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REPORT

DATA ANALYTICS

BI SOLUTIONS FOR AWC

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With limited knowledge, our project will not avoid mistakes. We hope you can contribute ideas to make our project better.

And once again, thank you, and wish you and your family health and happiness.

Group 4 – K18406C

COMMITMENT

We can assure the project “Data Analytic in Business” is independent research under the guidance of lecturer: Ph.D. Ho Trung Thanh. Also, there is not any duplication of others. The project and content of the report are the products that we have tried to research in the process of studying at the University of Economics and Law. The data and results presented in the report are completely truthful, I would like to take full responsibility and discipline of our lecturer Ph.D. Ho Trung Thanh to propose if any problem occurs.

Ho Chi Minh City, 2021

Group 4 – K18406C

TASK TABLE

Group 4

No.	Student Name	Task Name	% Contributed
1	Lâm Thị Hoài Thanh	<ul style="list-style-type: none"> - Team leader. - Keep track of various tasks and oversee all activities within a team. - Survey business process of the Purchasing department. - Analyze business requirements. - Define KPIs for Purchasing department. - Comment and edit for data visualization section. - Synthesize and check other members' content. - Evaluate projects and work results. - Write Chapter 3 and Chapter 7. 	100%
2	Trần Khánh Duy	<ul style="list-style-type: none"> - Analyze technical requirements. - Survey BI tools (PowerBI, Qlik). - Build data warehouse and 	100%

		integrate data. - Build KPIs system. - Analyze data with MDX and OLAP techniques. - Write Chapter 4 and Chapter 5.	
3	Ngô Hữu Tài	- Define the business case of the project. - Analyze business requirements. - Visualize data in Tableau and time series and forecasting analysis. - Comment and edit for data visualization section. - Write Chapter 1 and parts 6.1, 6.4, 6.5 of Chapter 6. - Create a presentation.	100%
4	Hồ Thủy Tiên	- Survey BI tools (SSAS, SAP). - Visualize data in PowerBI. - Write parts 2.1, 2.2, 2.3, and synthesize Chapter 2. - Write parts 6.2, 6.6 of Chapter 6. - Create a presentation.	98%

5	Nguyễn Phạm Thủy Tiên	<ul style="list-style-type: none"> - Survey BI tools (Excel, Tableau). - Visualize data in Excel. - Design the cover page and format the report in Word. - Write parts 2.4, 2.5 in Chapter 2. - Write part 6.3 and synthesize Chapter 6. 	95%
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LIST OF ACRONYMS

No.	Abbreviation	Explanation
1	AWC	Adventure Works Cycles
2	BI	Business Intelligence
3	DB	Database
4	EIM	Enterprise Information Management
5	ERP	Enterprise Resource System
6	ETL	Extracts - Transforms - Load
7	IT	Information Systems
8	KPI	Key Performance Indicator
9	MDX	MultiDemensional eXpression
10	OLAP	Online Analysis Processing
11	OLE	Object Linking and Embedding
12	OLTP	On-line transactional processing
13	RFPs	Request For Proposal
14	ROI	Return On Investment
15	SQL	Structured Query Language
16	SSAS	SQL Server Analysis Services
17	SSIS	SQL Server Integration Services
18	SSDT	SQL Server Data Tool
19	SSIS	SQL Server Integration Services
20	XML	eXtensible Markup Language

CHAPTER 1. INTRODUCTION

1.1. The business case for the project

In this project, our team will work with Adventure Works Cycles, the fictitious company on which the AdventureWorks sample databases are based, which is created by Microsoft for studying and researching. About the context, Adventure Works is a large, multinational company that specializes in manufacturing bicycles. The company's product line includes 97 different brands of bikes, grouped into three categories: mountain bikes, road bikes, and touring bikes. The company is not only selling bicycles, but it also provides accessories, clothing, and components. Many of those things are made by vendors, so Adventure Works stands as a reseller.

The company manufactures and sells metal and composite bicycles to North American, European, and Asian commercial markets. While its base operation is located in Bothell, Washington with 290 employees, several regional sales teams are located throughout their market base. There are 2 business models in Adventure Works which are retail stores that sell bikes, and internet sales that serve individual customers. Usually, Adventure Works sells in bulk to retail stores, which acts as resellers for its products.

