision

Our vision for BI is to create and support an infrastructure with secure and authorized access to data held anywhere in the enterprise.

In the future, through the application of BI solutions, we hope that in two years from now, Adventureworks Company will become a place to publish and distribute bicycles and accessories top 1 North America. To do that, we also set the goal to increase revenue for the company helping the company become a powerful global corporation.

Step 2. Establish BI governance processes

We define and implement the BI infrastructure through components:

- BI governance team consisting of 7 members, who will be responsible for governance processes.
- BI tools and lifecycle management or the design and development of BI architecture such as: Tableau, Power BI, Excel, SSAS, SSIS.

Step 3. Build a BI roadmap

When building a BI roadmap, we carry out two things: the implementation process and the management of the implementation progress.

Firstly, about the implementation process, we develop the lifecycle for the BI project. Specifically, we apply the incremental model, which is used where the total functionality of the system is to be delivered in phases over a period of time and it is sometimes termed ‘phased delivery’, to build the process’s lifecycle. We have four increments, in developmental order, they are: Data warehouse/Data mart - build an empty available local data storage; ETL - develop three things with the raw data including extract, transform and load; Analyze - analysis and calculations through tools to come up with supporting organization's strategic, tactical and operational business decisions; Visualize - visualize analytics and make predictions via dashboard and report.

Secondly, about the management of the implementation progress, we choose Microsoft Project Management where we manage the timeline, procedure work and resources of our

project. We apply the GANTT chart to manage them. Besides, we also use the PERT chart to calculate the progress of the implementation BI project.

Step 4. Document a BI strategy

The logic behind a strategy document is that it will be a point of reference for the whole organization and will be used for the strategy presentation. There are sections which we put in document:

- Summary an overview of steps and advancements we are planning to make to reach our strategic goals.
- BI strategy alignment with our corporate strategy
- Project scope and requirements
- BI governance team
- Explain deliverables and the metrics of success we will be calculating
- Appendices - provide additional information of our project

Step 5. Review our BI strategy every year

Our plan:

- Measure the success of our BI strategy
- Revisit our BI Maturity model to determine whether we are going in the right direction
- Measure the effectiveness of the BI governance group – whether all goals were met and if the priorities haven't shifted.

2.2 ETL Process

2.2.1 ETL Definition

ETL is a type of data integration process referring to three distinct but interrelated steps (Extract, Transform and Load). It is a process in which an ETL tool extracts the data from various data source systems, transforms it in the staging area and then finally, loads it into the Data Warehouse system.

2.2.2 ETL roles

ETL is essential to properly format and prepare data to load it in the data storage system of your choice. The triple combination of ETL provides crucial functions that are many times combined into a single application or suite of tools that help in areas such as offering deep historical context for business, enhancing Business Intelligence solutions for decision-making, enabling context and data aggregations so that businesses can generate higher revenue and/or save money, etc.

2.2.3 ETL Process

Extraction: This is the first step of the ETL process. In this step, data from various source systems is extracted which can be in various formats like relational databases, No SQL, XML, and flat files into the staging area. It is important to extract the data from various source systems and store it in the staging area first and not directly into the data warehouse because the extracted data is in various formats and can be corrupted also. Hence loading it directly into the data warehouse may damage it and rollback will be much more difficult. Therefore, this is one of the most important steps of the ETL process.

Transformation: This is the second step of the ETL process. In this step, a set of rules or functions are applied on the extracted data to convert it into a single standard format. It may involve following processes/tasks: filtering – loading only certain attributes into the data warehouse, cleaning – filling up the NULL values with some default values, joining – joining multiple attributes into one, etc.

Loading: This is the third and final step of the ETL process. In this step, the transformed data is finally loaded into the data warehouse. Sometimes the data is updated by loading into the data warehouse very frequently and sometimes it is done after longer but regular intervals. The rate and period of loading solely depend on the requirements and varies from system to system.

2.3 Data warehouse and Data mart

2.3.1 Definition of Data Warehouse and Data Mart

A data warehouse (DW) refers to a data repository that is maintained separately from an organization's operational databases. DW systems allow for the integration of a variety of application systems. They support information processing by providing a solid platform of consolidated historic data for analysis.

The four keywords distinguish data warehouses from other data repository systems, such as relational database systems, transaction processing systems, and file systems.

- ***Subject-oriented:*** A DW is organized around major subjects such as customer, supplier, product, and sales. Rather than concentrating on the day-to-day operations and transaction processing of an organization, a DW focuses on the modeling and analysis of data for decision-makers.
- ***Integrated:*** A DW is usually constructed by integrating multiple heterogeneous sources, such as relational databases, flat files, and online transaction records.
- ***Time-variant:*** Data is stored to provide information from a historic perspective. Every key structure in the data warehouse contains, either implicitly or explicitly, a time element.
- ***Nonvolatile:*** A data warehouse is always a physically separate store of data transformed from the application data found in the operational environment.

Due to this separation, a data warehouse does not require transaction processing, recovery, and concurrency control mechanisms. It usually requires only two operations in data accessing: initial loading of data and access of data.

A data mart is a subject-oriented database that is often a partitioned segment of an enterprise data warehouse like sales, finance, or marketing. Data Mart usually draws data from only a few sources compared to a Data warehouse. Data marts are small in size and are more flexible.

2.3.2 Benefits of a Data Warehouse

Organizations have a common goal – to make better business decisions. A data warehouse, once implemented into your business intelligence framework, can benefit your company in numerous ways.

- Delivers enhanced business intelligence
- Saves times
- Enhances data quality and consistency
- Generates a high Return on Investment (ROI)
- Provides competitive advantage
- Improves the decision-making process
- Enables organizations to forecast with confidence
- Streamlines the flow of information

2.3.3 Snowflake and Star schemas

Star schema: The most common modeling paradigm is the star schema, in which the data warehouse contains a large central table (fact table) containing the bulk of the data, with no redundancy, and a set of smaller attendant tables (dimension tables), one for each dimension. The schema graph resembles a starburst, with the dimension tables displayed in a radial pattern around the central fact table.

Snowflake schema: The snowflake schema is a variant of the star schema model, where some dimension tables are normalized, thereby further splitting the data into additional tables. The resulting schema graph forms a shape similar to a snowflake.

The major difference between the snowflake and star schema models is that the dimension tables of the snowflake model may be kept in normalized form to reduce redundancies. Such a table is easy to maintain and saves storage space. However, this space savings is negligible in comparison to the typical magnitude of the fact table. Furthermore, the snowflake structure can reduce the effectiveness of browsing, since more joins will be

needed to execute a query. Consequently, the system performance may be adversely impacted.

2.4 KPIs

2.4.1 Key Performance Indicator (KPI) Definition

A Key Performance Indicator is a measurable value that demonstrates how effectively a company is achieving key business objectives. Organizations use KPIs at multiple levels to evaluate their success at reaching targets. High-level KPIs may focus on the overall performance of the business, while low-level KPIs may focus on processes in departments such as sales, marketing, HR, support and others.

2.4.2 The advantages and disadvantages of KPIs

The KPI Advantages

- Measurable Results

As the sole goal of KPI would be to monitor progress, it shows real benefits in the shape of amounts, metrics, or data. The worker, staff, or company could quickly quantify or track the development of their goal and know which part of this job requires more attention.

- Alignment

KPI helps everybody remain aligned to the target since it makes the outcomes accessible to everybody involved with the job. This helps everybody stay inspired as nobody would love to see their titles or advancement marked red. Furthermore, it ensures everybody works in precisely the same direction.

- Future Strategies

Tracking the progress via KPIs can enable the supervisors to redesign or alter their plans depending on their prior target functionality. As KPIs help the organization understand everybody’s capacity, performance indicator, and productivity, it creates strategy or establishes future objectives.

- Rewards

Any worker intends to work better and hard towards getting an increase or bonuses for their hard work. With KPIs, every individual gets an opportunity to prove themselves and aid the supervisors to see the advancement and benefit accordingly.

Along with this, it helps workers to monitor their performance and enhance themselves.

KPI Disadvantages

- Decrease in Quality

With the prime focus on getting results for short-term objectives, there's an excellent likelihood of workers losing attention to the standard of the job. On account of the setting of financial objectives, there's a trend for metrics gaining additional weight instead of the credibility of the endeavor.

- Short-term Oriented

KPIs help attain short-term targets but might end up being disadvantageous in the instance of attaining long-term objectives. There are plenty of resources to quantify success in one area that can't be acceptable.

- Standardization

Since the goals are somewhat more result-oriented, there might be a prospect of reducing the degree of creativity of their workers. Because of this, it discourages workers from executing or considering innovative strategies.

- Loyalty

Since KPIs only demonstrate the advancement levels, it becomes hard to monitor the essence of the job. Consequently, it could impact the loyalty which is there between the company and the customer. Because of this, the company might lose them weaken the bond between them.

2.4.3 Categories of KPIs for Production

A manufacturing Key Performance Indicator (KPI) or metric is a well defined and quantifiable measure that the manufacturing industry uses to gauge its performance over time. Manufacturing companies specifically use KPIs to monitor, analyze, and optimize operations, often comparing their efficiencies to those of competitors in the same sector.

List of the manufacturing KPIs

- Production Volume: Track the quantities that you are able to produce
- Production Downtime: Analyze and optimize your maintenance
- Capacity Utilization: Maximize the use of your capacities
- Production Costs: Monitor the costs implied in the production
- Overall Operations Effectiveness (OOE): Evaluate your operational efficiency
- Defect Density: Track the damaged items right away
- On-time order: Ensure your products are ordered on time
- Profit Percentage: Revenue and cost difference
- Stocked Percentage: Evaluate product inventory levels
- Average Rating: Product satisfaction

2.5 MDX language for analyzing multidimensional data and OLAP

2.5.1 MDX language definition

Multidimensional Expressions or MDX is a calculation/query language to express queries for online analytical processing - OLAP, in a database management system. Multidimensional expression is an SQL extension to query data stored in a multidimensional structure. As for multidimensional databases they relate to OLAP cubes intended for reporting and analysis.

The MDX queries contribute to working with dimensions, hierarchies, members etc. in the OLAP application. It’s possible to exploit MDX to query data maintained in an SQL Server. As a result, an expression returns a dataset containing cell and axis data.

2.5.2 OLAP technique

2.5.2.1 Definition

Online Analytical Processing (OLAP) is a category of software that allows users to analyze information from multiple database systems at the same time. It is a technology that enables analysts to extract and view business data from different points of view.

2.5.2.2 Basic analytical operations of OLAP

There are four types of analytical operations in OLAP are:

Roll-up: Also known as "consolidation" or "aggregation." The Roll-up operation can be performed in 2 ways: Reducing Dimensions and Climbing up Concept Hierarchy which is a system of grouping things based on their order or level.

Drill-down: Fragmented into smaller parts. It is the opposite of the rollup process. It can be done via: Moving down the concept hierarchy and Increasing a dimension.

Slice and dice: Slice is one dimension selected, and a new sub-cube is created. Dice is similar to a slice. The difference is you select 2 or more dimensions that result in the creation of a sub-cube.

Pivot (rotate): rotate the data axes to provide a substitute presentation of data.

2.5.2.3 Types of OLAP systems

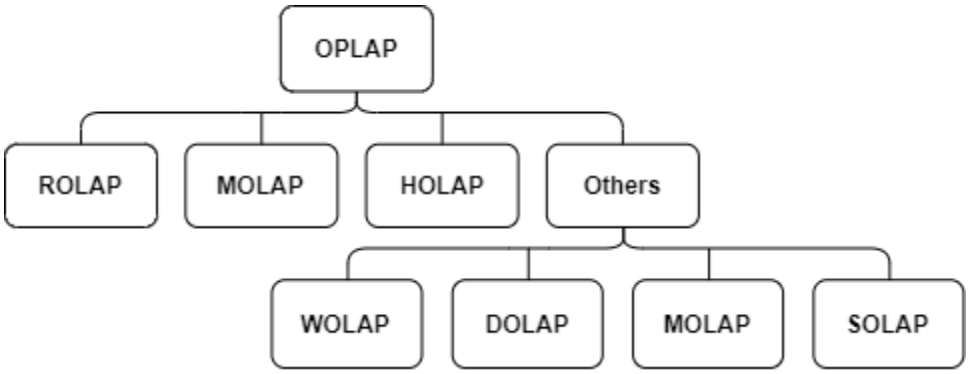


Figure 2-2. OLAP Hierarchical Structure

Relational OLAP (ROLAP): Extended RDBMS along with multidimensional data mapping to perform the standard relational operation.

Multidimensional OLAP (MOLAP): Implements operation in multidimensional data.

Hybrid Online Analytical Processing (HOLAP): approach the aggregated totals are stored in a multidimensional database while the detailed data is stored in the relational database.

Others: Desktop OLAP (DOLAP), Web OLAP (WOLAP), Mobile OLAP, Spatial OLAP are some other types of OLAP systems but are not less popular than the three ones above.

2.5.3 MDX method and structure

MDX language has strong support for calculation on multi-dimensional data blocks, it supports data access in an intuitive and easy way.

The structure of MDX is similar to SQL but is more extended to manipulate multidimensional databases. As the SELECT statement in MDX specifies a result set that contains a subset of multidimensional data returned from cube, to define this set an MDX query must contain the following clauses:

- ***WITH clause (Optional):*** allows to calculate the named sets during the processing of the SELECT and WHERE clauses
- ***SELECT clause:*** identifies which dimension members will be included in each axis for the MDX query structure.
- ***FROM clause:*** names the queried cube and determines which multidimensional data source to use for filling SELECT MDX statement result set.
- ***WHERE clause:*** defines which dimension or member is used as a slicer dimension (the slicer usually refers to the axis formed by the WHERE clause).

2.6 Azure Analysis Service

2.6.1 Introduction

Azure Analysis Services is a new preview service in Microsoft Azure where you can host semantic data models. Users in your organization can then connect to your data models using tools like Excel, Power BI and many others to create reports and perform ad-hoc data analysis.

Azure Analysis Services is a fully managed platform as a service (PaaS) that provides enterprise-grade data models in the cloud. Use advanced mashup and modeling features to combine data from multiple data sources, define metrics, and secure your data in a single, trusted tabular semantic data model.

2.6.2 Function

With Azure Analysis Services, you can encapsulate all the information needed into a semantic model which can be more easily queried by those users in an easy drag-and-drop

experience. And you can ensure that all users will see a single version of the truth. Some of the metadata included in the semantic model includes; relationships between tables, friendly table/column names, descriptions, display folders, calculations and row level security.

2.6.3 Establish service

- Click + Create a resource > Analytics > Analysis Services.
- In Analysis Services, fill in the required fields, and then press Create.

Chapter 3 - Requirements Analytics And Introduction To BI Solution

3.1. Business processes (Purchasing, Production, Sales, or HR)

3.1.1 Production department

3.1.1.1 Definition

The business firm is basically a producing unit it is a technical unit in which inputs are converted into output for sale to consumers, other firms and various government departments.

The production system can be seen as consisting of three elements – inputs (comprising natural resources like land, labor and capital equipment), the production process and outputs (economic goods and services). In reality, the outputs are the start-ing point of the operation inasmuch as they must be considered in the light of the market possibilities.

3.1.1.2 Division

There are many different types of production processes, and they can be classified in different ways. For example, production can involve either assembling or manufacturing. Assembling involves taking a number of component materials, such as a board, nuts, and bolts, and putting them together to produce the desired finished product, such as a skateboard. In contrast, manufacturing involves taking raw materials, such as plastic pellets, and creating something from them, such as a plate or a cup.

3.1.2 The purpose of Production

The purpose of production is consumption, their direct motivation for producing goods is to sell them for a profit. The Production Manager is responsible for making sure that raw materials are provided and made into finished goods effectively and that work is carried out smoothly.

Five production sub-functions

- ***The Production and planning department*** will set standards and targets for each section of the production process. The quantity and quality of products coming off a production line will be closely monitored.
- ***The Purchasing department*** will be responsible for providing the materials, components and equipment required to keep the production process running smoothly, ensuring stocks arrive on time and to the right quality.
- ***The Stores department*** will be responsible for stocking all the necessary tools, spares, raw materials and equipment required to service the manufacturing process.
- ***The Design and technical support department*** will be responsible for researching new products or modifications to existing ones, estimating costs for producing, design and testing of new product processes and product types.
- ***The Works department*** will be concerned with the manufacture of products.

3.1.3 Production process

3.1.3.1 A basic Production process

Before we proceed, however, we need to consider once again a key point, namely, that production processes in organizations are very complex. To explain them in plain terms and to focus on the key steps in these processes, we must make some simplifying assumptions. These assumptions are related to the availability of ***raw material*** in the warehouse, ***the production capacity*** in the work centers to produce the necessary goods, and ***the quality*** of the production process. Specifically, we will assume that the necessary raw materials are always available and they are of high quality.

3.1.3.2 6-stage manufacturing process and elements

Stage 1 – Planning

Planning is a critical step in this process. It is a best bet for protecting the investment and developing a profit-making product that meets the expectation.

At the core of the planning process is the Product Requirements Document (PRD) – also known as User Requirements Document (URS) which helps you to answer key questions and provides a road map for the entire manufacturing process.

Stage 2 – Design

The deliverable for this stage, the output of the design process, can be in many forms, but the minimum design output must be a set of documentation and design database information to repeatedly and reliably manufacture the product.

The design control process is a series of checkpoints that are necessary at major and minor design points. All design output should be reviewed before being released for manufacturing.

Stage 3 – Prototype

Building the prototypes is an important part of the product development cycle and marks the start of the production process.

An Alpha Prototype is designed to test, early in the design process, the fundamental technologies upon which the product is based. A Beta Prototype is the first prototype which is representative of the entire product. It may be lacking packaging or maybe the color is not final.

Stage 4 – Design for Manufacturing

During this stage, your product will undergo necessary design changes to correct any design deficiencies identified in the prototyping process and the design and manufacturing process will be updated to improve manufacturability and reliability.

A prototype, in and of itself, is not ready for manufacturing. It’s just one unit and the engineering team has been looking it over at every step. But to produce that product at a production level, steps need to be taken to allow that product to be built efficiently and repeatedly, and without engineers. This fits with mass production.

Stage 5 – Manufacturing

Manufacturing a product requires a significant investment in space, equipment, and personnel to build the product repeatedly and reliably.

It is easy to imagine getting started in manufacturing – a few benches and some hand tools, a couple of technicians and some drawings, parts arriving at the door and voila, a product. Good receipt completed products into finished good inventory. The production is completed.

Stage 6 – Post-Manufacturing

At this stage, your focus is on customer service – providing everything the customer needs to make full use of your product. Depending on the product, this may include a field service technician for installation, setup, and commissioning, maintenance, a repair depot and metrology lab for factory service and calibration, and factory training for your service personnel.

3.1.3.3 Business Process Model and Notation of the Production process

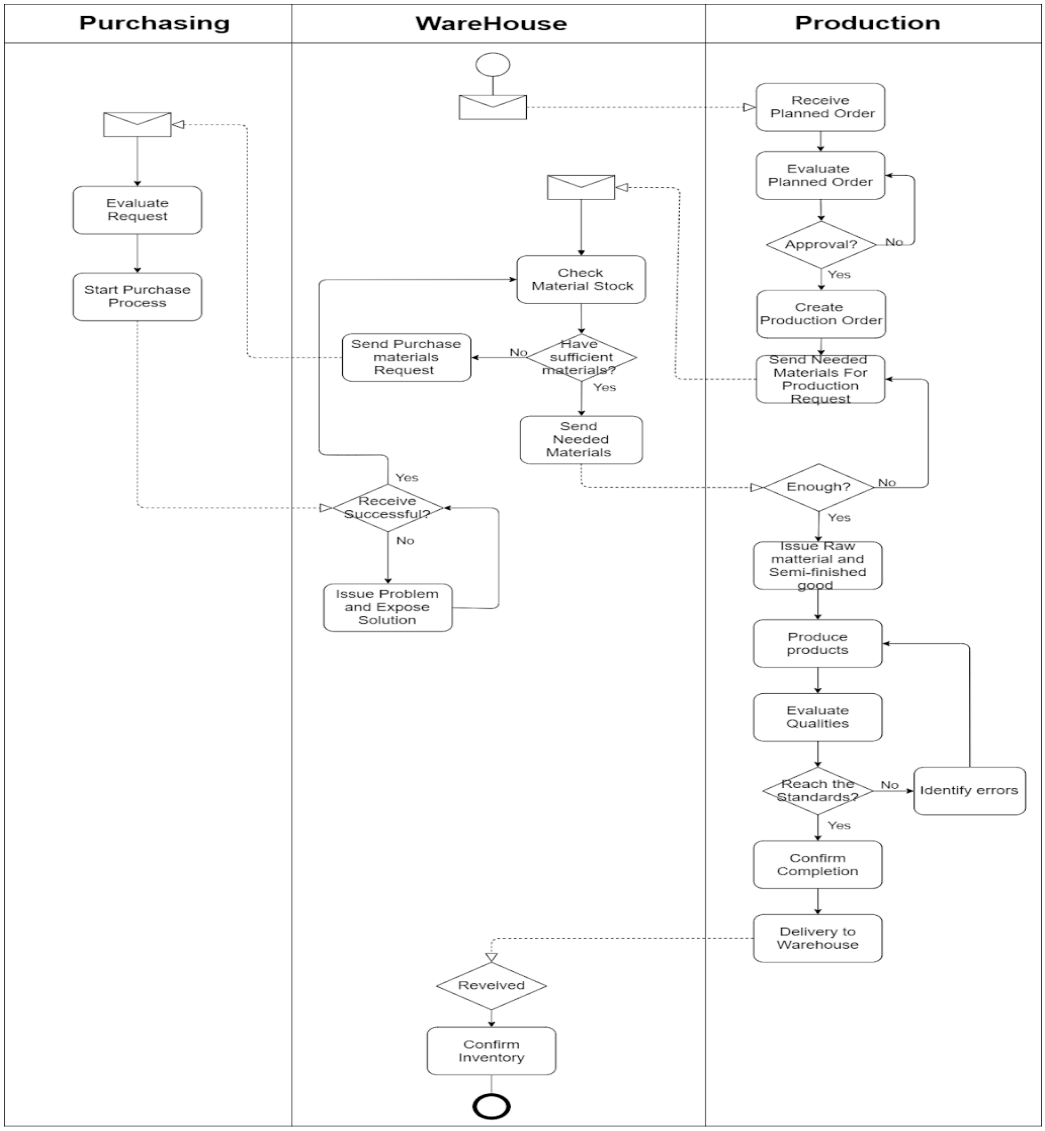


Figure 3-1. BPMN of Production Process

The process begins when the warehouse sends the planned order to the production department, after conducting a production assessment, the order will be converted into a Production Order. If there are enough materials, work center will proceed to production, if there is a shortage, proceed to buy more materials. Finished production process will proceed to product testing, rejecting defective products and stocking products.

3.2. Data source and challenges

3.2.1 Advantage

The data of the production module is quite large, describing in detail each component, helping the group to have many analytical directions. As a production module, we can be very flexible in having a general analysis with other parts.

3.2.2 Disadvantage

Many data but the cells in a table often have too many null values that prevent data from pouring into the Fact table. Database systems are complex, difficult, and time-consuming to analyze.

3.2.3 Challenges

Based on the database we have laid out requirements for our project. Thus to be able to solve all the problems posed, this project must use some complex software. Developers, designers, DBA and End-users of the database must have complete skills of analysis if they want to use it properly.

Using an enterprise database to create meaningful management insights requires a combination of very different skills:

We must have an enough understanding of the data resource. We need to use all available documentation and understand its limits; use our tools and skills to examine the data resource. We must define what is missing from the database like columns, records, cells and the reason why.

3.3 Business Requirements Analysis

3.3.1 Product cost optimization

Calculating how much time it takes, costs to manufacture a product, it is possible to come up with a more reasonable production formula.

3.3.2 Manufacturing strategy development

Comparing the cost as well as the selling price of each product to estimate the revenue and profit earned by the products. Establish statistics of profits, costs, revenue by month or quarter of each product, by giving specific strategies to promote appropriate business.

3.3.3 Inventory optimization

Estimating the number of products sold and inventories, predicting sales and production cycles by month, quarter or year to get a suitable safety stock level. Visualizing inventory movements to make a streamlined production and inventory plan.

3.3.4 Production line control

Identifying the difference between actual costs and planned costs, calculate the defect rate and find out the reasons, by planning to check product quality. The difference between planned time and actual time to manufacture products is one of the elements to optimize the production line. If the difference is too large, quickly find the solutions to solve the problem.

3.3.5 Increasing product quality

The managers can identify quality defects due to the rating of products, customer's review, the stock quantity or the scrap quantity, from which to promote a product quality improvement strategy.

3.4 IT Requirements Analysis (IT & Infrastructure)

For this project, we use SQL Server 2019 and Visual Studio 2019 as the main applications to support the data warehouse and business intelligence. One of the components of Microsoft SQL Server database software is SQL Server Integration Service (SSIS) that has the functionality to extract data from AdventureWorks database and consolidate it for better analysis. SQL also has the module that can create all of the basic elements, such as data sources, data source views, dimensions, cubes and roles, known as Analysis Services (SSAS).

We also use some BI tools such as Tableau, Power BI and Excel. These tools help prepare data for analysis so that we can create reports, dashboards, and data visualizations. The results give both employees and managers the power to accelerate and improve decision making, increase operational efficiency, pinpoint new revenue potentials, identify market trends, report genuine KPIs, and identify new business opportunities.

3.5. Comparative Analysis of BI and Data Visualization Tools

3.5.1 Surveying and evaluation BI tools

3.5.1.1 Tableau

Tableau zeros in on data analytics via visualization means. It is intended for easy creation and distribution of interactive data dashboards that provide an insightful depiction of dynamics, trends of change, and data density distributions via the convenient medium of simple, yet effective visuals.

Two main features make Tableau stand out — built-in data blending and real-time collaboration. The latter feature comes with a number of ways to share reports, which consist of publishing to a Tableau server, publishing a Tableau workbook, and sending the report in an email.

Features

- Complimentary sharing ability (with certain limitations)
- Support for connection to 30+ data source types
- Mixing data sources
- Support for cubes
- Integration with R Excellent in mapping Ready-made drivers for many databases
- Leadership in community building efforts (various training videos, blogs, forums, social network engagement)

Table 3-1. Pros & Cons of Tableau

Pros	Cons
- Intuitive and attractive user Interface. - Seamless integration with many modern big data platforms, from Hadoop to Google BigQuery. - Provides an extensive roster of native data connections allowing easy integration with data from many sources.	- Initial Data Preparation is required (structured data). - Features may seem too specialized and restricting - Although great for analytical purposes, Tableau and other Bl tools cannot

- Responsiveness - Tableau is supported by mobile platforms. - Powerful community collaboration. - Constant development. - Reliable customer support. - A vast library of video materials about the tool, online courses, learning blogs.	replace Financial Reporting applications. - Gives the ability to establish "row-level" security at the data level but implements it in a bit precarious way. - There is no concept of versioning with the Tableau server. - Requires some IT consultancy

3.5.1.2 Power BI

Power BI is an online service with various options for interaction, also featuring several outlets for connection to data provided by third-party software and services. Power BI provides a simple web-based interface with a plenitude of useful features varying from customizable visualization to certainly limited controls of data sources.

Power BI has connections to some other software from Microsoft's toolbelt but goes much farther than that by utilizing a whole suite of novel business analytics tools. Thus, Power BI is not just related to other products; it is tightly integrated with the main Microsoft tools including MS Excel, Azure Cloud Service, and SQL Server.

Features

- Power BI has a free basic version, giving users a chance to explore it first
- It supports plenty of ways to incorporate or import your data (streaming data, cloud services, excel spreadsheets, and third-party connections)
- It has interactive dashboards with a real-time feed of data
- Simple API for integrating Power BI with your application
- Different ways to share reports and dashboards
- Multiplatform support (Web, Desktop, Mobile)

Table 3-2. Pros & Cons of Power BI

Pros	**Cons**

- More affordable than its main competitors and offers a free version Integration with other Microsoft products: works within a suite of business tools along with Azure, Excel, SQL Server. - Is support for custom visualsGreat and gentle customer support. - Ability to connect to almost any kind of data source, either cloud-based or on-premises. - The intuitiveness of the Power Bl interface decisions.	- Unnecessary complexity when stepping outside basic functions, especially for users with limited previous exposure to MS Excel. - Performance issues when streaming or Importing big data sets in Power BI, such as time-outs and freezes The built-in library of visuals is impressive and robust, besides there. - Lack of data preparation and cleaning tools.

3.5.2 Proposing BI solution for the project

The diagram depicts five main phrases from our project. The first step is to define specifications, which can then be used to survey the AdventureWorks Database and plan the Production data warehouse. The next step is to construct a DW model before collecting and loading data that conforms to the required standard into a data warehouse. The Production DW is the outcome of Data Source and Data.

In the Data Analysis stage, we focus on the analysis of data after it’s handled, processed, and stored in former steps called Analytical databases (OLAP). This stage yields a report and a dashboard. The dashboard would highlight the data's "insights," which result from how the data warehouse and business intelligence work together.

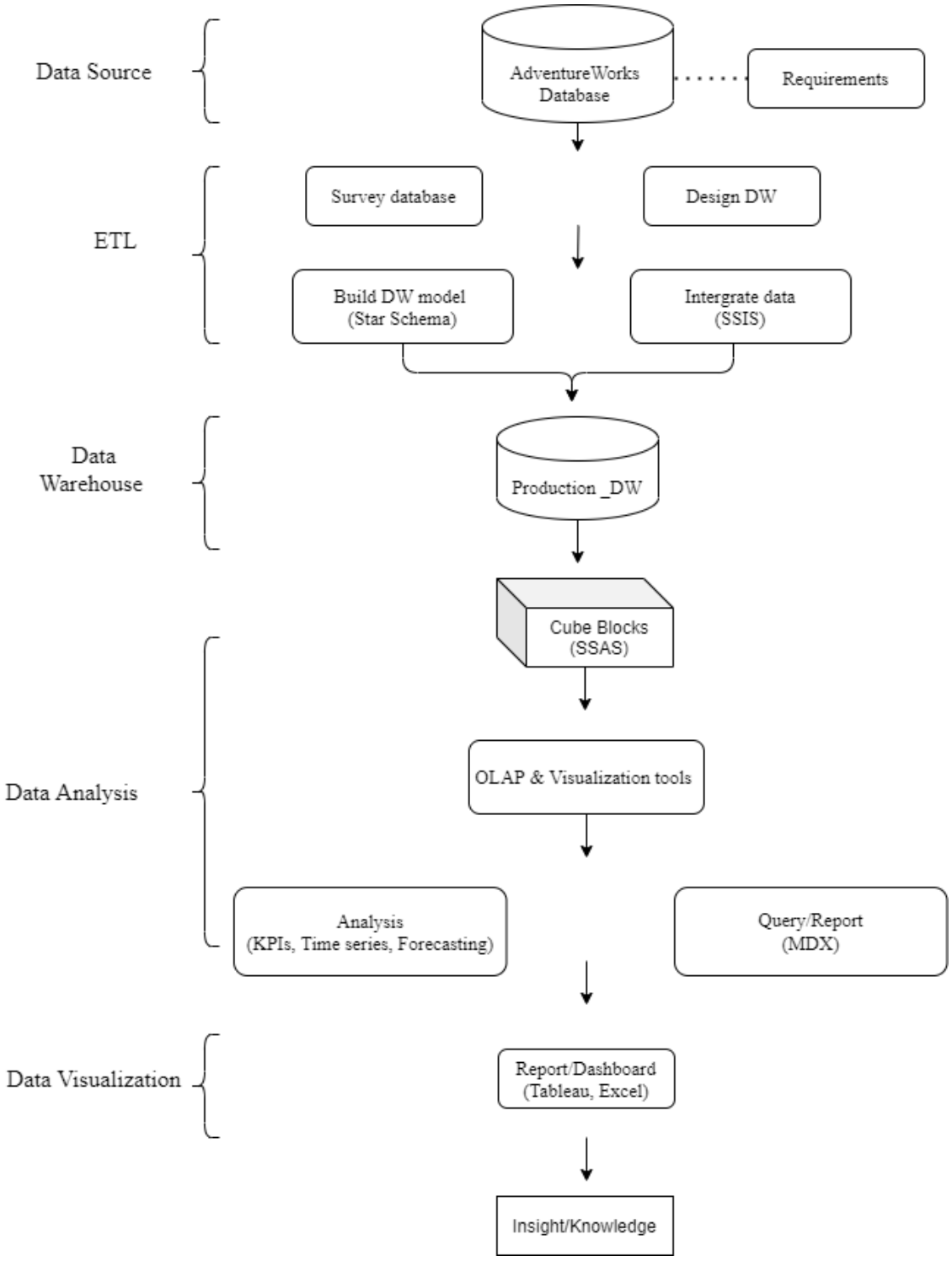


Figure 3-2. Proposing BI Solution

Chapter 4 -Building Data Warehouse And Integration Data

This is a process for analyzing data and presenting actionable information which helps executives, managers make informed business decisions. In this process we will design a way to transform the data from the AdventureWorks Database in SQL Server to our data warehouse to make facts off of that information.

4.1 Designing Data Warehouse

4.1.1. Bus Matrix

The bus matrix shows the business processes and the dimensions needed to support them.

Table 4-1. Bus Matrix

Business Process	Conformed Dimensions				
	Product	Location	Scrap Reason	Transaction Type	Time
Finished Goods Inventory	X	X			X
Product Review	X				X
Transaction	X			X	X
Work Order	X		X		X
Work Order Routing	X	X			X

4.1.2. Master Data

Master Data is data that remains unchanged over a period of time, such as personal attributes that can be stored in various standard infotypes as records with specific validity, is the data used to build the Dimension tables.

Table 4-2. Master data

Object	Comments
Product	Products sold or used in the manufacturing of sold products.
Product Category	High-level product categorization of Adventure Works Cycles products, for example: bikes, components, clothing, or accessories.
Product Sub Category	Product subcategories, for example: mountain bikes, wheels, gloves, helmets, and cleaners.
Location	Product inventory and manufacturing locations.
Scrap Reason	The reasons for manufacturing failures.

4.1.3. Transaction Data

Transactional data is data relating to the day-to-day transactions, used to construct Fact tables.

Table 4-3. Transaction data

Object	Comments
Product Inventory	Product inventory information. The transaction data is displayed for each product in an amount, in any location, shelf and bin.
Product Review	Customer reviews of the products they have purchased.
Transaction History	Purchase order, sales order, or work order transaction for the current year.
Product Work Order	The manufacturing work orders. Work orders control which products are manufactured in the appropriate quantity and in time to meet sales or inventory demands.

Product Work Order Routing	Manufacturing work order details, contains the planned and actual costs for each work center that is used to build the specified product.

4.1.4. Fact and dimension tables

4.1.4.1 Data mapping description

Table 4-4. Data mapping description

AdventureWorks2014		**Nhom6_Production_DW**		**Data Type**
Table	**Column**	**Table**	**Column**	
Production. Location		Dim_Location	LocationKey	Int
	LocationID		LocationID	Smallint
	Name		LocationName	Nvarchar(50)
		Dim_Product	ProductKey	Int
Production. Product	ProductID		ProductID	Int
	Name		ProductName	Nvarchar(50)
	ProductNumber		ProductNumber	Nvarchar(50)
	MakeFlag		MakeFlag	Bit

	FinishedGoodsFlag		FinishedGoodsFlag	Bit
	SafetyStockLevel		SafetyStockLevel	Smallint
	ReorderPoint		ReorderPoint	Smallint
	DaysToManufacture		DaysToManufacture	Int
	ProductLine		ProductLine	Nchar(2)
	Color		Color	Nvarchar(15)
	Class		Class	Nchar(2)
	Style		Style	Nchar(2)
	Size		Size	Nvarchar(5)
Production.ProductSubCategory	Name		SubCategoryName	Nvarchar(50)
Production.ProductCategory	Name		CategoryName	Nvarchar(50)
Production.ProductModel	Name		ProductModelName	Nvarchar(50)

		Dim_ScrapReason	ScrapReasonKey	Int
Production.ScrapReason	ScrapReasonID		ScrapReasonID	Smallint
	Name		ScrapReasonName	Nvarchar(50)
		Dim_TransactionType	TransactionTypeKey	Int
			TransactionTypeName	Nvarchar(50)
Production. TransactionHistory	TransactionType		TransactionTypeCode	Nchar(1)
		Fact_Inventory	FactInventoryKey	Int
Production.Product	ProductID		ProductKey	Int
Production.ProductInventory	LocationID		LocationKey	Int
	Shelf		Shelf	Nchar(10)
	Bin		Bin	tinyint
	Quantity		Quantity	Smallint

	ModifiedDate		ModifiedDate	Nvarchar(34)
		Fact_ProductReview	FactReviewKey	Int
Production.Product	ProductID		ProductKey	Int
Production.ProductReview	Comments		Comments	Nvarchar(3850)
	Rating		Rating	Int
	ReviewDate		ReviewDate	Nvarchar(34)
		Fact_Transaction	FactTransactionKey	Int
Production.TransactionHistory	TransactionDate		TransactionDate	Nvarchar(34)
	TransactionType		TransactionTypeKey	Int
	Quantity		Quantity	Int
	StandardCost		StandardCost	Money
Production.Product	ProductID		ProductKey	Int

	ActualCost		ActualCost	Money
	ListPrice		ListPrice	Money
		FactWorkOrder	FactWorkOrderKey	Int
Production.WorkOrder	ProductID		ProductKey	Int
	StartDate		StartDate	Nvarchar(34)
	EndDate		EndDate	Nvarchar(34)
	OrderQty		OrderQty	Int
	StockedQty		StockedQty	Computed
	ScrappedQty		ScrappedQty	Smallint
	ScrapReasonID		ScrapReasonKey	Int
			FactWorkOrderRoutingKey	Int
Production.WorkOrderRouting	ProductID		ProductKey	Int
	LocationID		LocationKey	Int

	PlannedCost		TotalPlannedCost	Money
	ActuaCost		TotalActualCost	Money
	ActualResourceHrs		TotalActualHours	Int
	ScheduledStartDate		ScheduledStartDate	Nvarchar(34)
	ScheduledEndDate		ScheduledEndDate	Nvarchar(34)
	ActualStartDate		ActualStartDate	Nvarchar(34)
	ActualEndDate		ActualEndDate	Nvarchar(34)

4.1.4.2 Fact and dimension tables description

Table 4-5. Fact and dimension tables description

Object	Description
Dim_Product	Describe information of each product in the company, including information such as name, color, category…
Dim_Time	Describe the time of each transaction
Dim_ Location	Describe product inventory and manufacturing locations
Dim_ScrapReason	Describe the reason for the defective product
Dim_TransactionType	Describe transaction types, include sales order, purchase order, and work order.
Fact_Transaction	Describe the details of each transaction, such as the type of transaction, product key, price and the cost of that product.
Fact_WorkOrder	Describe information related Work Order, such as: OrderQty start date, end date, stockedQty,…
Fact_WorkOrderRouting	Describe information such as: TotalPlannedCost, totalActuaCost,…
Fact_ProductReview	Describe the customer feedback and rating on the product of the business.
Fact_Inventory	Describe the level of inventory of each product.

4.1.5. Data Warehouse model

DB is designed and built in a Star Schema. Fact's key is generated by Dim's keys.

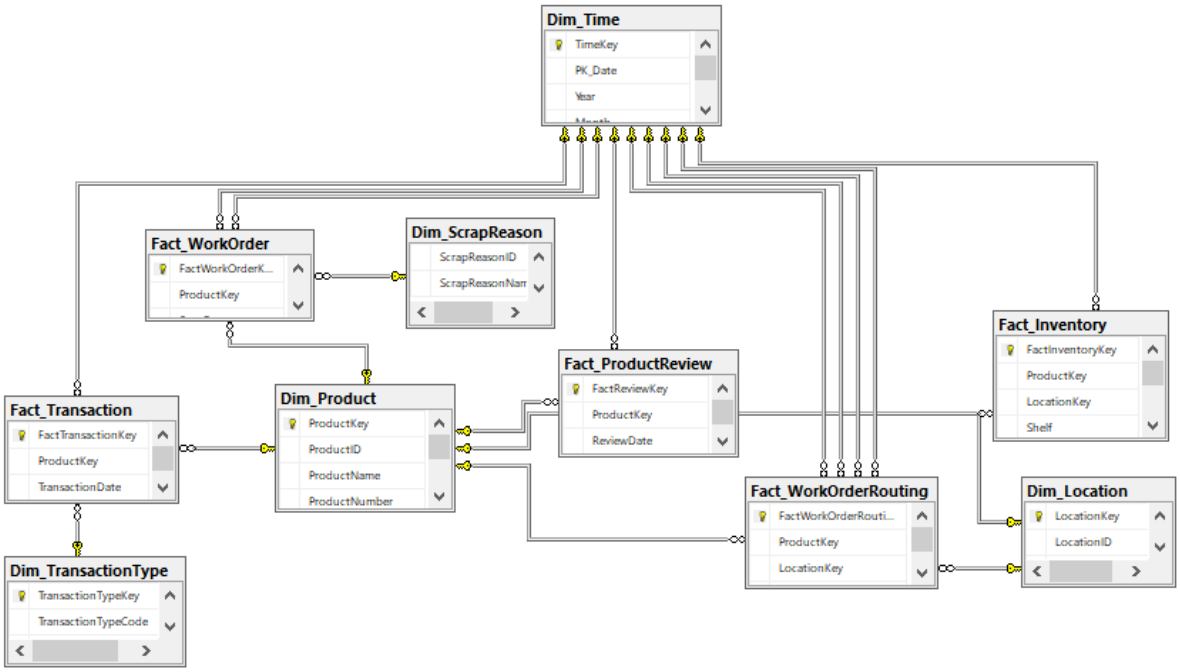


Figure 4-1. Star Schema of Production DW

Relationships among tables in diagram:

Table 4-6. Relationships among tables

Relationship	Relationship Type	Description
Dim_Product, Fact_ProductReview	1-n	A review belongs to a product but a product may have many reviews.
Dim_Product, Fact_Transaction	1-n	A product may have one or more lines in Fact_Transaction and a Transaction in Fact_Transaction has only a Product.

Dim_TransactionType, Fact_Transaction	1-n	A transaction type may have many transactions but a transaction only belongs to one transaction type.
Dim_Product, Fact_WorkOrder	1-n	A product may have one or more lines in Fact_WorkOrder and a WorkOrder in Fact_WorkOrder has only a Product.
Dim_ScrapReason Fact_WorkOrder	1-1	A ScrapReason may have one or more lines in Fact_WorkOrder and a WorkOrder in Fact_WorkOrder has no or only a ScrapReason.
Dim_Time Fact_WorkOrder	1-n	One row in Dim_Time has 1 or more line in Fact_WorkOrder and each row in Fact_Workorder has only one time point.
Dim_Location, Fact_Inventory	1-n	A Location can have one or more rows in the Fact_Inventory table and each Fact_Inventory row only has one Location.
Dim_Location, Fact_WorkOrderRouting	1-n	A Location can have one or more rows in the Fact_WorkOrderRouting table and each Fact_WorkOrderRouting row only has one Location.
Dim_Product, Fact_WorkOrderRouting	1-n	A product may have one or more lines in Fact_WorkOrderRouting and a WorkOrderRouting in Fact_WorkOrderRouting has only a Product.

Dim_Product, Fact_Inventory	1-n	A Product can have one or more rows in the Fact_Inventory table and each Fact_Inventory row only has one Product.
Dim_Time, Fact_Inventory	1-n	A Time can have one or more rows in the Fact_Inventory table and each Fact_Inventory row only has one Time.
Dim_Time, Fact_WorkOrderRouting	1-n	A Time can have one or more rows in the Fact_WorkOrderRouting table and each Fact_WorkOrderRouting row only has one Time.
Dim_Time, Fact_Transaction	1-n	A Time can have one or more rows in the Fact_Transaction table and each Fact_Transaction row only has one Time

4.2 ETL Process

For Adventure Work Cycles' project, the most appropriate ETL tool that meets the company's requirements is Microsoft SQL Server Integration Services (SSIS). After restoring the original Adventureworks2014 database in SSMS, we create dim tables, fact tables as well as star schema in our data mart. Then, go to Visual Studio to create a project SSIS to implement the ETL process.

4.2.1 Dimension Table

4.2.1.1 Dim_Product

In general, to dump data to the dimension table, we use the SSIS tool in Visual Studio. The steps are as follows:

Step 1: Connect SQL with SSIS

Before we dump data, we have to connect the database with SSIS once for all.

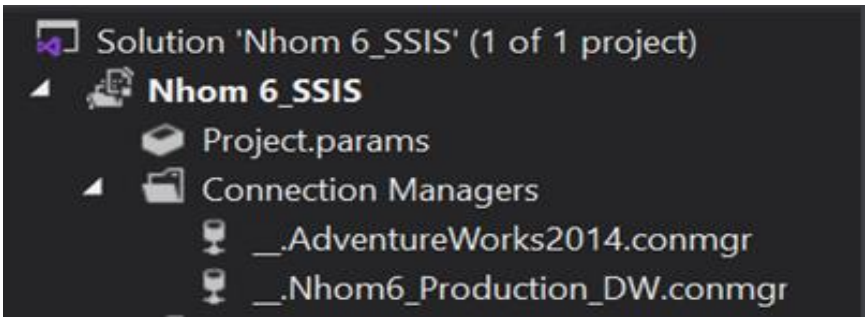


Figure 4-2. Connect Database with SSIS

Step 2: Create Data Flow Task

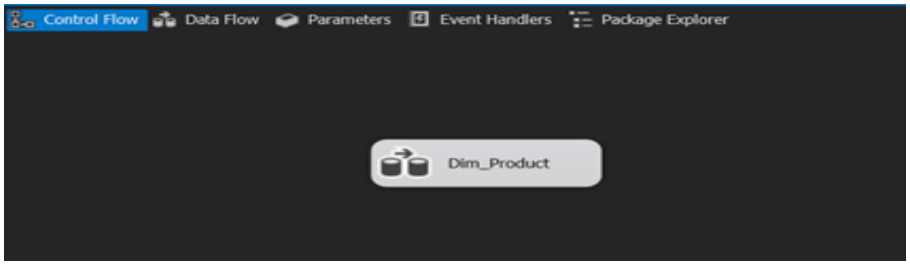


Figure 4-3. Create Data Flow Task

Step 3: Create DB Source

Connection with AdventureWorks2014 and use SQL command to extract specific data.