For now, Adventure Works Cycles is looking to broaden its market share by targeting its sales to its best customers, extending its product availability through an external Web site, and reducing its cost of sales through lower production costs.

The function which our team manages to work within this project is called **“Purchasing”** - a department that handles all of the paperwork involved with purchasing and delivery of supplies and materials. Purchasing ensures timely delivery of materials from vendors, generates and tracks purchase orders, and works alongside the receiving department and the accounts payable department to ensure that promised deliveries were received in full and are being paid for on time. This is an essential department. Why? Because in a manufacturing company like AWC, purchasing needs to procure all the materials needed first, then with all the “ingredients” gathered, the production department and sales department can start their work after.

1.2. Objectives of the project

1.2.1. General objective

To build, deploy and operate business intelligence solutions to provide timely metrics, reports, and proactive alerts, enabling companies to reach their strategic goals by making substantiated decisions.

1.2.2. Specific objectives

- All team members understand the impact and benefits of data analysis in the Purchasing function.
- All team members understand every process in a data analysis project and can apply lessons learned in the future.
- The project team will influence at least 3 Business Intelligence tools after the project ends, including Tableau, Excel, and Power BI.
- The project output will be a detailed report about what is going on in the Purchasing department of AWC and the way forward to develop further.
- The project report will cover almost all the requirements of the subject.

1.3. Research objects

- Company: A fictitious, multinational manufacturing company called Adventure Works Cycles.
- Product and services providing: Bicycle and Components.
- Database: AdventureWorks Database – a Microsoft product sample for an online transaction processing database highlighting SQL Server features. However, due to the specification of the project, our team only works with the Purchasing department including entities whose header started with [Purchasing.EntityName] and entities from other departments related to Purchasing as well.
- OLTP Database version: 2014.
- Sample Data Warehouse version: 2014.

1.4. Scope of the project

Our main functional scope will be the Purchasing department and everything related to it as we mentioned above. We will utilize the data provided in the AWC data warehouse to generate precious and helpful results to give the direction forward for the department. Therefore, the technical scope will be planning, analyzing, and evaluating the output information based on what we have.

1.5. Value and desired outcome of the project

Mentioning value, we think the most value this project and report can provide will be **sustainability**. In the first place, we won't be so confident that our project will be super among the class. But as if it can be a useful document for the next generation like K19, K20 can refer and consider their project in the future, we won't ever be happier as our work makes an impact not only for the moment of us but also for the future. Time passes and maybe there will be another database that will be applied to this subject but we hope the way we work and think through the project will inspire them to their solution because to us, data analysis is all about logical thinking.

1.6. Structure of the project

- *Chapter 1: Introduction* - Overview of the business case, objective, and research scope of the project.
- *Chapter 2: Theoretical basis* - Introduce and describe the theory to carry out this project with the information related to BI, Data Warehouse, processes, and Business Data Analytics techniques to build a Business Intelligence support decision-making system and solution.
- *Chapter 3: Requirements analytics and introduction to BI solution* - Analyze business requirements, technical requirements, and BI solutions needed for this project.

- *Chapter 4: Building data warehouse and integrating data* - Detail about the building data warehouse process for the purchasing module as well as integrate data from the Adventureworks2014 data sample into our data warehouse.
- *Chapter 5: Data analytics* - Use the SSAS technology and the MDX and OLAP technique to make a presentation for the information from the Data Warehouse and visualizing them to help the manager make a better decision.
- *Chapter 6: Visualization and Forecasting* - Visualize the requirements and significations of the report according to data in the data warehouse we built and using some BI tools to conclude statistical reports.
- *Chapter 7: Conclusion and future works* - Present the results of the topic, the limitations of the topic, the practical meaning, and the next development direction of the topic.

CHAPTER 2. THEORETICAL BASIS

2.1. Overview about BI

2.1.1. What is BI?

Business intelligence (BI) leverages software and services, combining data gathering, data storage, and knowledge management with data analysis to evaluate and transform complex data into actionable insights that inform an organization's strategic and tactical business decisions. Business intelligence environments consist of a variety of technologies, applications, processes, strategies, products, and technical architectures used to enable the collection, analysis, presentation, and dissemination of internal and external business information.