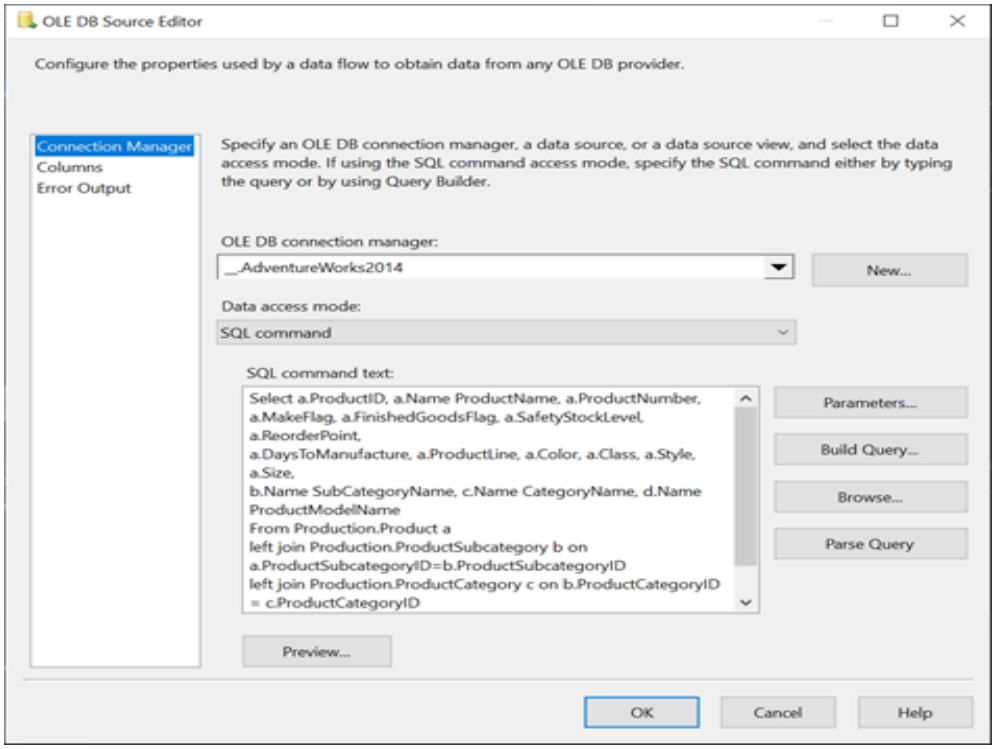


Figure 4-4. Create OLE DB Source

Step 4: Insert a Slowly Changing Dimension

In the Slowly Changing Dimension Wizard box, we select our data warehouse, particularly "Nhom6_Production_DW", and our destination table that we want to transfer data into. Then, set the "Business Key" for the "ProductID" column and press "Next".

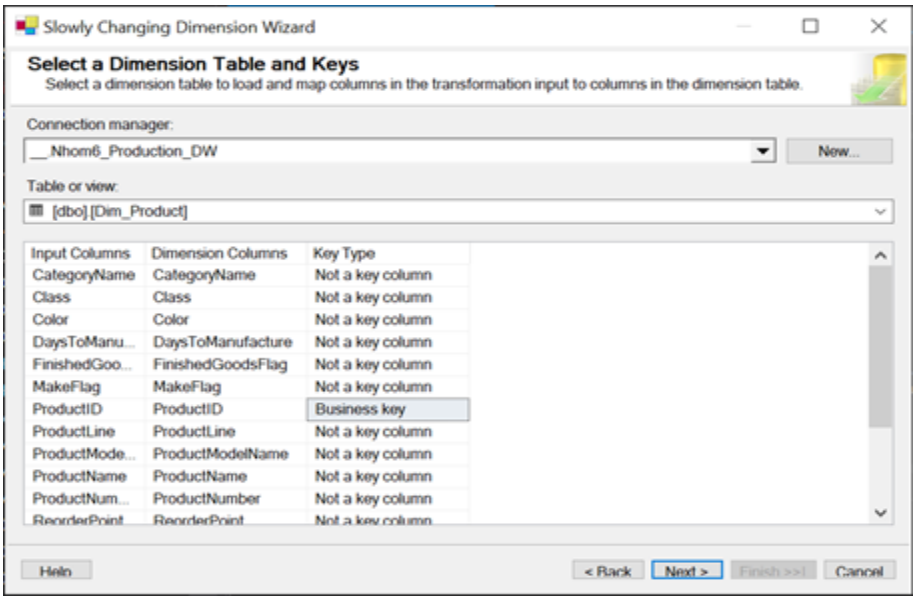


Figure 4-5. Select a Dimension Table and Keys

Then, we choose all Dimension columns and Change Type is "Changing attribute". Press Next -> Next -> Finish and we will have Completed Data Flow for ETL Process as below:

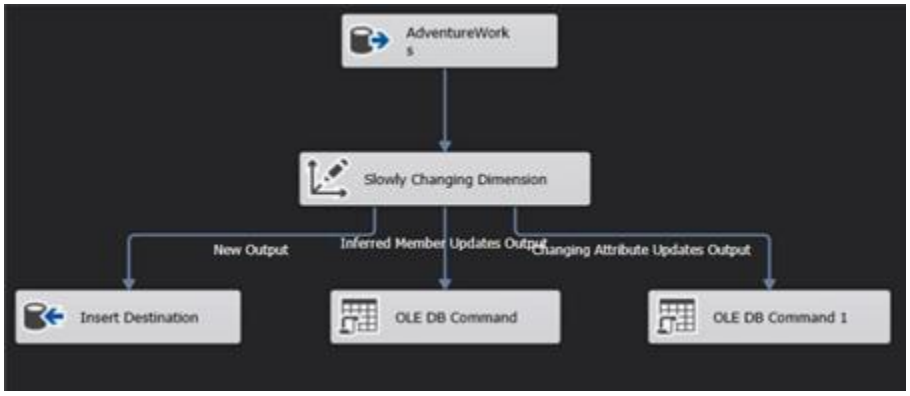


Figure 4-6. Data flow for ETL process

Step 5: Press "Start" to dump data and we will have Dim_Product with all data that we need for analysing from AdventureWorks2014 Database.

4.2.2.2 Dim_Location

Similar to the steps for dumping data into the Dim_Product table.

Using SQL Command:

Select LocationID,Name LocationName From Production.Location

Set “Business Key” for the “LocationID” column.

4.2.2.3 Dim_ ScrapReason

Similar to the steps for dumping data into the Dim_Product table.

Using SQL Command:

select ScrapReasonID, Name ScrapReasonName from Production.ScrapReason

Set “Business Key” for the “ScrapReasonID” column.

4.2.2.4. Dim_TransactionType

Because in the original database we don’t have any table that has suitable data for our Dim_TransactionType table in new data warehouse, so we will create data that we want to use it for analysing and visualizing in the future by right click on dbo.Dim_TransactionType > Edit Top 200 Rows, then edit data as below:

NHVA\SQLEXPRESS...._TransactionType | NHVA\SQLEXPRESS...._Trans

	TransactionTypeKey	TransactionTypeCode	TransactionTypeName
	1	P	Purchase Order
	2	S	Sales Order
	3	W	Work Order
▶*	NULL	NULL	NULL

Figure 4-7. Create data for Dim_TransactionType Table

4.2.2.5 Dim_Time

To create Dim_Time, we use the SSAS Tool in Visual Studio. Generating a time table in the data source, select from 1/1/2006 to 31/12/2020 and Year, Half Year, Quarter, Month, Week and Date. Connecting with our data warehouse to create a “temporary time table”. Using a query to customize data attributes that we want it to be and dump into the Dim_Time Table and we have the final Dim_Time table as below.

Results Messages

	TimeKey	PK_Date	Year	Month	Day	DateName	DayNumberOfWeek	DayNumberOfMonth	DayNumberOfYear	WeekNumberOfYear	Quarter
1	20060101	2006-01-01 00:00:00.000	2006	1	1	Sunday	1	1	1	1	1
2	20060102	2006-01-02 00:00:00.000	2006	1	2	Monday	2	2	2	1	1
3	20060103	2006-01-03 00:00:00.000	2006	1	3	Tuesday	3	3	3	1	1
4	20060104	2006-01-04 00:00:00.000	2006	1	4	Wednesday	4	4	4	1	1
5	20060105	2006-01-05 00:00:00.000	2006	1	5	Thursday	5	5	5	1	1
6	20060106	2006-01-06 00:00:00.000	2006	1	6	Friday	6	6	6	1	1
7	20060107	2006-01-07 00:00:00.000	2006	1	7	Saturday	7	7	7	1	1
8	20060108	2006-01-08 00:00:00.000	2006	1	8	Sunday	1	8	8	2	1
9	20060109	2006-01-09 00:00:00.000	2006	1	9	Monday	2	9	9	2	1
10	20060110	2006-01-10 00:00:00.000	2006	1	10	Tuesday	3	10	10	2	1
11	20060111	2006-01-11 00:00:00.000	2006	1	11	Wednesday	4	11	11	2	1
12	20060112	2006-01-12 00:00:00.000	2006	1	12	Thursday	5	12	12	2	1
13	20060113	2006-01-13 00:00:00.000	2006	1	13	Friday	6	13	13	2	1
14	20060114	2006-01-14 00:00:00.000	2006	1	14	Saturday	7	14	14	2	1
15	20060115	2006-01-15 00:00:00.000	2006	1	15	Sunday	1	15	15	3	1
16	20060116	2006-01-16 00:00:00.000	2006	1	16	Monday	2	16	16	3	1
17	20060117	2006-01-17 00:00:00.000	2006	1	17	Tuesday	3	17	17	3	1
18	20060118	2006-01-18 00:00:00.000	2006	1	18	Wednesday	4	18	18	3	1

Figure 4-8. Dim_Time Table

4.2.2 Fact table's ETL Process

First, create a new SSIS Package named after the fact table such as FactInventory (we'll use FactInventory to particularly demonstrate the workflow). Next, drag "Data Flow Task" into the "Control Flow" and rename it "FactInventory". This stage connects through the connection manager to the source data, performs transformations and loads the result to the destination. Then, follow these steps to complete the process:

Step 1. To create source data, drag "OLE DB Source" into "Data Flow" named "AdventureWorksDB". As "OLE DB Source Editor" showed, choose Adventureworks2014 database and choose Data access mode with SQL command then write queries to get the needed data.

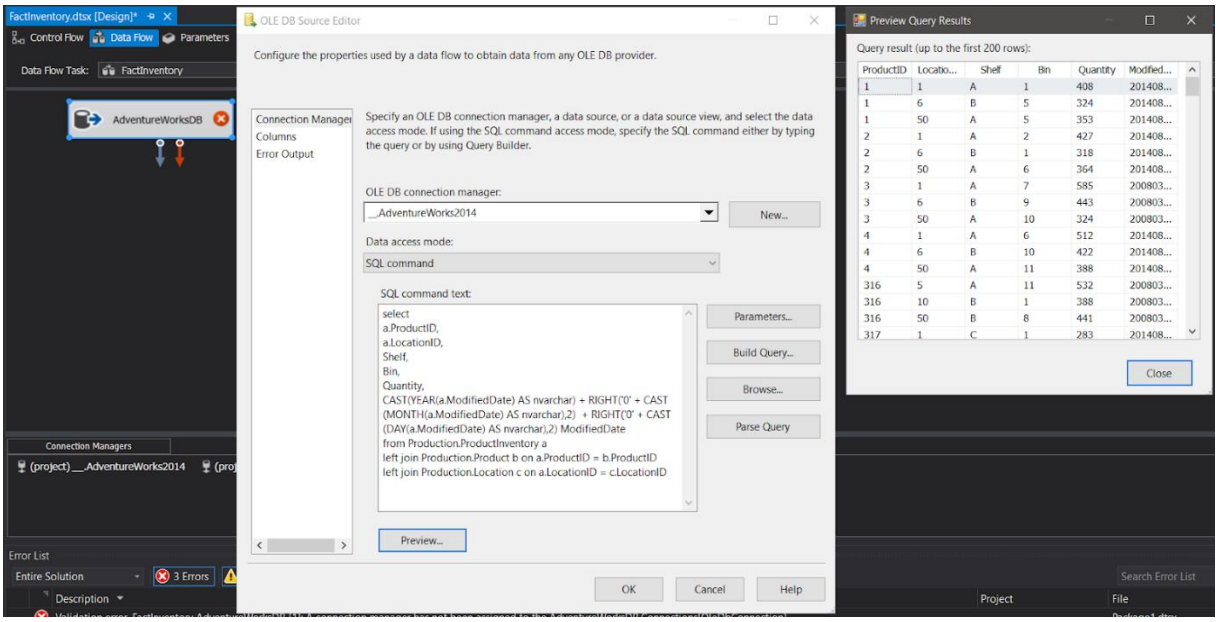


Figure 4-9. Create OLE DB Source

Similarly, create destination data by dragging “OLE DB Source", named it “FactInventory”, choose Nhom6_Production_DW and table FactInventory. Then, click on Columns to check whether the attributes matched and in Output Column, change ProductKey into ProductKeyDW, LocationKey into LocationKeyDW and Quantity into QuantityDW to distinguish attributes between Adventureworks’ and ProductionDW’s.

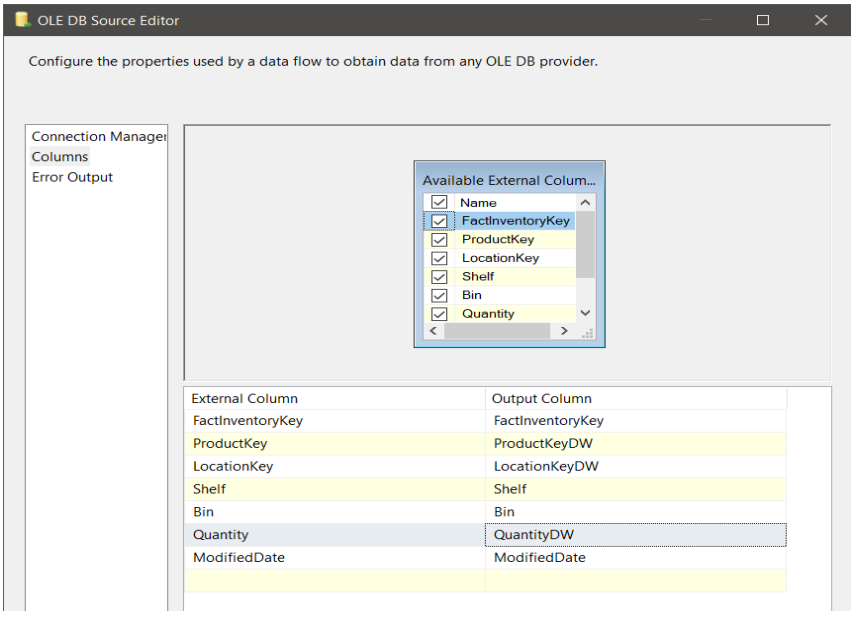


Figure 4-10. Check mapping columns in FactInventory

Step 2. Drag "Lookup" and connect to "AdventureWorksDB" as well as "FactInventory" above to compare the source and destination data, this stage filters out the matched and unmatched data in the specified destinations. In the FactInventory case, we lookup with ProductKey in the Dim_Product table and LocationKey in the Dim_Location table.

In the Lookup Transformation Editor, click on the Columns, and it shows the source and destination table. Drag on the ProductID column from the source and move it to the destination ProductID column, it draws an arrow as shown in the following image, then click on to ProductKey in the destination table.

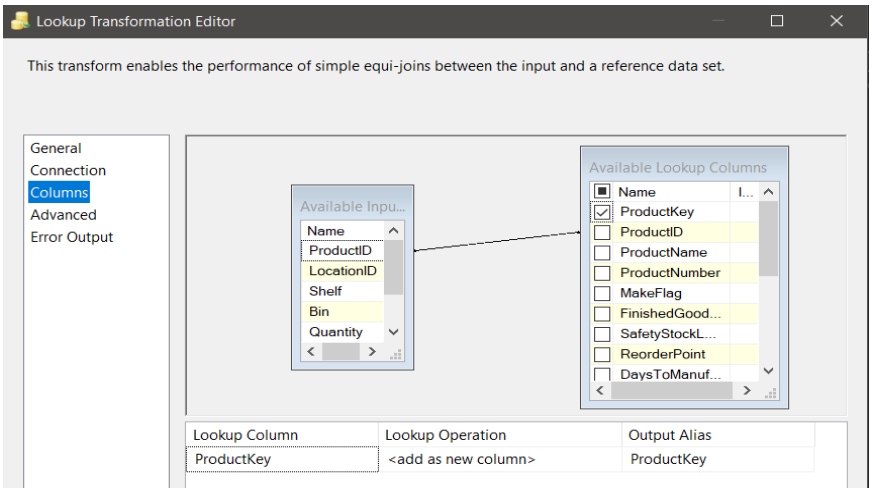


Figure 4-11. Check mapping columns in LookupProduct

Then, we do the same to LocationID but click on LocationKey, instead.

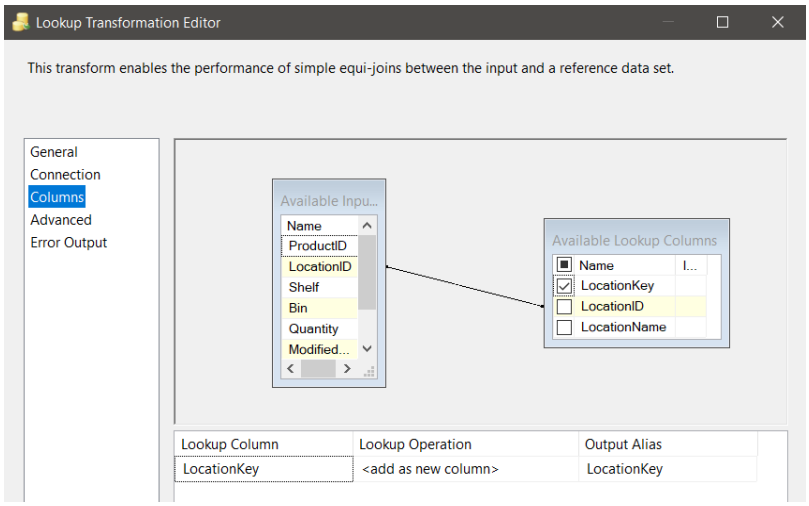


Figure 4-12. Check mapping columns in LookupProduct

Step 3. Drag "Sort", rename "SortAdventureworks", connect "LookupLocation" to "SortAdventureworks", choose Lookup Match Output and tick ProductKey and LocationKey.

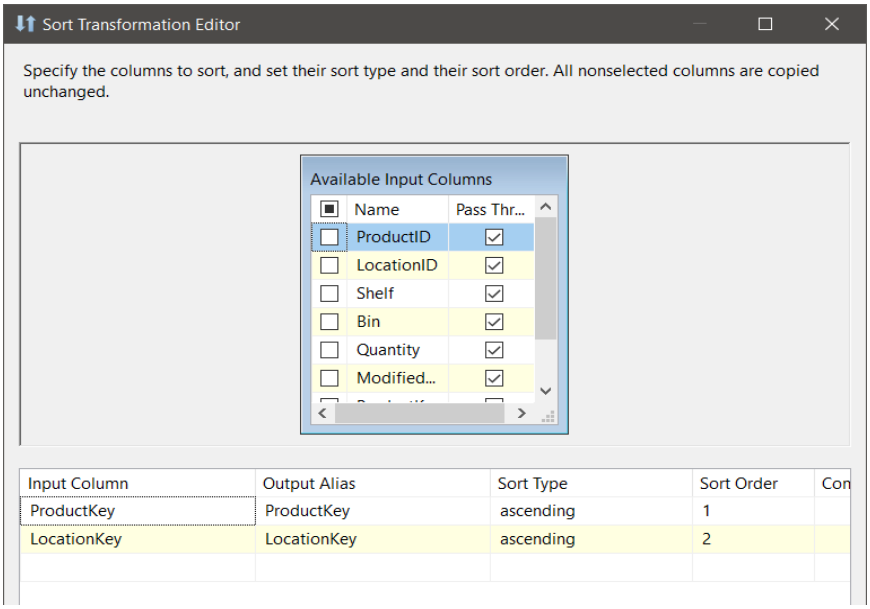


Figure 4-13. Selected attributes in SortAdventureworks

Likewise, drag another "Sort" and rename it "SortFactInventory", connect "FactInventory" to "SortFactInventory", choose Lookup Match Output and tick ProductKeyDW as well as LocationKeyDW.

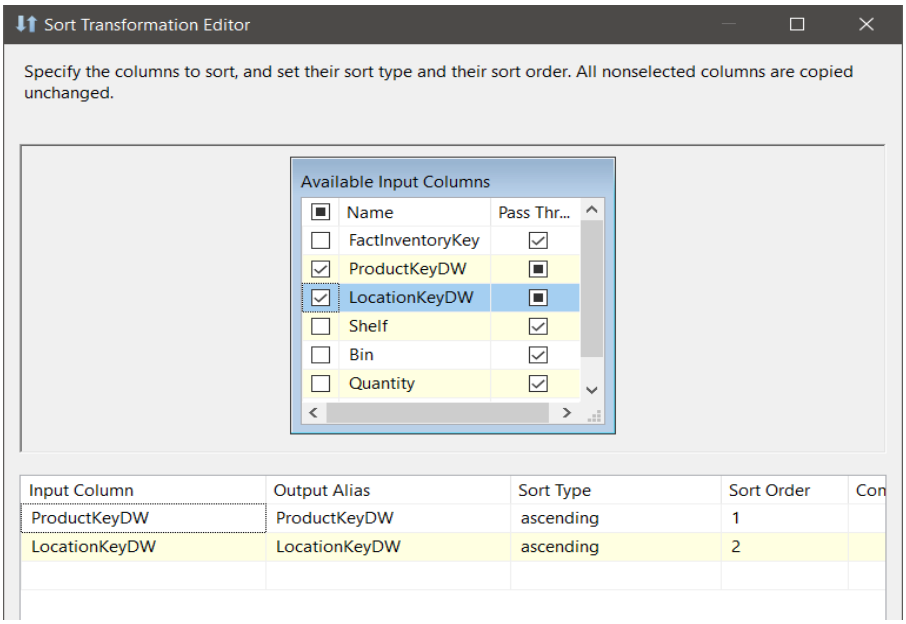


Figure 4-14. Selected attributes in SortFactInventory

Step 4. Drag "Merge Join", connect "SortAdventureworks" into "Merge Join" and in Input, choose Merge Join Left Input then connect "SortFactInventory" into "Merge Join", too. As "Merge Join Transformation Editor" showed, in Join type, choose Left outer join. In "SortAdventureworks", tick every attribute except for the ones that have ID in it. In "SortFactInventory", tick ProductKeyDW, LocationKeyDW and Quantity.

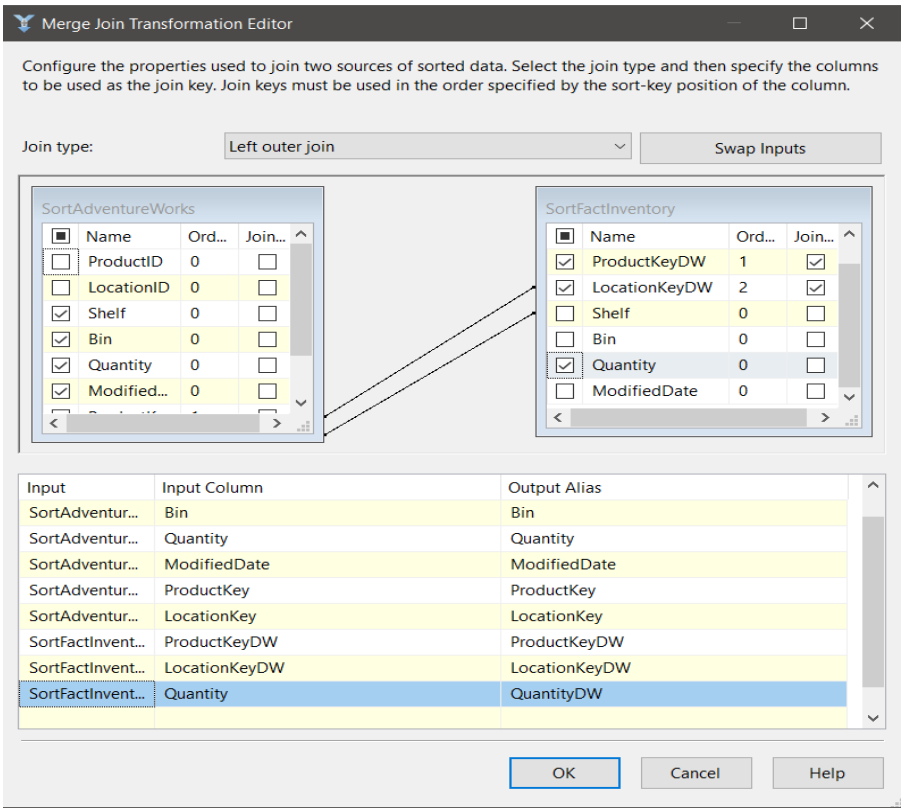


Figure 4-15. Merge Join between "SortAdventureworks" and "SortFactInventory"

Step 5. Drag "Conditional Split", connect "Merge Join" to it. This is the stage checking for the specified condition. It moves the data to an appropriate destination depending upon the condition. In this case, the conditions are shown in the figure below.

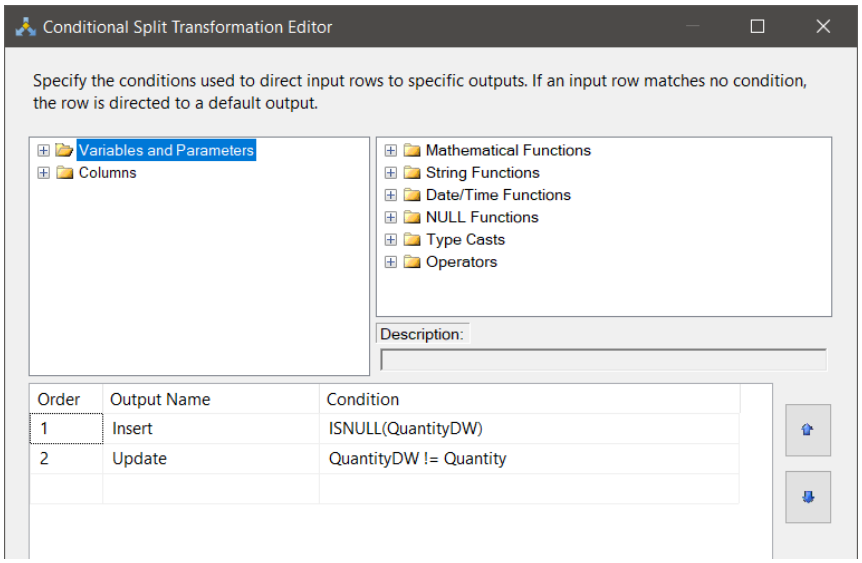


Figure 4-16. Syntax in Conditional Split Transformation

Step 6. Drag "OLE DB Destination" and rename "InsertFactInventory". In Output, choose Insert. As "OLE DB Destination Editor" showed, choose Nhom6_Production_DW and FactInventory table. Check whether the mappings are correct.

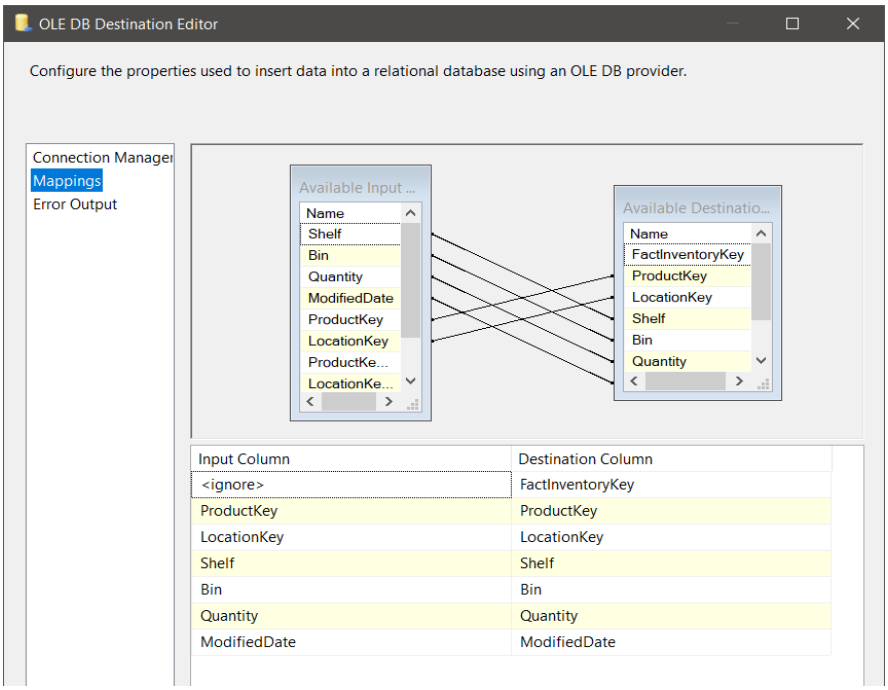


Figure 4-17. Check columns mapping in OLE DB Destination

Step 7. Drag "OLE DB Command" and rename "UpdateFactInventory". In Output, choose Update.

As “Advanced Editor for UpdateFactInventory” showed, in tab Connection Managers, in Connection Manager, choose Nhom6_Production_DW. In tab Component Properties, in Custom Properties, SQL Command, write a query to update the table. In tab Column Mappings, in Input Column, choose ProductKey and LocationKey relatively match with the Param in Destination Column.

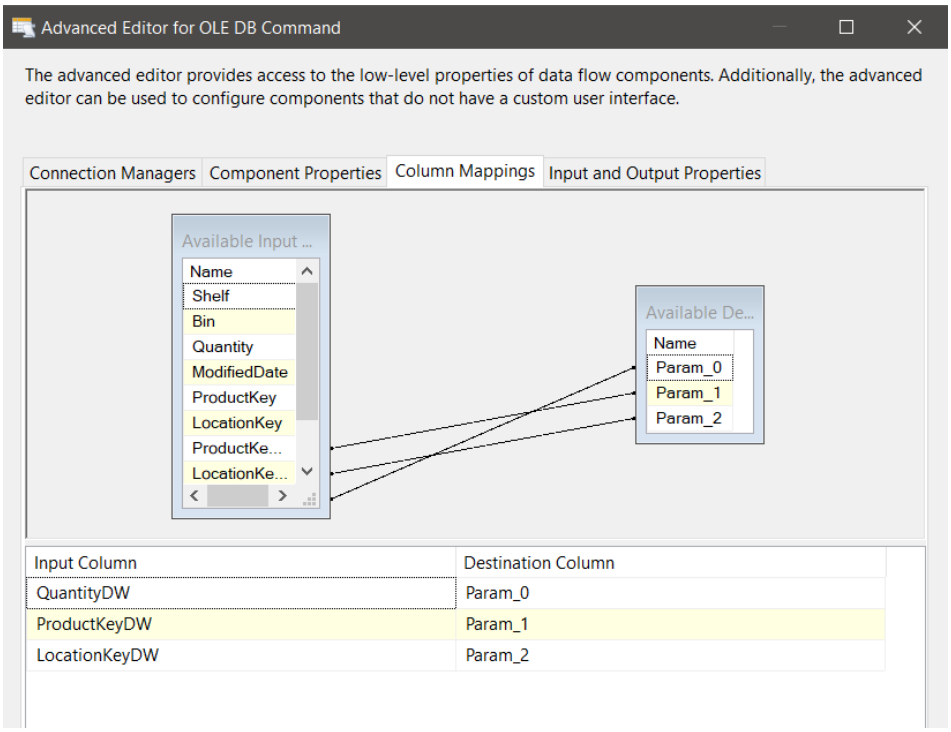


Figure 4-18. Check column mappings in OLE DB Command

Step 8. Deploy SSIS and go to SSMS to check whether the data are transferred or not.

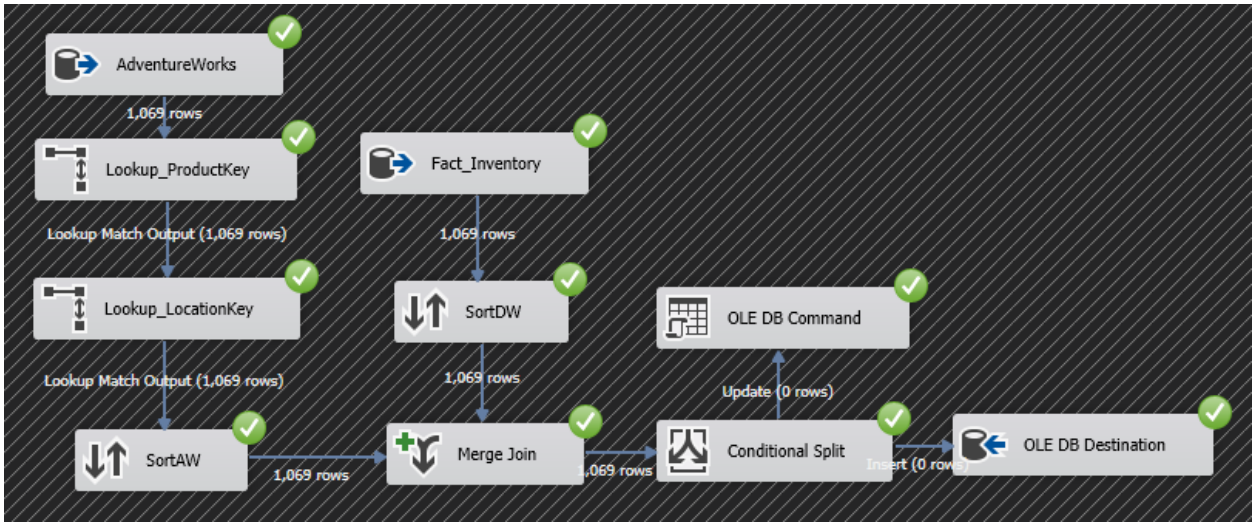


Figure 4-19. Running process of FactInventory SSIS

Results | Messages

	FactInventoryKey	ProductKey	LocationKey	Shelf	Bin	Quantity	ModifiedDate
1	1	1	8	B	5	324	20140808
2	2	1	14	A	5	353	20140808
3	3	1	15	A	1	408	20140808
4	4	2	8	B	1	318	20140808
5	5	2	14	A	6	364	20140808
6	6	2	15	A	2	427	20140808
7	7	3	8	B	9	443	20080331
8	8	3	14	A	10	324	20080331
9	9	3	15	A	7	585	20080331

C | (local) (15.0 RTM) | NHVA\mamamayo (56) | Nhom6_Production_DW | 00:00:00 | 1.069 rows

Figure 4-20. FactInventory table after SSIS

Above are step by step to ETL a fact table into DW, the remaining fact tables such as FactWorkOrder, FactWorkOrderRouting, FactTransaction and FactProductReview are implemented the same.

Chapter 5 - Data Analytics

5.1. Data analytics with SSAS technology

5.1.1. Building the cube

The steps to building the cube are as follows:

Step 1: Connecting with Data Source

New Data Source → Create Data Source based on an existing or new connection.

Step 2: Creating Data Source View

New Data Source View → Choose data source has been connected → Include all necessary table.

Step 3: Creating Cube

New Cube → Using existing tables → Sort dim tables and fact tables and finish → insert all attributes in edit dimension tables and save.

Step 4: Processing and receiving results.

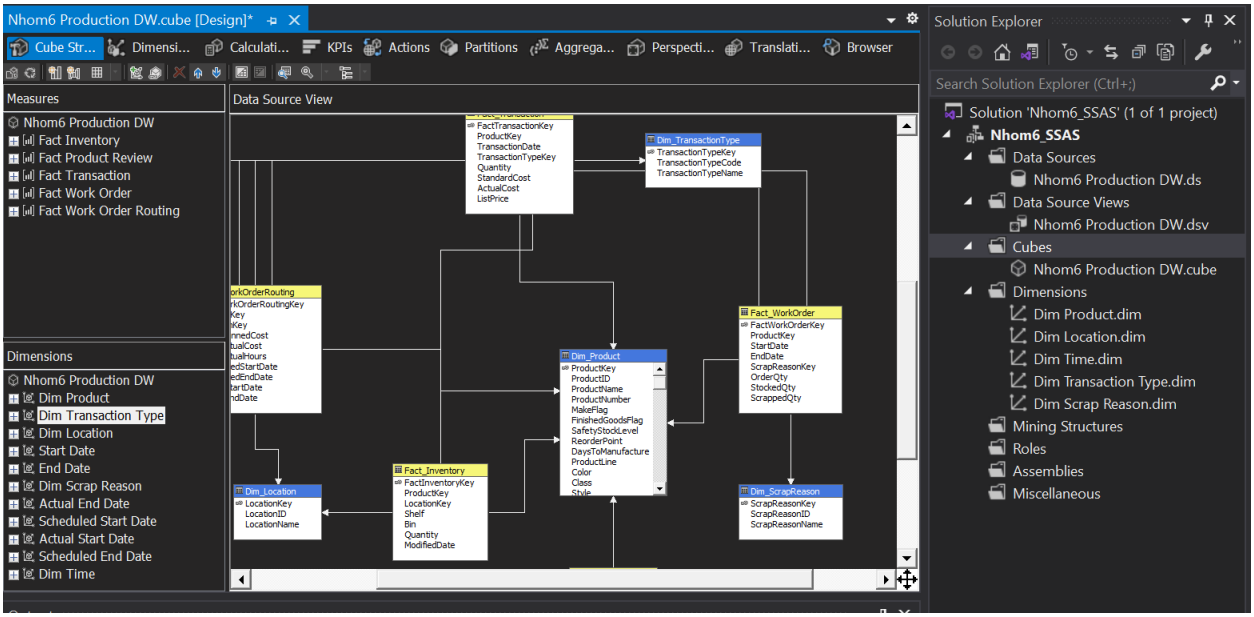


Figure 5-1. Build OLAP cube with SSAS

5.1.2.1. Calculation Building

After the data has been connected to SSAS Tools, we can analyze and visualize the data, build KPIs. However, there is some information we need for analysis that is not really

available in the database. In order to extract that information, we need to combine the appropriate attributes with calculations through the creation of “Calculations” in SSAS.

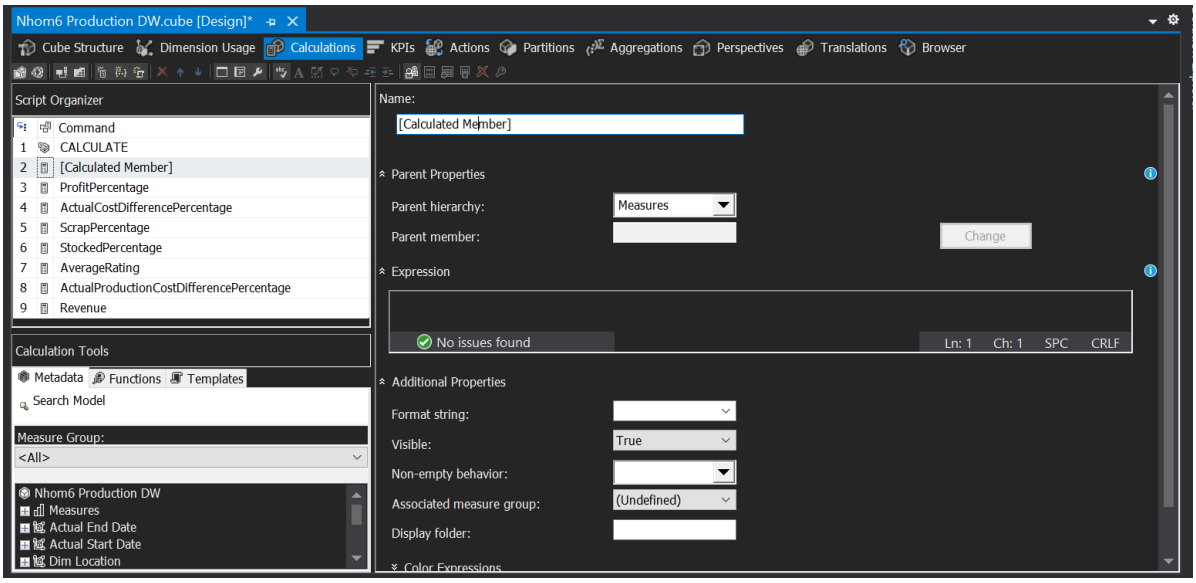


Figure 5-2. Create a Calculation

Rename in tag Name. Drag and drop attributes from Calculation Tools or manually write attributes, combine them with calculation in Expression Section and change appropriate Format string to create a needed Calculation.

The calculations were created for this analysis:

ProfitPercentage: ([Measures].[Quantity - Fact Transaction]*[Measures].[List Price]-[Measures].[Quantity - Fact Transaction]*[Measures].[Actual Cost])/([Measures].[Quantity - Fact Transaction]*[Measures].[List Price])

ActualCostDifferencePercentage: ([Measures].[Actual Cost]-[Measures].[Standard Cost])/[Measures].[Standard Cost]

ScrapPercentage: [Measures].[Scrapped Qty]/[Measures].[Order Qty]

StockedPercentage: [Measures].[Stocked Qty]/[Measures].[Order Qty]

AverageRating: [Measures].[Rating]/[Measures].[Fact Product Review Count]

ActualProductionCostDifferencePercentage: ([Measures].[Total Actual Cost]-[Measures].[Total Planned Cost])/[Measures].[Total Planned Cost]

Revenue: [Measures].[Quantity - Fact Transaction]*[Measures].[List Price]

5.1.2. Analysis with SSAS

The data analysis is conducted in the Browser tab. After having all the BI solution requirements, the easiest way to analyze the data in SSAS is to drag and drop the appropriate attributes, which is needed to resolve the requirement, into the space. Then press "Execute to the query" to get Analysis results.

Analyze Revenue and Profit

To analyze revenue and profit. We need to analyze some of the most fundamental factors: the company's total revenue by categories and products, percentage of profits. Relying on this analysis will help company leaders come up with the most effective business strategies.

Category Name	Product Model Name	Year	Revenue	ProfitPercentage
Accessories	Road Tire Tube	2013	30447550,35	-0,00760408483896311
Accessories	Road Tire Tube	2014	59670298,38	-0,0113625184456469
Accessories	Sport-100	2013	600255199,5	0,0666674972717168
Accessories	Sport-100	2014	655964213,09	0,0368008213516488
Accessories	Touring Tire	2013	147171503,7	-0,0180698472505992
Accessories	Touring Tire	2014	365919172,449999	-0,0240848761899851
Accessories	Touring Tire Tube	2013	24040412,82	-0,0050111495131971
Accessories	Touring Tire Tube	2014	48889924,1999999	-0,006323212462661
Accessories	Water Bottle	2013	27869409,48	0,0459770114942528
Accessories	Water Bottle	2014	32915267,54	0,0244610646722394
Bikes	Mountain-200	2013	34228420611,8211	0,350950539545859
Bikes	Mountain-200	2014	35322557433,0512	0,335266014344138
Bikes	Mountain-400-W	2013	785244538,259996	0,406907378335948
Bikes	Mountain-400-W	2014	826380704,169995	0,424045261669022
Bikes	Mountain-500	2013	2429652217,82999	0,366706925263628
Bikes	Mountain-500	2014	1531123282,88999	0,413602049821806

Figure 5-3. Analyzing the revenue and profit percentage of products from year to year

Analyze sales volume and inventory quantity

Capture product sales and inventory to effectively plan production in the future.

Category Name	Product Model Name	Year	Quarter	Quantity - Fact Transaction
Accessories	All-Purpose Bike St...	2013	3	46
Accessories	All-Purpose Bike St...	2013	4	65
Accessories	All-Purpose Bike St...	2014	1	66
Accessories	All-Purpose Bike St...	2014	2	47
Accessories	Bike Wash	2013	3	816
Accessories	Bike Wash	2013	4	698
Accessories	Bike Wash	2014	1	688
Accessories	Bike Wash	2014	2	466
Accessories	Cable Lock	2013	3	1
Accessories	Fender Set - Mountain	2013	3	322
Accessories	Fender Set - Mountain	2013	4	563
Accessories	Fender Set - Mountain	2014	1	505
Accessories	Fender Set - Mountain	2014	2	528
Accessories	Hitch Rack - 4-Bike	2013	3	931

Figure 5-4. Analyzing product sale quantity by quarters

Category Name	Product Model Name	Location ID	Location Name	Quantity	Bin
Accessories	HL Road Tire	6	Miscellaneous Storage	299	10
Accessories	Hydration Pack	7	Finished Goods Storage	108	0
Accessories	LL Mountain Tire	50	Subassembly	369	1
Accessories	LL Mountain Tire	6	Miscellaneous Storage	240	2
Accessories	LL Road Tire	50	Subassembly	252	6
Accessories	LL Road Tire	6	Miscellaneous Storage	236	6
Accessories	Minipump	7	Finished Goods Storage	288	0
Accessories	ML Mountain Tire	50	Subassembly	284	3
Accessories	ML Mountain Tire	6	Miscellaneous Storage	385	3
Accessories	ML Road Tire	50	Subassembly	192	7
Accessories	ML Road Tire	6	Miscellaneous Storage	382	8
Accessories	Mountain Bottle Cage	7	Finished Goods Storage	288	0
Accessories	Mountain Pump	7	Finished Goods Storage	324	0
Accessories	Mountain Tire Tube	50	Subassembly	243	15

Figure 5-5. Tracking product inventory

Analyze Scrap Percentage and Product Rating

Reviews from customers tell us whether the product is pleasing to the customer or not, thereby improving product quality. Through the rate of defects in production, we know we will be aware of existing production lines and improve them.

Category Name	Product Model Name	ScrapPercentage
Bikes	Road-550-W	0,00111374077683419
Bikes	Road-650	0,00295303537963541
Bikes	Road-750	0,0024763619990995
Bikes	Touring-1000	0,00157430730478589
Bikes	Touring-2000	0,000743494423791822
Bikes	Touring-3000	0,00070064809949203
Components	Front Derailleur	0,00191038745731821
Components	HL Bottom Bracket	0,0032488628979857
Components	HL Crankset	0,000892366831411312
Components	HL Fork	0,000783004677422678
Components	HL Headset	0,00288529204785362
Components	HL Mountain Frame	0,00154746967795901
Components	HL Mountain Front Wheel	0,0027063599458728
Components	HL Mountain Handlebars	0,00229460767197087

Figure 5-6. Analyzing Scrap Percentage

Category Name	Product Model Name	AverageRating
Bikes	Road-550-W	5
Clothing	Mountain Bike Socks	5
Components	HL Mountain Pedal	3

Figure 5-7. Product Rating from Customer Reviews

5.1.3. Building KPIs system

5.1.3.1. Profit Percentage KPI

Setting KPIs for the profit rate helps us to know which products are profitable, and which products are not profitable, helping us to orient the right product development.

And because the characteristics of each product are different leading to different profitability, we need to set separate KPIs for each type of product**.** KPI: Profit Percentage of Bikes (>=35%), Clothing (>=10%), Accessories (>=5%), Components (>=25%).

Name: ProfitPercentage

Value Expression: [Measures].[ProfitPercentage]

Goal Expression:

```
CASE
WHEN [Dim Product].[Category Name] is [Dim Product].[Category Name].&[Bikes] THEN 0.35
WHEN [Dim Product].[Category Name] is [Dim Product].[Category Name].&[Clothing] THEN 0.1
WHEN [Dim Product].[Category Name] is [Dim Product].[Category Name].&[Accessories] THEN 0.05
WHEN [Dim Product].[Category Name] is [Dim Product].[Category Name].&[Components] THEN 0.25
ELSE 0.4
END
```

Status:

```
CASE
WHEN KPIVALUE("ProfitPercentage")/KPIGOAL("ProfitPercentage")>0.9 THEN 1
WHEN KPIVALUE("ProfitPercentage")/KPIGOAL("ProfitPercentage")>0.8 AND KPIVALUE("ProfitPercentage")/KPIGOAL("ProfitPercentage")<=0.9 THEN 0
ELSE -1
END
```

Trend:

```
CASE
WHEN ISEMPTY(PARALLELPERIOD([Dim Time].[Year].[Year],1,[Dim Time].[Year])) THEN 0
WHEN [Measures].[ProfitPercentage]>(PARALLELPERIOD([Dim Time].[Year].[Year],1,[Dim Time].[Year]),[Measures].[ProfitPercentage]) THEN 1
WHEN [Measures].[ProfitPercentage]=(PARALLELPERIOD([Dim Time].[Year].[Year],1,[Dim Time].[Year]),[Measures].[ProfitPercentage]) THEN 0
ELSE -1
```

END

Row Labels	ProfitPercentage	ProfitPercentage Goal	ProfitPercentage Status	ProfitPercentage Trend
2013	59,60%	40,00%		
2014	23,01%	40,00%		
Accessories				
All-Purpose Bike Stand				
2013	0,00%	5,00%		
2014	0,00%	5,00%		
Bike Wash				
2013	13,85%	5,00%		
2014	9,23%	5,00%		
Cable Lock				
2013	40,00%	5,00%		
2014		5,00%		
Fender Set - Mountain				
2013	0,00%	5,00%		
2014	0,00%	5,00%		
Headlights - Dual-Beam				
2013		5,00%		
2014		5,00%		
Headlights - Weatherproof				
2013		5,00%		
2014		5,00%		

Figure 5-8. Profit Percentage KPI

5.1.3.2. Actual Cost Difference Percentage KPI

Because standard costs and actual costs of each category are different, we need to set KPIs to control and improve the resources to produce products in the most effective method. KPI: Cost difference percentage <= 2%.

Name: ActualCostDifferencePercentage

Value Expression: [Measures].[ActualCostDifferencePercentage]

Goal Expression: 0.02

Status:

```
CASE
WHEN
KPIVALUE("ActualCostDifferencePercentage")/KPIGOAL("ActualCostDifferencePercentage")>0.9 OR
KPIVALUE("ActualCostDifferencePercentage")/KPIGOAL("ActualCostDifferencePercentage")<-0  THEN -1
```

```
WHEN
KPIVALUE("ActualCostDifferencePercentage")/KPIGOAL("ActualCostDifferencePerc
entage")>0.8 AND
KPIVALUE("ActualCostDifferencePercentage")/KPIGOAL("ActualCostDifferencePerc
entage")<=0.9 THEN 0
ELSE 1
END
```

Trend:

```
CASE
WHEN ISEMPTY(PARALLELPERIOD([Dim Time].[Year].[Year],1,[Dim
Time].[Year])) THEN 0
WHEN [Measures].[ActualCostDifferencePercentage]>(PARALLELPERIOD([Dim
Time].[Year].[Year],1,[Dim
Time].[Year]),[Measures].[ActualCostDifferencePercentage]) THEN 1
WHEN [Measures].[ActualCostDifferencePercentage]=(PARALLELPERIOD([Dim
Time].[Year].[Year],1,[Dim
Time].[Year]),[Measures].[ActualCostDifferencePercentage]) THEN 0
ELSE -1
END
```

Row Labels	ActualCostDifferencePercentage	ActualCostDifferencePercentage Goal	ActualCostDifferencePercentage Status	ActualCostDifferencePercentage Trend
2013				
1		2,00%		
2		2,00%		
3	-30,07%	2,00%		
4	-55,10%	2,00%		
2014				
1	-36,23%	2,00%		
2	14,19%	2,00%		
3	#NUM!	2,00%		
4		2,00%		
Accessories				
2013				
1		2,00%		
2		2,00%		
3	144,02%	2,00%		
4	156,26%	2,00%		
2014				
1	155,83%	2,00%		
2	162,79%	2,00%		
3	262,04%	2,00%		
4		2,00%		
Bikes				
2013				
1		2,00%		
2		2,00%		
3	5,73%	2,00%		
4	4,09%	2,00%		
2014				
1	4,63%	2,00%		
2	3,40%	2,00%		
3		2,00%		
4		2,00%		
Clothing				
2013				
1		2,00%		
2		2,00%		
3	39,97%	2,00%		

Figure 5-9. Actual Cost Difference Percentage KPI

5.1.3.3. Scrap Percentage KPI

Despite detailed planning, production line standardization and strict process management. In fact, the product still has an error. We need to set KPIs to identify irregularities in the production of a particular product. KPI: Scrap Percentage of Bikes (<=0,1%), Clothing (<=0,3%), Accessories (<=0,2%) and Components (<=0,15%).

Name: ScrapPercentage

Value Expression: [Measures].[ScrapPercentage]

Goal Expression:

```
CASE
WHEN [Dim Product].[Category Name] is [Dim Product].[Category Name].&[Bikes]
THEN 0.001
```

```
WHEN [Dim Product].[Category Name] is [Dim Product].[Category Name].&[Clothing] THEN 0.003
WHEN [Dim Product].[Category Name] is [Dim Product].[Category Name].&[Accessories] THEN 0.002
WHEN [Dim Product].[Category Name] is [Dim Product].[Category Name].&[Components] THEN 0.0015
ELSE 0.001
END
```

Status:

```
CASE
WHEN KPIVALUE("ScrapPercentage")/KPIGOAL("ScrapPercentage")<1 THEN 1
WHEN KPIVALUE("ScrapPercentage")/KPIGOAL("ScrapPercentage")>1 AND KPIVALUE("ScrapPercentage")/KPIGOAL("ScrapPercentage")<=1.4 THEN 0
ELSE -1
END
```

Row Labels	ScrapPercentage	ScrapPercentage Goal	ScrapPercentage Status
⊟			
	0,25%	0,10%	◆
⊞ **Accessories**		**0,20%**	●
⊟ **Bikes**			
Mountain-100	0,30%	0,10%	◆
Mountain-200	0,16%	0,10%	◆
Mountain-300	0,14%	0,10%	▲
Mountain-400-W	0,00%	0,10%	●
Mountain-500	0,00%	0,10%	●
Road-150	0,04%	0,10%	●
Road-250	0,14%	0,10%	▲
Road-350-W	0,04%	0,10%	●
Road-450	0,14%	0,10%	▲
Road-550-W	0,11%	0,10%	▲
Road-650	0,30%	0,10%	◆
Road-750	0,25%	0,10%	◆
Touring-1000	0,16%	0,10%	◆
Touring-2000	0,07%	0,10%	●
Touring-3000	0,07%	0,10%	●
⊞ **Clothing**		**0,30%**	●
⊟ **Components**			
Chain		0,15%	●
Front Brakes		0,15%	●
Front Derailleur	0,19%	0,15%	▲
HL Bottom Bracket	0,32%	0,15%	◆
HL Crankset	0,09%	0,15%	●
HL Fork	0,08%	0,15%	●
HL Headset	0,29%	0,15%	◆
HL Mountain Frame	0,15%	0,15%	▲
HL Mountain Front Wheel	0,27%	0,15%	◆
HL Mountain Handlebars	0,23%	0,15%	◆

Figure 5-10. Scrap Percentage KPI

5.1.3.4. Stocked Product Percentage KPI

Set KPI for the percentage of stocked product quantity to the number of products produced at different times to identify the cause and resolve it if problems arise during the production process. KPI: Stocked Percentage >= 99,9%

Name: StockedPercentage

Value Expression: [Measures].[StockedPercentage]

Goal Expression: 0.999

Status:

```
CASE
WHEN KPIVALUE("StockedPercentage")/KPIGOAL("StockedPercentage")>1 THEN 1
WHEN KPIVALUE("StockedPercentage")/KPIGOAL("StockedPercentage")>0.998 AND
KPIVALUE("StockedPercentage")/KPIGOAL("StockedPercentage")<=1 THEN 0
ELSE -1
END
```

Trend:

```
CASE
WHEN ISEMPTY(PARALLELPERIOD([End Date].[Year].[Year],1,[End Date].[Year]))
THEN 0
WHEN [Measures].[StockedPercentage]>(PARALLELPERIOD([End
Date].[Year].[Year],1,[End Date].[Year]),[Measures].[StockedPercentage]) THEN 1
WHEN [Measures].[StockedPercentage]=(PARALLELPERIOD([End
Date].[Year].[Year],1,[End Date].[Year]),[Measures].[StockedPercentage]) THEN 0
ELSE -1
END
```

Row Labels	StockedPercentage	StockedPercentage Goal	StockedPercentage Status	StockedPercentage Trend
⊞	99,73%	99,90%	▲	→
⊞ Accessories		99,90%	◆	→
⊟ Bikes				
⊟ 2013				
⊟ 1				
1	99,59%	99,90%	◆	↓
2	99,74%	99,90%	▲	↑
3	99,54%	99,90%	◆	↓
⊟ 2				
4	99,69%	99,90%	◆	↑
5	100,00%	99,90%	●	↑
6	99,89%	99,90%	▲	↓
⊟ 3				
7	99,91%	99,90%	●	↑
8	99,95%	99,90%	●	↓
9	100,00%	99,90%	●	↑
⊟ 4				
10	99,95%	99,90%	●	↓
11	99,83%	99,90%	▲	↑
12	99,89%	99,90%	▲	↓
⊟ 2014				
⊟ 1				
1	99,94%	99,90%	●	↑
2	99,75%	99,90%	▲	↑
3	99,90%	99,90%	▲	↑
⊟ 2				

Figure 5-11. Stocked Product Percentage KPI

5.1.3.5. Average Product Rating KPI

Set KPI for product rating to ensure product quality for consumers and maintain company reputation. KPI: Average Rating >= 4

Name: AverageRating

Value Expression: [Measures].[AverageRating]

Goal Expression: 4

Status:

```
CASE
WHEN KPIVALUE("AverageRating")/KPIGOAL("AverageRating") >=1 THEN 1
WHEN KPIVALUE("AverageRating")/KPIGOAL("AverageRating") > 0.9
AND KPIVALUE("AverageRating")/KPIGOAL("AverageRating") < 1
THEN 0
```

```
ELSE -1
END
```

Row Labels	AverageRating	AverageRating Goal	AverageRating Status
			4
Accessories			**4**
Bikes			
Mountain-100			4
Mountain-200			4
Mountain-300			4
Mountain-400-W			4
Mountain-500			4
Road-150			4
Road-250			4
Road-350-W			4
Road-450			4
Road-550-W		5	4
Road-650			4
Road-750			4
Touring-1000			4
Touring-2000			4
Touring-3000			4
Clothing			
Classic Vest			4
Cycling Cap			4
Full-Finger Gloves			4
Half-Finger Gloves			4
Long-Sleeve Logo Jersey			4
Men's Bib-Shorts			4
Men's Sports Shorts			4
Mountain Bike Socks		5	4
Racing Socks			4
Short-Sleeve Classic Jersey			4

Figure 5-12. Average Product Rating KPI

5.1.3.6. Actual Production Cost Difference Percentage KPI

Set KPI for Actual Production Cost Difference Percentage to ensure quality in effectively planning production. KPI: Production Cost Difference <= 0,5%

Name: ActualProductionCostDifferencePercentage

Value Expression: [Measures].[ActualProductionCostDifferencePercentage]

Goal Expression: 0.005

Status:

```
CASE
WHEN
KPIVALUE("ActualProductionCostDifferencePercentage")/KPIGOAL("ActualProductio
nCostDifferencePercentage")>0.9 OR
KPIVALUE("ActualProductionCostDifferencePercentage")/KPIGOAL("ActualProductio
nCostDifferencePercentage")<-0 THEN -1
WHEN
KPIVALUE("ActualProductionCostDifferencePercentage")/KPIGOAL("ActualProductio
nCostDifferencePercentage")>0.8 AND
KPIVALUE("ActualProductionCostDifferencePercentage")/KPIGOAL("ActualProductio
nCostDifferencePercentage")<=0.9 THEN 0
ELSE 1
END
```

Trend:

```
CASE
WHEN ISEMPTY(PARALLELPERIOD([Dim Time].[Year].[Year],1,[Dim
Time].[Year])) THEN 0
WHEN [Measures].[StockedPercentage]>(PARALLELPERIOD([Dim
Time].[Year].[Year],1,[Dim Time].[Year]),[Measures].[StockedPercentage]) THEN 1
WHEN [Measures].[StockedPercentage]=(PARALLELPERIOD([Dim
Time].[Year].[Year],1,[Dim Time].[Year]),[Measures].[StockedPercentage]) THEN 0
ELSE -1
END
```

Row Labels	ActualProductionCostDifferencePercentage	ActualProductionCostDifferencePercentage Goal	ActualProductionCostDifferencePercentage Status	ActualProductionCostDifferencePercentage Trend
2013				
1	0,00%	0,50%		
2	0,00%	0,50%		
3	0,00%	0,50%		
4	0,00%	0,50%		
2014				
1	0,00%	0,50%		
2	0,00%	0,50%		
3	0,00%	0,50%		
4	0,00%	0,50%		
Accessories		0,50%		
Bikes				
2013				
1	0,00%	0,50%		
2	0,00%	0,50%		
3	0,00%	0,50%		
4	0,00%	0,50%		
2014				
1	0,00%	0,50%		
2	0,00%	0,50%		
3	0,00%	0,50%		
4	0,00%	0,50%		
Clothing				
2013				

Figure 5-13. Actual Production Cost Difference Percentage KPI

5.2. Data analytics with MDX and OLAP technique

❖ Revenue through each quarter of 2014

Users can use the following statements to enforce the requirement about "Measure revenue (Gross profit & net profit).

```
/*Revenue through each quarter of 2014*/

With member [Measures].[Revenue] as ([Measures].[List Price]*[Measures].[Quantity])
select ([Measures].[Revenue]) on columns,
([Dim Time].[Quarter].members) on rows
from [Nhom6 Production DW]
where [Dim Time].[Year].&[2014]
```

102 %

Messages | Results

	Revenue
All	57428171464557.2
1	14853833534652.6
2	10402707520896.7
3	2726575529.17999
4	(null)

Figure 5-14. Revenue through each quarter of 2014

❖ Top 10 products with the highest sales in 2014

Users can use the following statements to enforce the requirement about forecast production plan (statistic sold).

```
/*Top 10 products with the highest sales in 2014*/

With member [Measures].[Revenue] as ([Measures].[List Price]*[Measures].[Quantity])
select topcount ([Dim Product].[Product Name].children,10,([Measures].[Revenue])) on rows ,
([Measures].[Revenue])  on columns
from [Nhom6 Production DW]
where [Dim Time].[Year].&[2014]
```

102 %

Messages | Results

	Revenue
Mountain-200 Black, 38	1330818801.2
Mountain-200 Silver, 38	1070086107.54
Mountain-200 Black, 42	1060645693.43
Mountain-200 Silver, 42	841467332.969998
Mountain-200 Silver, 46	827245794.269998
HL Mountain Tire	805651560
Mountain-200 Black, 46	799046668.299998
Road-350-W Yellow, 48	731750589.089999
Road-350-W Yellow, 40	675623022.059998
ML Mountain Tire	560717451.859999

Figure 5-15. Top 10 products with the highest sale in 2014

❖ The product purchased more than 1000 in 2014

Through the commands below, we can grasp the product manufacturing strategy. Users can get the products purchased the most for the year 2014. From this statement, it is easy to develop a separate strategy for each product, which product should be promoted

```
/*The product purchased more than 1000 in 2014*/

select filter ({[Dim Product].[Product Name].CHILDREN},
[Dim Transaction Type].[Transaction Type Name].&[Purchase Order] and [Measures].[Quantity]>1000) on ROWS ,
 ([Measures].[Quantity]) ON  COLUMNS
FROM [Nhom6 Production DW]
where [Dim Time].[Year].&[2014]
```

102 %

Messages | Results

	Quantity
Front Derailleur	19306
HL Bottom Bracket	4285
HL Crankset	3180
HL Fork	9978
HL Headset	2761
HL Mountain Handlebars	3529
HL Mountain Seat Assembly	3405
HL Road Front Wheel	1146
HL Road Handlebars	1312
HL Road Rear Wheel	1146
HL Road Seat Assembly	1146
HL Touring Handlebars	4006
HL Touring Seat Assembly	2761
LL Bottom Bracket	8561
LL Crankset	6165
LL Fork	7790
LL Headset	5851
LL Mountain Front Wheel	2336

Figure 5-16. The product purchase more than 1000 units in 2014

❖ Statistics average review of products in 2014

Users can use the following statements to enforce the requirement about "Evaluating product quality". From here we can perform product quality optimization**:** evaluating product quality by analyzing rating of products. Thereby we can identify products with quality defects and if they need to improve product quality or not.

```
/*Statistics average review of products in 2014*/
with member [Measures].[Average_Rating] as[Measures].[Rating]/[Measures].[Fact Product Review Count]
select filter ({[Dim Product].[Product Name].children}, [Measures].[Average_Rating]>0) on columns,
[Measures].[Average_Rating] on rows
from [Nhom6 Production DW]
where [Dim Time].[Year].&[2014]
```

102 %

Messages | Results

	HL Mountain Pedal	Mountain Bike Socks, M	Road-550-W Yellow, 40
Average_Rating	3	5	5

Figure 5-17. Statistics average review of product in 2014

❖ Statistics of the number of products produced in 2014

Through the results of the command, the user can see the products with the top production volume, which helps the user to realize that these products with high sales need to pay more attention in the production cycle to boost revenue.

```
/*Statistics of the number of products produced in 2014*/
select filter ([Dim Product].[Product Name].children, [Measures].[Order Qty]) on rows,
([Measures].[Order Qty]) ON columns
FROM [Nhom6 Production DW]
where[End Date].[Year].&[2014]
```

102 %

Messages | Results

	Order Qty
BB Ball Bearing	193760
Blade	47066
Chain Stays	47066
Down Tube	23533
Fork Crown	23533
Fork End	47066
Front Derailleur	19491
Handlebar Tube	19650
Head Tube	23533
HL Bottom Bracket	4220
HL Crankset	3051
HL Fork	10201
HL Headset	2824
HL Hub	29330
HL Mountain Frame - Black, 38	845
HL Mountain Frame - Black, 42	781
HL Mountain Frame - Black, 46	514
HL Mountain Frame - Silver, 38	792

Figure 5-18. Statistics of the number of products produced in 2014

❖ Top 10 products with the most number of scrapped in 2014

Users can list products that frequently encounter errors, from which they can check product quality and offer solutions to change in the production cycle accordingly, decreasing errors.

```
/*Top 10 products with the most number of scrapped in 2014*/
select
TopCount (([Dim Product].[Product Name].children ) ,10,
[Measures].[Scrapped Qty]) on 1,
 ([Measures].[Scrapped Qty]) on 0
from [Nhom6 Production DW]
where [End Date].[Year].&[2014]
```

102 %

Messages | Results

	Scrapped Qty
Fork End	289
Head Tube	195
Fork Crown	145
Down Tube	140
BB Ball Bearing	136
Front Derailleur	113
Steerer	107
Stem	87
LL Fork	76
Rear Derailleur	54

Figure 5-19. Top 10 products with the most number of scrapped in 2014

❖ **Scrapped Quantity and Reason by each product in 2014**

Users can use the following statements to enforce the requirement about "Identify an inefficient process", from this they can identify product error and the cause of that problem.

```
/*Scrapped Quantity and Reason by each product in 2014*/
select filter ([Dim Product].[Product Name].children,[Measures].[Scrapped Qty] ) on columns,
([Dim Scrap Reason].[Scrap Reason Name].children) ON rows
FROM [Nhom6 Production DW]
where ([Measures].[Scrapped Qty],[End Date].[Year].&[2014])
```

102 %

Messages | Results

	BB Ball Bearing	Blade	Chain Stays	Down Tube	Fork Crown	Fork End	Front Derailleur	Handlebar Tube	Head Tube	HL Crankset
Brake assembly not as ordered	6	3	2	1	(null)	(null)	53	(null)	(null)	(null)
Color incorrect	(null)	1	(null)	1	(null)	(null)	(null)	(null)	(null)	(null)
Drill pattern incorrect	(null)	1	(null)	1	(null)	(null)	(null)	1	(null)	(null)
Drill size too large	(null)	(null)	(null)	131	1	2	(null)	(null)	(null)	(null)
Drill size too small	9	(null)	1	(null)	1	2	(null)	(null)	(null)	1
Gouge in metal	(null)	(null)	(null)	(null)	1	2	(null)	(null)	85	(null)
Handling damage	7	(null)	3	(null)	(null)	(null)	(null)	(null)	(null)	(null)
Paint process failed	(null)	(null)	(null)	(null)	135	263	(null)	(null)	1	(null)
Primer process failed	31	2	1	1	(null)	(null)	(null)	(null)	(null)	(null)
Seat assembly not as ordered	(null)	1	(null)	2	(null)	1	(null)	(null)	(null)	(null)
Stress test failed	45	(null)	1	(null)	1	3	(null)	(null)	(null)	(null)
Thermoform temperature too high	(null)	6	3	1	(null)	(null)	60	(null)	(null)	(null)
Thermoform temperature too low	10	(null)	(null)	(null)	3	5	(null)	(null)	(null)	(null)
Trim length too long	20	8	1	2	(null)	(null)	(null)	(null)	(null)	(null)
Trim length too short	(null)	2	(null)	(null)	1	5	(null)	(null)	109	(null)
Wheel misaligned	8	(null)	(null)	(null)	2	6	(null)	(null)	(null)	(null)
Unknown	0	0	0	0	0	0	0	0	0	0

Figure 5-20. Scrapped Quantity and Reason by each product in 2014

❖ Top 10 most common Scrap Reasons

From this command, users can identify the most common errors for products, showing that the business cycle still has problems when creating products with these errors. From there, it is easy to find ways to change the production operation process more rationally and efficiently.

```
/*Top 10 most common Scrap Reasons*/
select
TopCount (([Dim Scrap Reason].[Scrap Reason Name].children ),10,
[Measures].[Scrapped Qty]) on 1, ([Measures].[Scrapped Qty]) on 0
from [Nhom6 Production DW]
where [End Date].[Year].&[2014]
```

102 %

Messages | Results

	Scrapped Qty
Paint process failed	420
Wheel misaligned	175
Drill size too large	137
Trim length too short	135
Thermoform temperature too low	129
Gouge in metal	112
Drill size too small	104
Thermoform temperature too high	95
Handling damage	74
Brake assembly not as ordered	68

Figure 5-21. Top 10 most common Scrap Reasons

❖ Top 10 products with the most number of Stocked in 2014

```
/*Top 10 products with the most number of Stocked in 2014*/
select
TopCount (([Dim Product].[Product Name].children ) ,10,
[Measures].[Stocked Qty]) on 1,
 ([Measures].[Stocked Qty]) on 0
from [Nhom6 Production DW]
where[End Date].[Year].&[2014]
```

102 %

Messages | Results

	Stocked Qty
BB Ball Bearing	193624
Seat Stays	94088
Chain Stays	47054
Blade	47042
Fork End	46777
HL Hub	29315
Top Tube	23532
Seat Tube	23527
Steerer	23426
Down Tube	23393

Figure 5-22. Top 10 products with the most number of Stocked in 2014

❖ Total Actual Cost and Total Planned Cost of products in 2014

Users can use the following statements to enforce the requirement about "Product cost optimization". From there, it is possible to comment on the difference between the actual cost and the planned cost, find the reason for this difference so that it can be overcome and increase production efficiency.

```
/*Total Actual Cost and Total Planned Cost of products in 2014*/
select filter ([Dim Product].[Product Name].CHILDREN, [Measures].[Total Actual Cost]) on 1,
{[Measures].[Total Actual Cost],[Measures].[Total Planned Cost]} ON 0
FROM [Nhom6 Production DW]
where [Actual End Date].[Year].&[2014]
```

102 %

Messages | Results

	Total Actual Cost	Total Planned Cost
Front Derailleur	45408	45408
HL Bottom Bracket	6468	6468
HL Crankset	6357.75	6357.75
HL Fork	44118	44118
HL Headset	6174	6174
HL Mountain Frame - Black, 38	235494	235494
HL Mountain Frame - Silver, 38	261648	261648
HL Mountain Handlebars	113013	113013
HL Mountain Seat Assembly	29326.5	29326.5
HL Road Front Wheel	5145	5145
HL Road Handlebars	92878.5	92878.5
HL Road Rear Wheel	5145	5145
HL Road Seat Assembly	24010	24010
HL Touring Handlebars	112363.5	112363.5
HL Touring Seat Assembly	28812	28812
LL Bottom Bracket	6394.5	6394.5
LL Crankset	6468	6468
LL Fork	44118	44118

Figure 5-23. Total Actual Cost and Total Planned Cost of products in 2014

❖ **The top 10 products have the most manufactured time in 2014**

Users can use this command to find out which products take up the longest production time, which leads to high production costs. From here, it is necessary to find a way to overcome this problem in order to reduce the cost of the business

```
/*The top 10 products have the most manufactured time in 2014 */
select
TopCount (([Dim Product].[Product Name].children ) ,10,
[Measures].[Total Actual Hours]) on Rows,
(([Measures].[Total Actual Hours])) on Columns
from [Nhom6 Production DW]
where [Actual End Date].[Year].&[2014]
```

102 %

Messages | Results

	Total Actual Hours
HL Mountain Frame - Silver, 38	14904
HL Mountain Frame - Black, 38	13608
ML Road Frame-W - Yellow, 38	10368
ML Mountain Frame-W - Silver, 38	7668
HL Mountain Handlebars	5742
HL Touring Handlebars	5709
ML Road Handlebars	5643
LL Mountain Handlebars	5544
LL Road Handlebars	5544
HL Road Handlebars	4719

Figure 5-24. The top 10 products have the most manufactured time in 2014

❖ **Total Actual Cost of products in 2014**

Users can use the following statements to enforce the requirement about “Product cost optimization”. From there, it is possible to comment on the difference between the actual cost and the planned cost, find the reason for this difference so that it can be overcome and increase production efficiency.

```
/*Total Actual Cost of products in 2014*/
select filter ([Dim Product].[Product Name].CHILDREN, [Measures].[Total Actual Cost]) on rows,
(([Measures].[Total Actual Cost]))  ON columns
FROM [Nhom6 Production DW]
where [Actual End Date].[Year].&[2014]
```

102 %

Messages | Results

	Total Actual Cost
Front Derailleur	45408
HL Bottom Bracket	6468
HL Crankset	6357.75
HL Fork	44118
HL Headset	6174
HL Mountain Frame - Black, 38	235494
HL Mountain Frame - Silver, 38	261648
HL Mountain Handlebars	113013
HL Mountain Seat Assembly	29326.5
HL Road Front Wheel	5145
HL Road Handlebars	92878.5
HL Road Rear Wheel	5145
HL Road Seat Assembly	24010
HL Touring Handlebars	112363.5
HL Touring Seat Assembly	28812
LL Bottom Bracket	6394.5
LL Crankset	6468
LL Fork	44118

Figure 5-25. Total Actual Cost of products in 2014

❖ **The top 10 products have the most manufactured cost in 2014**

Users can measure production costs and identify products with the highest production costs. From there, the direction of changing all the problems of production to reduce costs for the company

```
/*The top 10 products have the most manufactured cost  in 2014*/
select
TopCount (([Dim Product].[Product Name].children ) ,10,
[Measures].[Total Actual Cost]) on 1,
([Measures].[Total Actual Cost]) on 0
from [Nhom6 Production DW]
where [Actual Start Date].[Year].&[2014]
```

102 %

Messages | Results

	Total Actual Cost
HL Mountain Frame - Silver, 38	246480
HL Mountain Frame - Black, 38	222411
ML Road Frame-W - Yellow, 38	166341
ML Mountain Frame-W - Silver, 38	134616
HL Mountain Handlebars	105219
HL Touring Handlebars	104569.5
ML Road Handlebars	103270.5
LL Mountain Handlebars	101971.5
LL Road Handlebars	101322
LL Touring Handlebars	87682.5

Figure 5-26. The top 10 products have the most manufactured cost in 2014

❖ **Top 10 most in stock products**

Users can see that these are the most in-stock products, which means that these products have low sales. From there, users should find a way to change the product in terms of both form and quality to promote sales in match with the amount produced.

```
/*Top 10 most in stock products*/
Select
TopCount (([Dim Product].[Product Name].children ),10,[Measures].[Quantity - Fact Inventory]) on rows,
([Measures].[Quantity - Fact Inventory]) on columns
from [Nhom6 Production DW]
where [Actual End Date].[Year].&[2014]
```

102 %

Messages | Results

	Quantity - Fact Inventory
Hex Nut 7	1911
Hex Nut 23	1901
Thin-Jam Hex Nut 3	1901
Hex Nut 10	1888
Hex Nut 14	1880
Metal Tread Plate	1837
Hex Nut 18	1824
Hex Nut 2	1808
Hex Nut 6	1781
Thin-Jam Hex Nut 7	1781

Figure 5-27. Top 10 most in stock products

❖ **Top locations have the highest number of products in stock**

Through this command, users can understand the inventory status of each warehouse, from which they can analyze to get an idea of the sales of each of them. From there, they can make plans to produce and import inventory in the reasonable future.

```
/*Top locations have the highest number of products in stock*/
Select
TopCount (([Dim Location].[Location Name].children ),10,[Measures].[Quantity - Fact Inventory]) on rows,
([Measures].[Quantity - Fact Inventory]) on columns
from [Nhom6 Production DW]
where [Dim Time].[Year].&[2014]
```

102 %

Messages | Results

	Quantity - Fact Inventory
Subassembly	76291
Miscellaneous Storage	72834
Tool Crib	68919
Metal Storage	9365
Final Assembly	7971
Sheet Metal Racks	5549
Frame Forming	5115
Frame Welding	355
Paint Shop	186
Paint	117

Figure 5-28. Top locations have the highest number of products in stock

Chapter 6 - Visualization And Forecasting

6.1. Report and dashboard systems (structure)

❖ Power BI

The dashboard brings the data about the product reviews into a structured format and we can analyze the data more easily. Product Review dashboard is set of charts designed from data in Fact_ProductReview table.

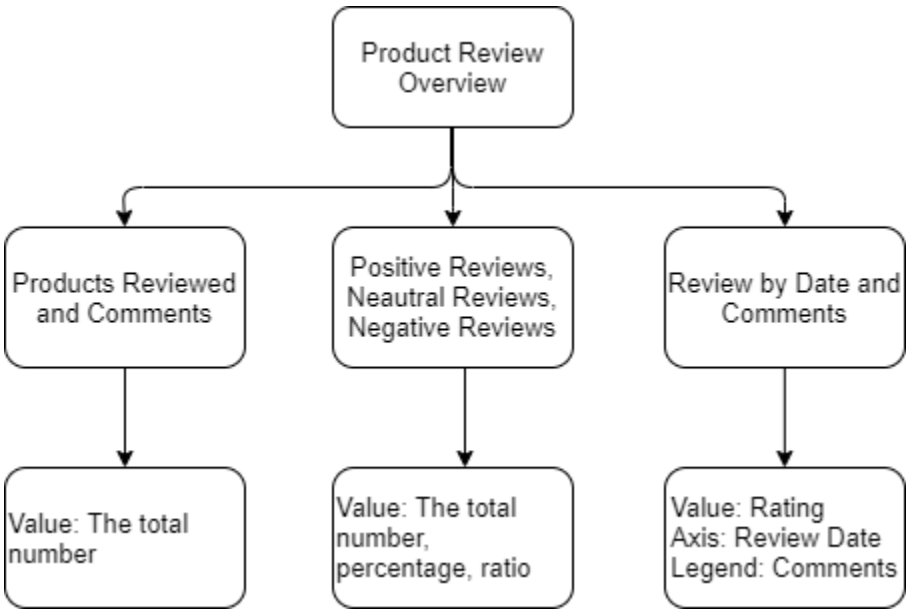


Figure 6-1. Product Review Dashboard Structure

❖ Excel

A total of 4 different Dashboards: Revenue and Profit Dashboard, Sale Product Quantity Tracking Dashboard, Scrap Dashboard and Cost Variance Dashboard serving different purposes. Each dashboard is composed of many small charts built from specific attributes in Dim, Fact tables to visualize data to extract useful information. The structure of each dashboard is described as follow:

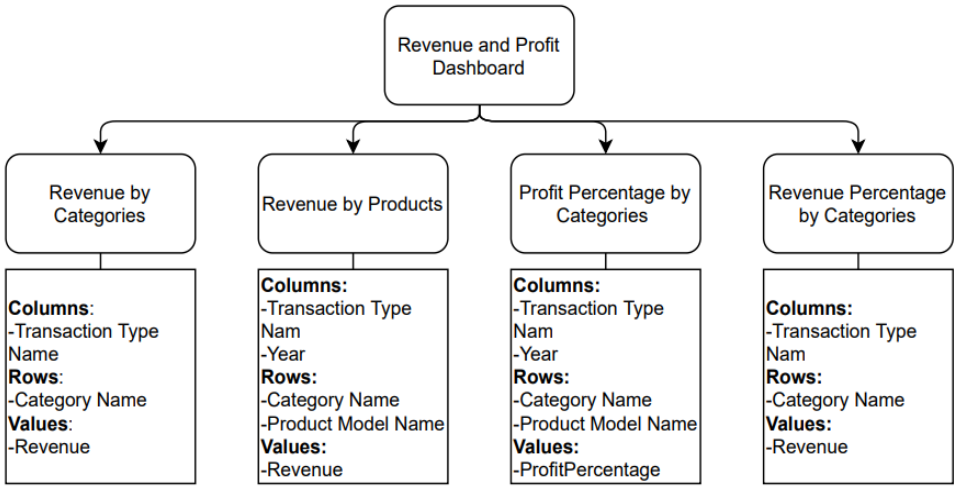


Figure 6-2. Revenue and Profit Dashboard Structure

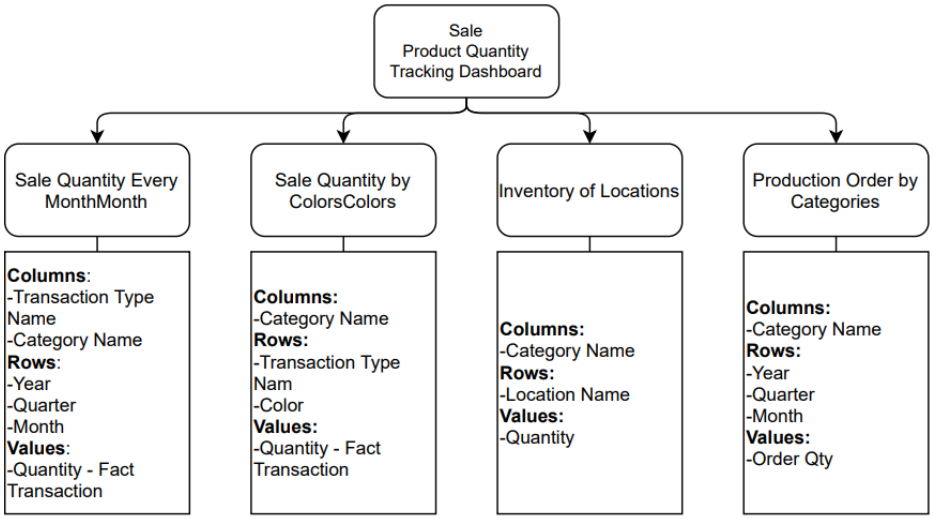


Figure 6-3. Sale Product Quantity Tracking Dashboard Structure

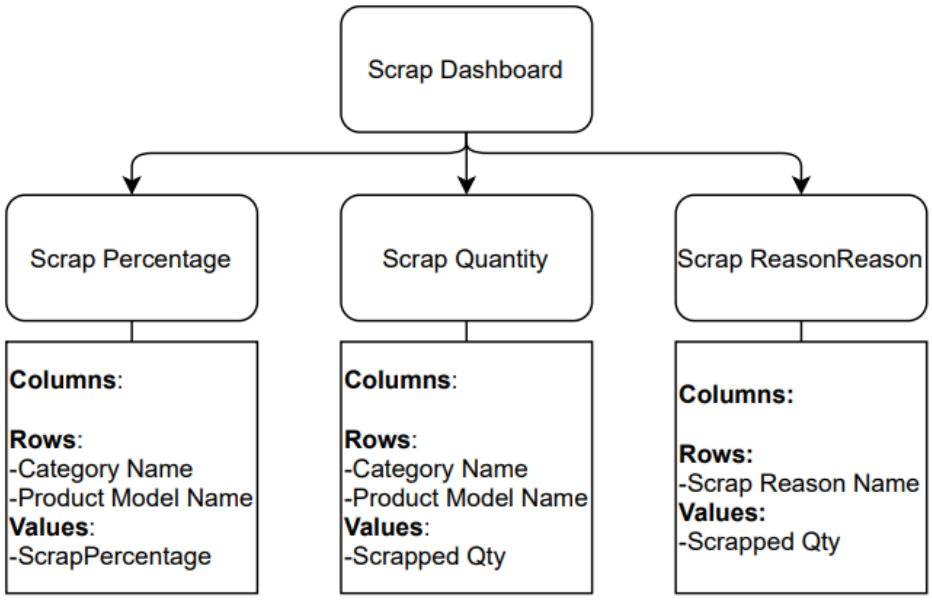


Figure 6-4. Scrap Dashboard Structure

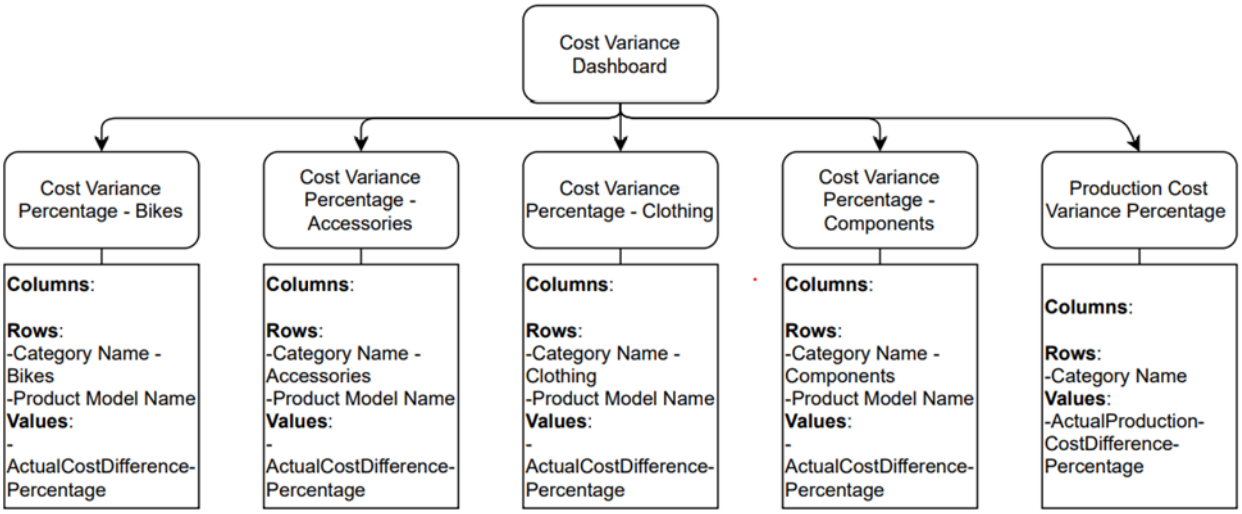


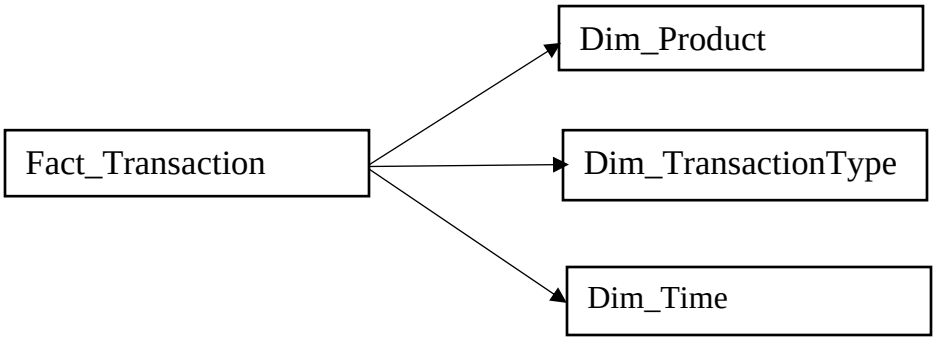
Figure 6-5. Cost Variance Dashboard Structure

❖ Tableau

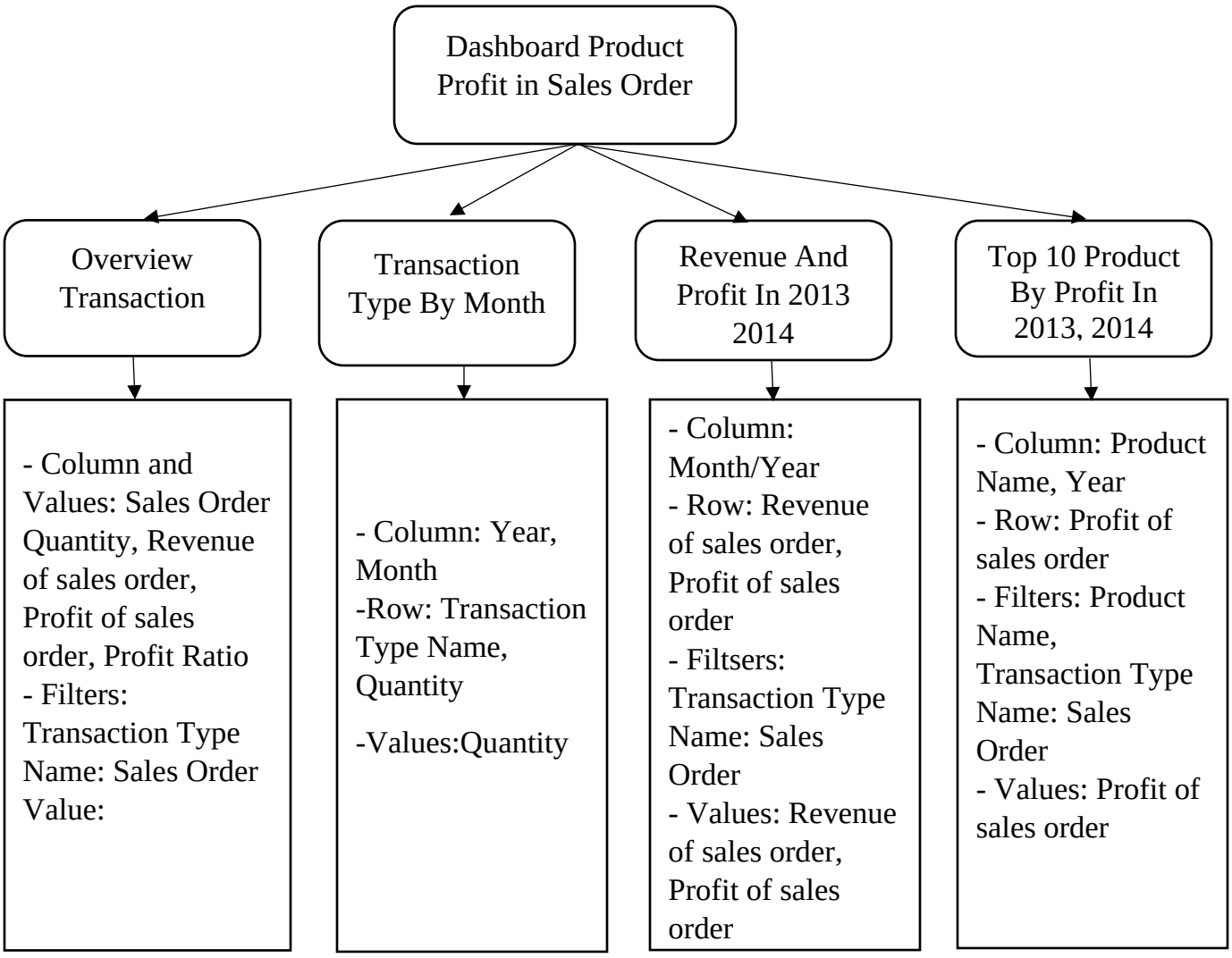
Build two dashboards from Fact_WorkOrder and Fact_Transaction.

- Dashboard Product Profit in Sales Order:

We will create link among tables related Fact_Transcation and after that we perform visualize reports:

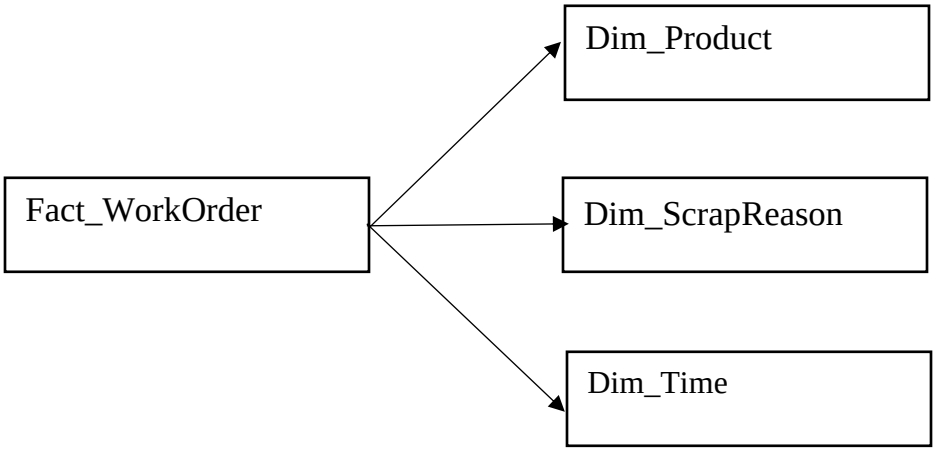

Dim_Product
Fact_Transaction
Dim_TransactionType
Dim_Time

Structure:

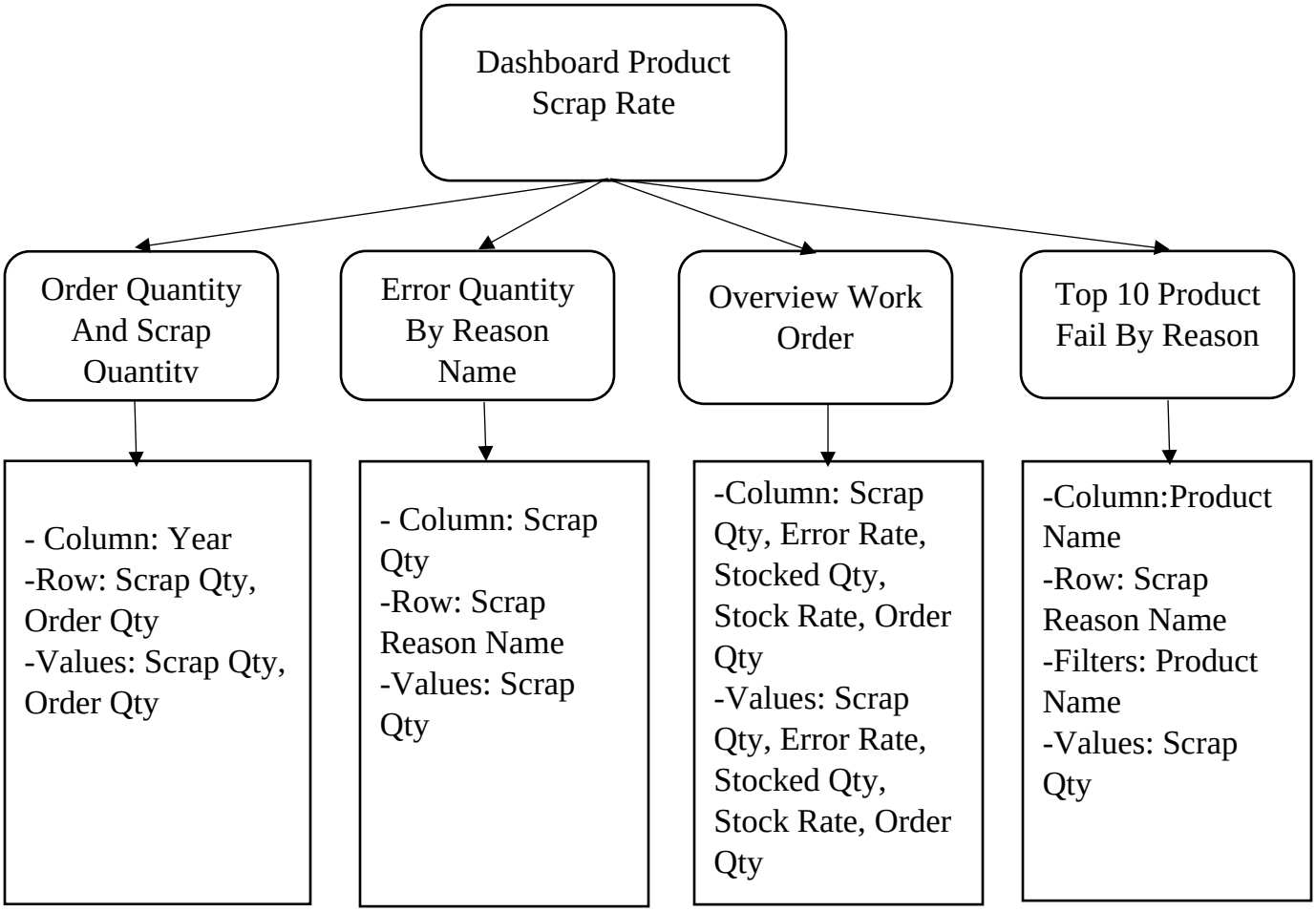

Dashboard Product Profit in Sales Order
Overview Transaction
Transaction Type By Month
Revenue And Profit In 2013 2014
Top 10 Product By Profit In 2013, 2014
- Column and Values: Sales Order Quantity, Revenue of sales order, Profit of sales order, Profit Ratio
- Filters: Transaction Type Name: Sales Order Value:
- Column: Year, Month
-Row: Transaction Type Name, Quantity
-Values:Quantity
- Column: Month/Year
- Row: Revenue of sales order, Profit of sales order
- Filtsers: Transaction Type Name: Sales Order
- Values: Revenue of sales order, Profit of sales order
- Column: Product Name, Year
- Row: Profit of sales order
- Filters: Product Name, Transaction Type Name: Sales Order
- Values: Profit of sales order

- Dashboard Product Scrap Rate:

We will create link among tables related Fact_WorkOrder and after that we perform visualize reports:



Structure:



6.2. Data analysis with Power BI

Through the ***product review dashboard***, we can visualize analytics on our product performance in terms of product reviews and ratings.

This dashboard shows us the number of products reviewed, the comments. It also categorizes into positive, neutral and negative reviews. We can see the number, the percentage of each type of reviews and the average rating of each category.

From the chart "Reviews by Date and Comments", we can analyze how negative and positive feedback influences our product demand and develop new ideas and strategies to achieve a more successful branding.

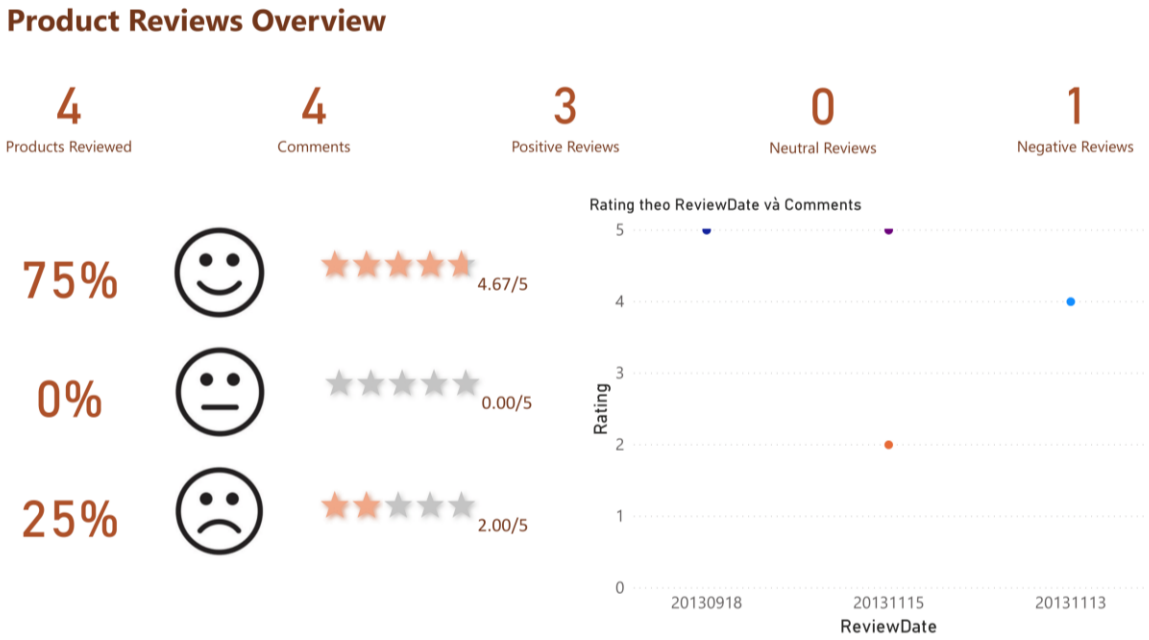


Figure 6-6. Product Reviews Overview by Power BI

6.3. Data analysis with the Pivot Table tool in Microsoft Excel

6.3.1. Revenue and Profit Dashboard

Revenue and Profit Dashboard shows the sales of each category and product, the percentage of profits earned from that product. At the same time, we can observe the ratio and total sales between types of goods over the years.

According to the dashboard, we can see that the main product of the company is bicycles, accounting for 90% of the company's revenue. In terms of sales over the years, in general, revenue in 2014 has significantly decreased compared to 2013. Bicycles, clothing decreased about 26-30%, components decreased sharply, nearly 1.5 times compared to the previous year. In contrast, Accessories has a slight increase of about 12%. About the products that bring in the highest sales: Mountain-200, Touring-2000, Road-350-W are the company's main products.

In terms of profit ratio, Clothing and bicycles bring in quite stable profits over the years, the product lines profit from 5% to 30-35% of the total selling price. Accessories have a huge difference. there are products sold that bring huge profits such as Cable Lock (40%), Hitch Rack (22%),... besides, there are many products that do not bring in revenue.

Through observing the chart, the administrator can know which products are the main products that bring in the highest revenue of the company. The strength of the company is which categories and products are most profitable. Know the trend of selling products over the years... From there create an effective product business strategy.

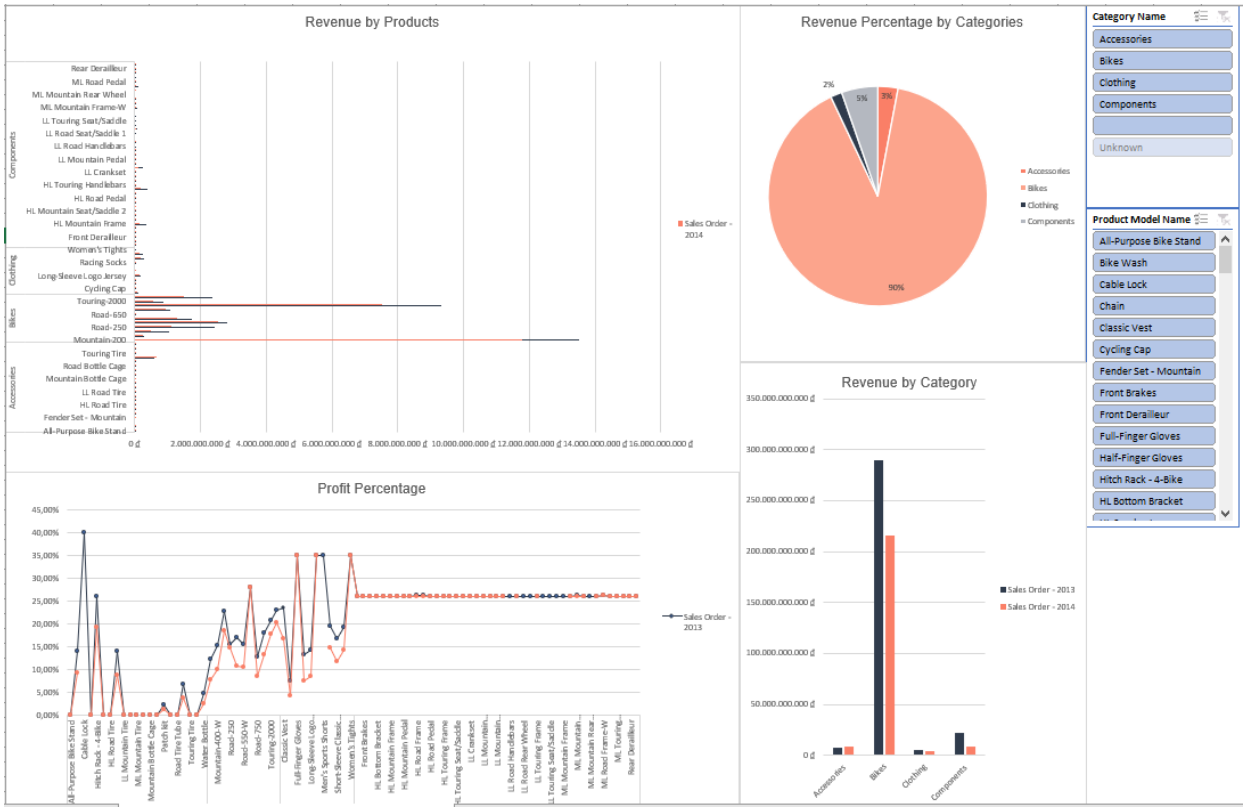


Figure 6-7. Revenue and Profit Dashboard by Excel

6.3.2. Sale Product Quantity Tracking Dashboard

Sale Product Quantity Tracking Dashboard shows the number of products sold and the production volume ordered by the product each month. Besides that shows us the ratio of colors sold on the same product line and product stock overview.

Looking at the chart, we can see that the sales volume varies among periods of the year. In the period from July to January, although the sales volume increased and decreased slightly, but it was quite stable, there was not much change, but components fluctuated more than other categories and tended to go down more. From February, it started to be volatile, this month was the period when sales were at company's lowest, then increased sharply in March - the peak of the company's sales then plummeted again nearly as much as sales in January. Then it rallied again in May and dropped again the following month. The preference of colors in the categories is also different. While blue, black and yellow are the 3 most sold colors of bicycles, components are silver, black or no color. Clothing is black, multi, yellow and Accessories are no color accounting for more than 70% of the

total. In terms of production order, the average monthly production of bicycles ranges from 2000 to 4500 units, in June 2014 alone, the production volume decreased sharply to 773 units. Similar to bikes, the average production is about 20000 to 50,000 pieces per month, June 2014 dropped sharply to 7474 units.

The administrator through the chart can plan the future production of products based on knowing which colors are most popular, balancing between sales and production, and tracking product volumes in different stocks in to have a better production planning and minimize inventory at a safe level. In terms of production order, the average monthly production of bicycles ranges from 2000 to 4500 units, in June 2014 alone, the production volume decreased sharply to 773 units. Similar to bikes, the average production is about 20000 to 50,000 pieces per month, June 2014 dropped sharply to 7474 units.

The administrator through the chart can plan the future production of products based on knowing which colors are most popular, balancing between sales and production, and tracking product volumes in different stocks in to minimize inventory at a safe level.

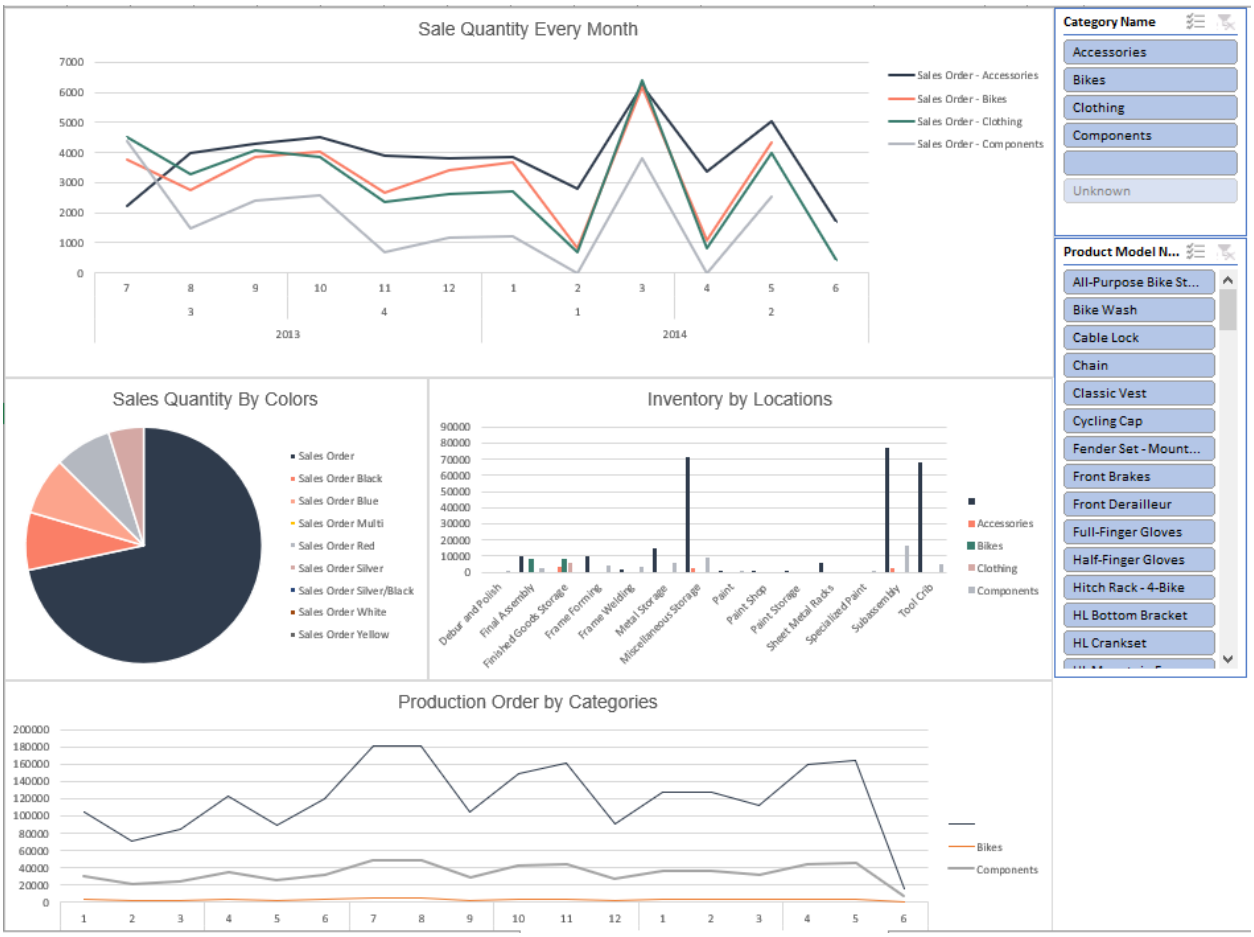


Figure 6-8. Sale Product Quantity Tracking Dashboard by Excel

6.3.3. Scrap Dashboard

The chart shows the percentage of defective products during manufacture, the number of defective products for each type of product and the reasons for the defect. Through knowing more or less product defects.

The defect rate on bikes are 0.16% and components are 0.21%. For components, Touring rear wheel has the highest failure rate, 0.59%, followed by Mountain Front Wheel (0.56%) and ML Road Rear Wheel (0.42%). For bicycles, the top 3 products with the highest failure rates are Mountain-100(0.3%), Road-650(0.3%) and Road-750(0.25%). There are 10651 scraps , including 8512 onces without label. There are total 16 causes of errors, but the cause of the most scraps is Paint process failed, while the least frequent error is Stress test failed.

The administrator can know whether there is any unusual problem with a specific product production line or not, the reasons for the product error, which are the major causes,... From there find the right solutions to overcome and improve the quality and production line of products

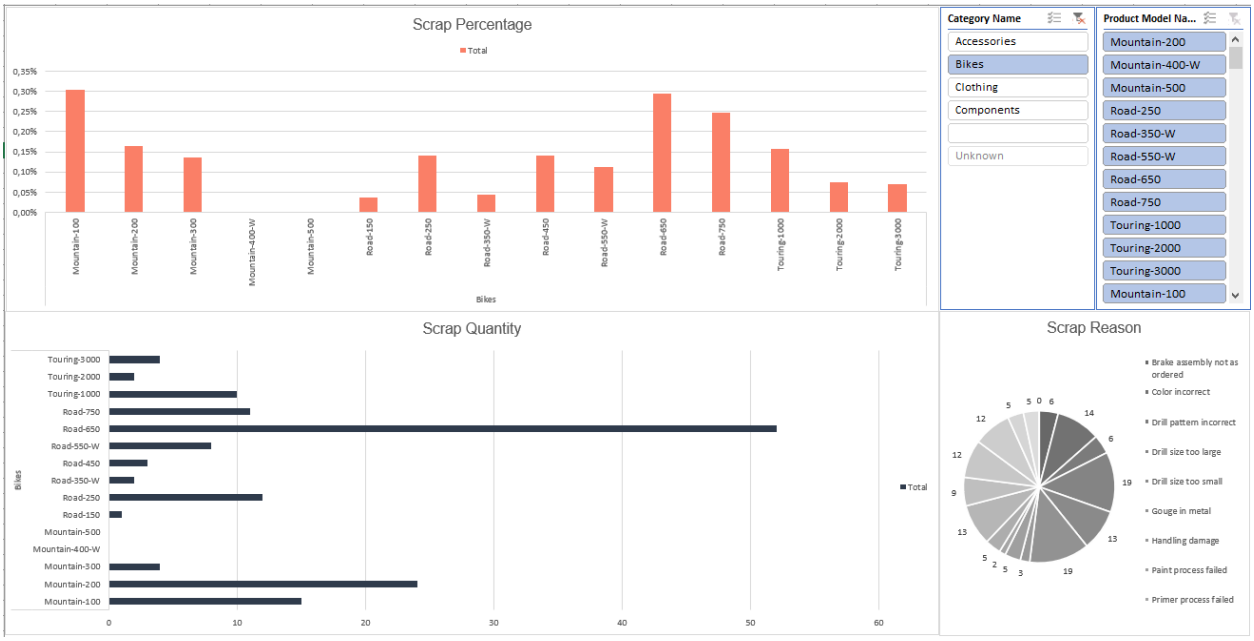


Figure 6-9. Scrapped Overview Dashboard by Excel

6.3.4. Cost Difference Dashboard

Cost Variance Dashboard shows the actual cost difference from the standard cost of the products and the variance between the actual cost of production and the planned cost of production.

There is a big difference between the actual cost and the standard cost among bicycle product lines. While the Mountain-200's actual cost is 20.46% more than its standard cost, the Road-650 has an actual cost up to 40.52% lower. Touring-3000 is the product line with the lowest difference, 0.97%

For Accessories, the difference is huge across all products, ranging from 100% to 200%. Only Cable Lock is 45.45%.

For Clothing, Half-Finger Gloves is the product with the largest cost variance, with a difference of 139.84%. In the contrast, Short-Sleeve Classic Jersey has just 11.33% cost variance.

For Components, it has an avarage cost variance of 59.11%. However, the difference between products is huge. There are products whose actual cost is greater than the standard cost, the highest being ML Road Seat/Saddle 2 with 75.16%. There are products on the contrary, the actual cost is lower, reaching the lower threshold of 100%.

And about production cost variance, there is no difference in production costs from planning to actual production in both bikes and components.

Through the dashboard, administrators can keep track of this discrepancy. From there reviewing everything: estimation steps, planning instructions, production processes, resources, production lines, external impacts, ... that affect product costs if the difference is unusual. Since then, the production process is improved.

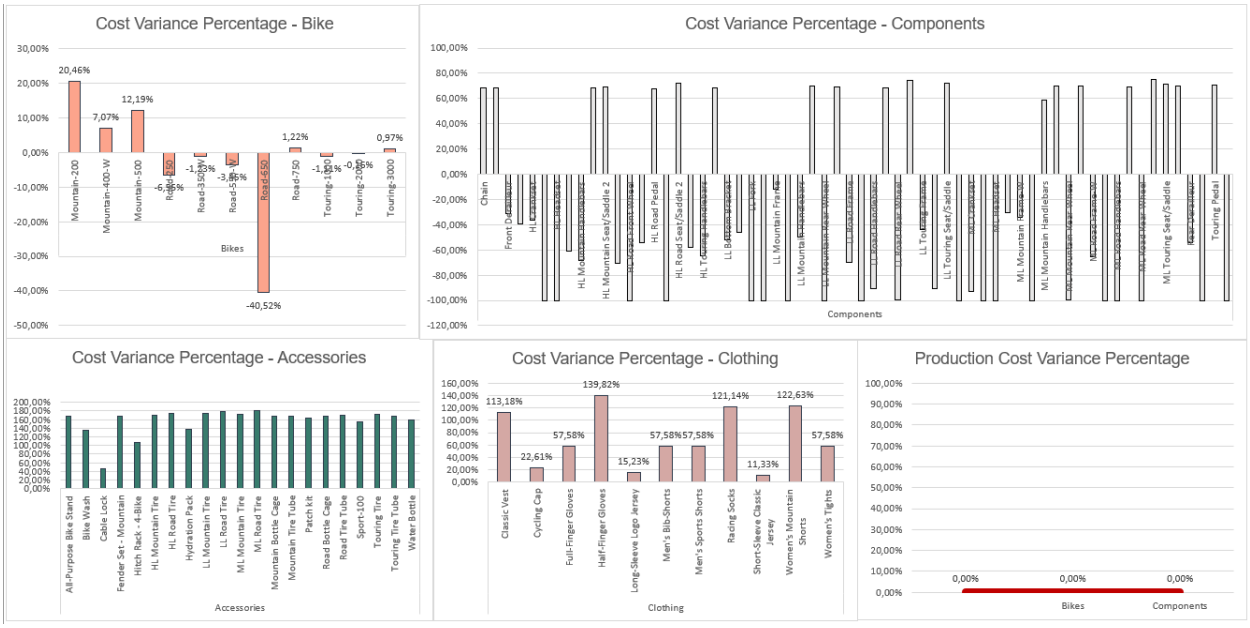


Figure 6-10. Cost Variance Dashboard by Excel

6.4 Data analysis with Tableau

6.4.1 Dashboard Product Profit in Sales Order

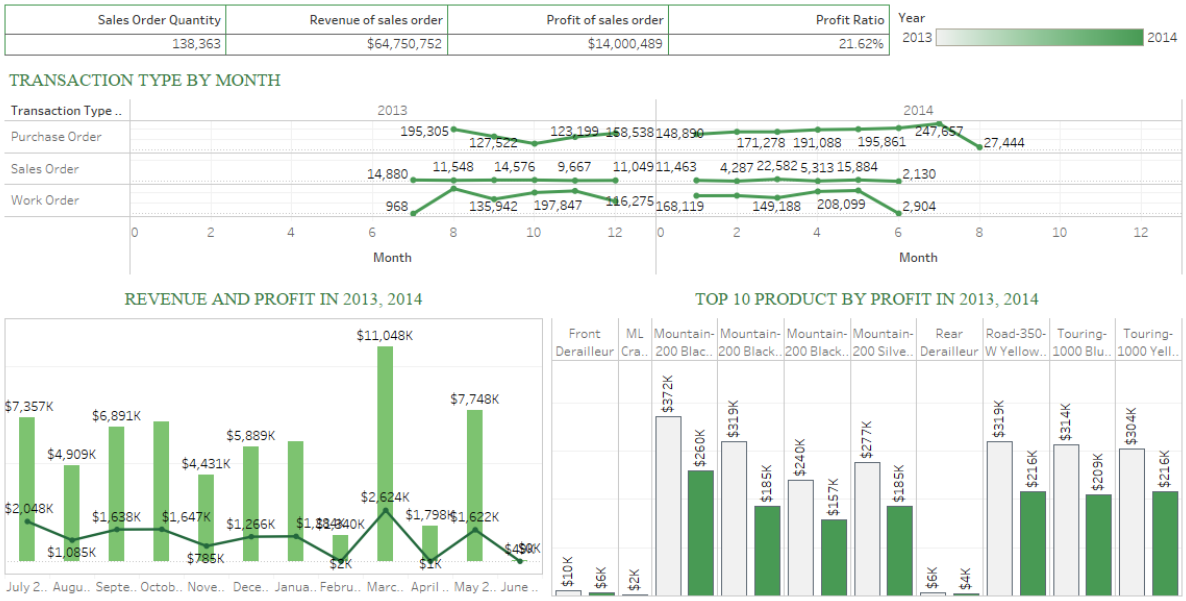


Figure 6-11. Dashboard Product Profit in Sales Order by Tableau

Work orders and purchase orders transactions vary from month to month. Sales order seems to be stable without much change with an average sales about 11,000 units/ month. The business situation is quite good, with the following figures: total sold products is 138,363 units, profit is 37,716,998 USD, rate of return is 21.62%.

Look at the chart "Revenue and Profit in 2013,1014" we can see in 2013 the business situation of the company was quite steady but in 2014 there were fluctuations. Some months in 2014 have a very high selling rate, but the next month the revenue has dropped dramatically. For instance, in March, the revenue was 11,048,371 USD, but in April it dropped deeply to 1,797,363 USD.

The diagram in the right corner demonstrates the top 10 products by profit that brought in a lot of revenue for the company in 2013 and 2014. There are slightly increased in Front Derailleur; HL Fork... By contrast, Mountain-200 Black, 42; Road-350-W Yellow, 48… recorded an reduce in sales profit.

The profitability rate of 21.62% is not high, businesses should reconsider production and sales costs to improve profitability. In addition, the company must focus on 10 products that bring in high sales to create a suitable marketing and sales strategy for these products to ensure that a certain level of sales is always maintained. Hence, the company should look at the products that decrease the revenue, find out the reasons for that problem and improve them.

6.4.2 Dashboard Product Defects/Scrap Rate

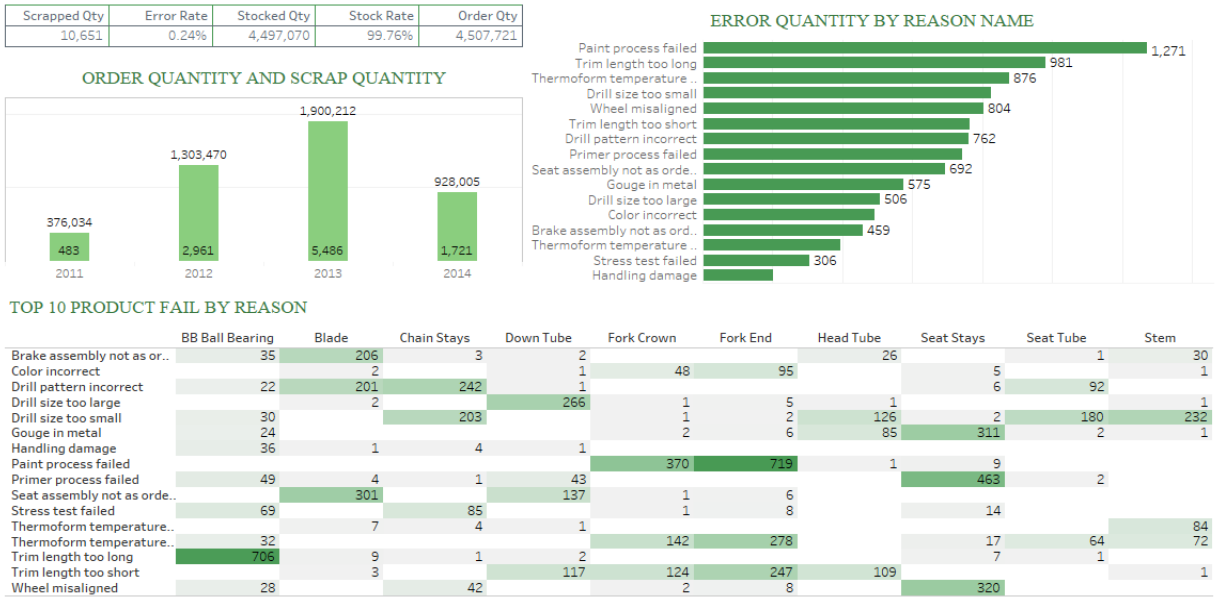


Figure 6-12. Dashboard Product Defects/Scrap Rate by Tableau

The total number of defective products accounts for 0.24% of the total manufactured products, this is an acceptable number. The rate of defective products in each year is not too different, so it can be said that this production line has achieved good efficiency.

As the "Error quantity by scrap reason name" diagram showed, in the Top 10 Best-selling products, the most common errors are "Paint process failed", "Trim length too long"... On the other hand, the least common errors are "Handling damage" and "Stress test failed".

The product will have various manufacturing defects, some of them are common in certain products like the “Paint process failed” usually appear in Fork End and Fork Crown. A

product that only has a certain defect like the BB Ball Bearing usually has “Trim length too long” error.

The company should focus on the Top product fail by reason table, look at the figures with a darker background color to know which error is common in this product. From there it is possible to optimize the production line of that product, in order to overcome those problems.

6.5. Time series and Forecasting with Tableau

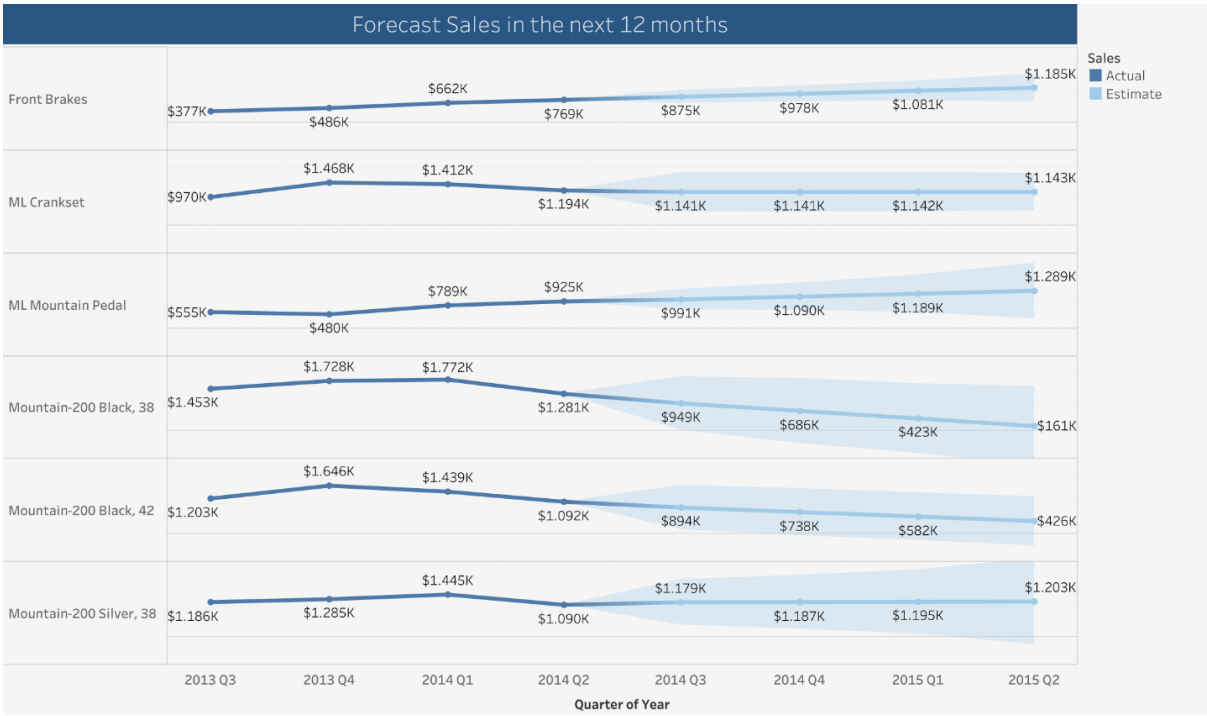


Figure 6-13. Sales Forecast by Tableau

About the forecast

Based on the sales transaction history from July 2013 to June 2014, computed the exponential smoothing model and additive model, whose contributions are summed components, in trend to forecast sales for the top 6 best-selling in the next twelve months, which is June 2015.

In the original database, transactions did exist in July and August 2014, which are involved in third quarter 2014. This can cause a problem because the value for this fractional quarter is treated by the forecasting model as a full quarter. If the forecasting model is allowed to

consider this data, the resulting forecast will be inaccurate. Therefore, we choose to ignore data in July and August 2014.

Conclusion

As the diagram showed, there are ascending trend lines in sales of Front Brakes, ML Mountain Pedal, these two products belong to the "Components" category. Particularly, sales in Front Brakes will increase $848.000 and in ML Mountain Pedal $173.000. There are many assumptions we can make, for instance, we can assume that there is efficiency in production, customers' interest in how we make these products or these are hanging in the market trends. This is a good sign, therefore, managers should take a look back at the production process of Front Brakes and ML Mountain Pedal to optimize the remaining products.

On the other hand, there are descending trend lines in sales of Mountain-200 Black, 38 and Mountain-200 Black, 42 with respectively figures -$1.292.000 and -$777.000. These both belong to the "Bike" category, our main product distribution, which turns out to be odd with the forecast's result. This can be viewed as ineffectiveness in the production process, lack of interest from customers or increase in competitiveness in the market. Managers should take into consideration these two products' production process and focus on researching the bike market trend, therefore, improve the quality of products and reach the business' objectives.

Chapter 7 - Conclusion And Future Works

In this report, we showed that constructing a data warehouse is a step toward addressing some of the major challenges that businesses face in data distribution and acquisition. We discovered that constructing a data warehouse and multidimensional blocks is an effective method for investigating the behavior of the Production module in order to generate supply reports, thereby providing "insights" for ERP systems.

7.1. Results

The project focused on designing and implementation of DW and BI system for a Production cycle industry using AdventureWork2014 database as case study.

We defined the aim that needs to be accomplished using the AdventureWork2014 database and project specifications, which is to create a multidimensional data block to evaluate and generate reports to explain the picture of the business (particularly the Production module) in order to prepare strategy through predictive analysis and optimal analysis.

After creating a data warehouse and using SSIS and SSAS software to integrate and analyze data, as well as BI tools include Power BI, Tableau, Excel, etc. to "slice and dice" data into reports that show trends, date-range comparisons, and even forecasts, our team compared and analyzed the results to generate knowledge information for business strategy development.

In conclusion, we have succeeded in designing how data can be made available to business for day to day activities of their businesses and have developed a data analysis template that users can interact with to get an immediate answer to the business question.

7.2. Limitations

The main limitations here are the lack of experience of our team members in extracting data as well as good understanding of the Production module. We point out the requirements based solely on a cursory scan of the Internet without a detailed knowledge of Adventure Work Cycle company's Production module. As a result, without further post-

processing such findings can be very confusing and incomprehensible for a user without additional post processing, usually with appropriate visualization.

Another shortcoming is insufficient details database. To put it another way, there are several lines of attributes with null breaks, which makes analyzing and reporting results difficult, as well as predicting patterns incorrectly. The data collection is severely deficient in chronology, making it impossible to evaluate several year cycles for future strategic planning.

7.3. Future works

The research in this thesis suggests various avenues for future work in large-scale data analytics for data-driven decision making. We present a few directions below that may be good avenues for future work.

Finding the best knowledge

We've built a slew of data-driven reports and dashboards. However, we had to manually determine what kind of expertise is needed for our specifications as well as for the operational and executive levels. It would be useful for doing a more effective review of multiple aspects of data and providing "insight" for making decisions and planning the enterprise's resources.

Improved database for re-learn and more accurate reporting

Processing and interfering more thoroughly at the source data analysis step, constructing a data warehouse content is more complete, meeting managers' criteria for higher quality, more specifically, the findings are more accurate. Extend dynamic features reports of nested reporting.

Group Member Evaluation

No.	Full name	Student ID	Position	Assignment	Completion Rate
1	Nguyen Hoang Van Anh	K184060706	Leader	• Research and write report in: ○ Chapter 1 (1.5) ○ Chapter 2 (2.2) ○ Chapter 4 (4.2) • Analyze, visualize Time Series by Tableau in Chapter 6 (6.5) • Presentator	100%
2	Le Trung Kien	K184060722	Member	• Research and write report in: ○ Chapter 1 (1.1) ○ Chapter 2 (2.5) ○ Chapter 4 (4.2) • Analyze data with SSAS by using KPIs system in Chapter 5 (5.1) • Analyze, visualize data by Pivot Excel in Chapter 6 (6.3) • Presentator	100%
3	Nguyen Thi Tuyet Nhi	K184060743	Secretary	• Research and write report in: ○ Chapter 1 (1.2) ○ Chapter 2 (2.6) ○ Chapter 3 (3.1 & 3.2) • Analyze data with MDX and OLAP technique in Chapter 5 (5.2) • Design presentation slides in Microsoft Powerpoint	100%

4	Nguyen Thi Hong Nhung	K184060744	Member	• Research and write report in: ○ Chapter 1 (1.6) ○ Chapter 2 (2.3) ○ Chapter 4 (4.1) ○ Chapter 7 • Presentator • Design and make the official report in Microsoft Word	100%
5	Tran Huu Thai	K184060753	Member	• Research and write report in: ○ Chapter 1 (1.3) ○ Chapter 2 (2.1) ○ Chapter 4 (4.1) • Analyze data with MDX and OLAP technique in Chapter 5 (5.2)	100%
6	Vu Dai Toan	K184060759	Member	• Research and write report in: ○ Chapter 1 (1.2) ○ Chapter 2 (2.4) ○ Chapter 3 (3.5) • Analyze, visualize data by Tableau in Chapter 6 (6.4) • Presentator	100%
7	Vuong Bao Tran	K184060763	Member	• Research and write report in: ○ Chapter 1 (1.4) ○ Chapter 3 (3.4) • Analyze, visualize data by Power BI in Chapter 6 (6.2) • Design and make the official report in Microsoft Word	100%

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Appendix A

1. Query Design in SQL

1.1 Create new DW tables

Dim_Product

```
CREATE TABLE [dbo].[Dim_Product](
	[ProductKey] [int] IDENTITY(1,1) NOT NULL,
	[ProductID] [int] NOT NULL,
	[ProductName] [nvarchar](50) NOT NULL,
	[ProductNumber] [nvarchar](25) NOT NULL,
	[MakeFlag] [bit] NOT NULL,
	[FinishedGoodsFlag] [bit] NOT NULL,
	[SafetyStockLevel] [smallint] NOT NULL,
	[ReorderPoint] [smallint] NOT NULL,
	[DaysToManufacture] [int] NOT NULL,
	[ProductLine] [nchar](2) NULL,
	[Color] [nvarchar](15) NULL,
	[Class] [nchar](2) NULL,
	[Style] [nchar](2) NULL,
	[Size] [nvarchar](5) NULL,
	[SubCategoryName] [nvarchar](50) NULL,
	[CategoryName] [nvarchar](50) NULL,
	[ProductModelName] [nvarchar](50) NULL,
PRIMARY KEY([[ProductKey]])
```

Dim_Location

```
CREATE TABLE [dbo].[Dim_Location] (
	[LocationKey] [int] IDENTITY(1,1) NOT NULL,
	[LocationID] [smallint] NOT NULL,
	[LocationName] [nvarchar](50) NULL,
	PRIMARY KEY ([LocationKey]))
```

Dim_SrapReason

```
CREATE TABLE [dbo].[Dim_ScrapReason] (
[ScrapReasonKey] [int] IDENTITY(1,1) NOT NULL,
[ScrapReasonID] [smallint] NOT NULL,
[ScrapReasonName] [nvarchar](50) NULL,
PRIMARY KEY ([ScrapReasonKey]))
```

Dim_TransactionType

```
CREATE TABLE [dbo].[Dim_TransactionType] (
	[TransactionTypeKey] [int] IDENTITY(1,1) NOT NULL,
	[TransactionTypeCode] [nchar](1) NOT NULL,
	[TransactionTypeName] [nvarchar](50) NULL,
	PRIMARY KEY ([TransactionTypeKey]))
```

Fact_WorkOrder

```
CREATE TABLE [dbo].[Fact_WorkOrder] (
	[FactWorkOrderKey] [int] IDENTITY(1,1) NOT NULL,
	[ProductKey] [int] NOT NULL,
	[StartDate] [nvarchar] NOT NULL,
	[EndDate] [nvarchar] NULL,
	[ScrapReasonKey] [int] NOT NULL,
	[OrderQty] [int] NOT NULL,
```

```
	[StockedQty] [smallint] NOT NULL,
	[ScrappedQty] [smallint] NOT NULL
	PRIMARY KEY ([FactWorkOrderKey]))
```

Fact_WorkOrderRouting

```
CREATE TABLE [dbo].[Fact_WorkOrderRouting](
	[FactWorkOrderRoutingKey] [int] IDENTITY(1,1) NOT NULL,
	[ProductKey] [int] NOT NULL,
	[LocationKey] [int] NOT NULL,
	[TotalPlannedCost] [money]  NULL,
	[TotalActualCost] [money] NULL,
	[TotalActualHours] [int]  NULL,
	[ScheduledStartDate] [nvarchar](34) NOT NULL,
	[ScheduledEndDate] [nvarchar](34) NOT NULL,
	[ActualStartDate] [nvarchar](34) NULL,
	[ActualEndDate] [nvarchar](34) NULL,
	PRIMARY KEY ([FactWorkOrderRoutingKey]))
```

Fact_ProductReview

```
CREATE TABLE [dbo].[Fact_ProductReview](
	[FactReviewKey] [int] IDENTITY(1,1) NOT NULL,
	[ProductKey] [int] NOT NULL,
	[ReviewDate] [nvarchar](34) NULL,
	[Rating] [int] NOT NULL,
	[Comments] [nvarchar](3850) NULL,
	PRIMARY KEY ([FactReviewKey]))
```

Fact_Transaction

```
CREATE TABLE [dbo].[Fact_Transaction](
	[FactTransactionKey] [int] IDENTITY(1,1) NOT NULL,
	[ProductKey] [int] NULL,
	[TransactionDate] [nvarchar](34)
	[TransactionTypeKey] [int] NULL,
	[Quantity] [int] NULL,
	[StandardCost] [money] NULL,
	[ActualCost] [money] NULL,
	[ListPrice] [money] NULL,
	PRIMARY KEY ([FactTransactionKey]))
```

Fact_Inventory

```
CREATE TABLE [dbo].[Fact_Inventory](
	[FactInventoryKey] [int] IDENTITY(1,1) NOT NULL,
	[ProductKey] [int] NOT NULL,
	[LocationKey] [int] NOT NULL,
	[Shelf] [nchar](10) NULL,
	[Bin] [tinyint] NULL,
	[Quantity] [smallint] NULL,
	[ModifiedDate] [nvarchar](34) NULL,
	PRIMARY KEY([FactInventoryKey])
```

1.2 Extract data from data source

Dim_Product

```
SELECT a.ProductID, a.Name ProductName, a.ProductNumber, a.MakeFlag,
a.FinishedGoodsFlag, a.SafetyStockLevel, a.ReorderPoint,
	a.DaysToManufacture, a.ProductLine, a.Color, a.Class, a.Style, a.Size,
	b.Name SubCategoryName, c.Name CategoryName, d.Name ProductModelName
FROM Production.Product a
	left join Production.ProductSubcategory b on
	a.ProductSubcategoryID=b.ProductSubcategoryID
	left join Production.ProductCategory c on b.ProductCategoryID =
	c.ProductCategoryID
	left join Production.ProductModel d on a.ProductModelID = d.ProductModelID
```

Dim_Location

```
SELECT LocationID,
	Name LocationName
FROM Production.Location
```

Dim_ScrapReason

```
SELECT ScrapReasonID,
	Name ScrapReasonName
FROM Production.ScrapReason
```

Dim_TransactionType (Create new data)

NHVA\SQLEXPRESS...._TransactionType | NHVA\SQLEXPRESS...._Trans

	TransactionTypeKey	TransactionTypeCode	TransactionTypeName
	1	P	Purchase Order
	2	S	Sales Order
	3	W	Work Order
▶*	*NULL*	*NULL*	*NULL*

Fact_WorkOrder

```
SELECT ProductID,
	CAST(YEAR(StartDate) AS nvarchar) + RIGHT('0' + CAST(MONTH(StartDate) AS
	nvarchar),2) + RIGHT('0' + CAST(DAY(StartDate) AS nvarchar),2) StartDate,
	CAST(YEAR(EndDate) AS nvarchar) + RIGHT('0' + CAST(MONTH(EndDate) AS
	nvarchar),2) + RIGHT('0' + CAST(DAY(EndDate) AS nvarchar),2) EndDate,
	ScrapReasonID, OrderQty,
	StockedQty, ScrappedQty
FROM Production.WorkOrder
```

Fact_WorkOrderRouting

```
SELECT A.ProductID, A.LocationID,
	ISNULL(B.TotalPlannedCost, 0) AS TotalPlannedCost,
	ISNULL(B.TotalActualCost, 0) AS TotalActualCost,
	ISNULL(B.TotalActualResourceHrs, 0) AS TotalActualHours,
```

```
	CAST(YEAR(A.ScheduledStartDate) AS nvarchar) + RIGHT('0' +
	CAST(MONTH(A.ScheduledStartDate) AS nvarchar),2)  + RIGHT('0' +
	CAST(DAY(a.ScheduledStartDate) AS nvarchar),2) ScheduledStartDate,
	CAST(YEAR(A.ScheduledEndDate) AS nvarchar) + RIGHT('0' +
	CAST(MONTH(A.ScheduledEndDate) AS nvarchar),2)  + RIGHT('0' +
	CAST(DAY(a.ScheduledEndDate) AS nvarchar),2) ScheduledEndDate,
	CAST(YEAR(A.ActualStartDate) AS nvarchar) + RIGHT('0' +
	CAST(MONTH(A.ActualStartDate) AS nvarchar),2)  + RIGHT('0' +
	CAST(DAY(a.ActualStartDate) AS nvarchar),2) ActualStartDate,
	CAST(YEAR(A.ActualEndDate) AS nvarchar) + RIGHT('0' +
	CAST(MONTH(A.ActualEndDate) AS nvarchar),2)  + RIGHT('0' +
	CAST(DAY(a.ActualEndDate) AS nvarchar),2) ActualEndDate
FROM Production.WorkOrderRouting A LEFT JOIN
	(SELECT WorkOrderID,
		SUM(ActualResourceHrs) AS TotalActualResourceHrs,
		SUM(PlannedCost) AS TotalPlannedCost,
		SUM(ActualCost) AS TotalActualCost
	FROM Production.WorkOrderRouting
	GROUP BY WorkOrderID) as B
	ON A.WorkOrderID = B.WorkOrderID
```

Fact_ProductReview

```
SELECT a.ProductID,
	a.ProductReviewID,
	CAST(YEAR(a.ReviewDate) AS nvarchar) + RIGHT('0' + CAST(MONTH(a.ReviewDate) AS
	nvarchar),2) + RIGHT('0' + CAST(DAY(a.ReviewDate) AS nvarchar),2) ReviewDate,
	a.Rating, a.Comments
FROM Production.ProductReview a
	left join Production.Product b on a.ProductID = b.ProductID
```

Fact_Transaction

```
SELECT a.ProductID,
	CAST(YEAR(a.TransactionDate) AS nvarchar) + RIGHT('0' +
	CAST(MONTH(a.TransactionDate) AS nvarchar),2)  + RIGHT('0' +
	CAST(DAY(a.TransactionDate) AS nvarchar),2) TransactionDate,
	a.TransactionType,
	a.Quantity,  b.StandardCost, a.ActualCost, b.ListPrice
FROM  Production.TransactionHistory a
	join Production.Product b on a.ProductID = b.ProductID
```

Fact_Inventory

```
SELECT a.ProductID, a.LocationID,
	Shelf, Bin, Quantity,
	CAST(YEAR(a.ModifiedDate) AS nvarchar) + RIGHT('0' +
	CAST(MONTH(a.ModifiedDate) AS nvarchar),2)  + RIGHT('0' +
	CAST(DAY(a.ModifiedDate) AS nvarchar),2) ModifiedDate
FROM Production.ProductInventory a
	left join Production.Product b on a.ProductID = b.ProductID
	left join Production.Location c on a.LocationID = c.LocationID
```