2.1.2. BI Architecture

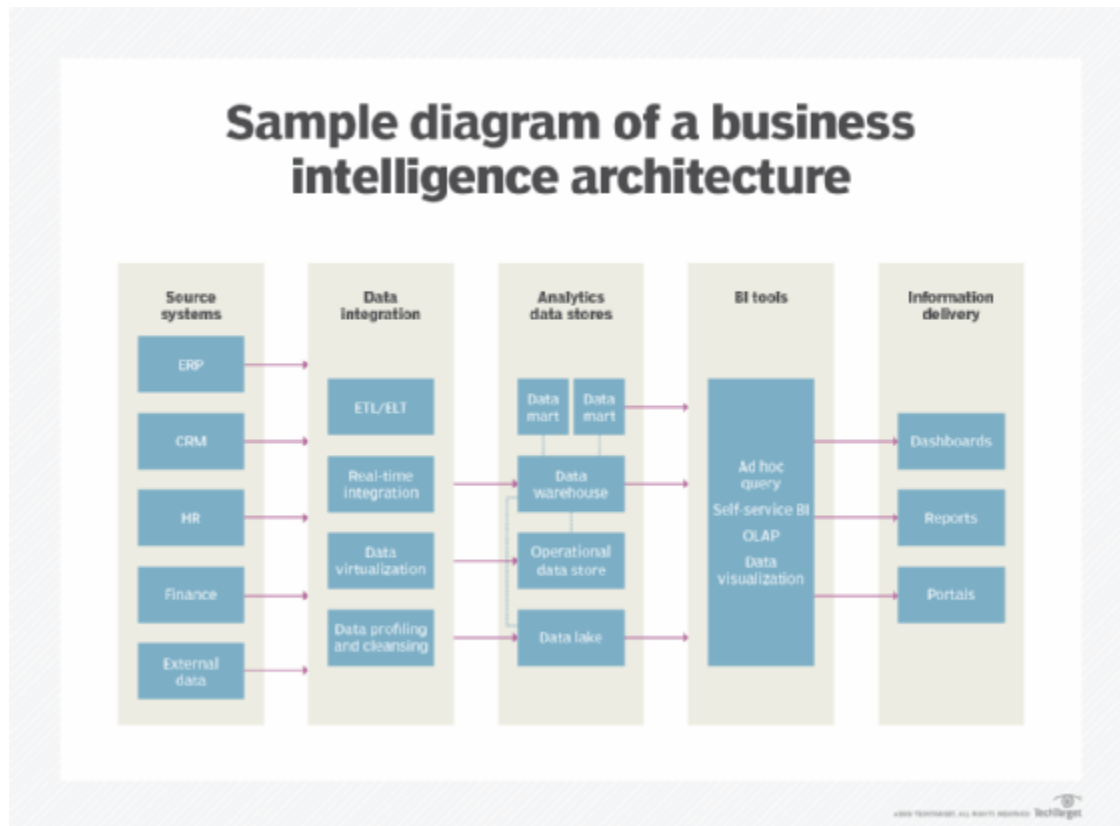


Figure 2.1. Diagram of BI architecture (Source: TechTarget)

A BI architecture can be deployed in an on-premises data center or the cloud. In either case, it contains a set of core components that collectively support the different

stages of the BI process, from data collection, integration, storage, and analysis to data visualization, information delivery, and the use of BI data in business decision-making.

The core components include the following items:

- Source systems
- ETL process
- Data modeling
- Data warehouse
- Enterprise information management (EIM)
- Appliance systems
- Tools and technologies

2.1.3. Advantage of BI in enterprises

There are some key advantages enterprises can get with Business Intelligence on board:

- **Faster analysis, intuitive dashboards:** BI tools pull in data from multiple sources into a data warehouse, and then analyze the data according to user queries, drag-and-drop reports, and dashboards.
- **Increased organizational efficiency:** BI provides leaders the ability to access data and gain a holistic view of their operations, and the ability to benchmark results against the larger organization.
- **Data-driven business decisions:** Having accurate data and faster reporting capability provides for better business decisions.
- **Improved customer experience:** The operational benefits of BI tools help collect & analyze customer buying patterns. It helps get better customer knowledge.
- **Improved employee satisfaction:** BI is designed to be scalable, providing data solutions to departments who need it and for employees who crave data.

- **Trusted and governed data:** BI platforms can combine all of these internal databases with external data sources such as customer data, social data, and even historical weather data into one data warehouse. Departments across an organization can access the same data at one time.
- **Increased competitive advantage:** With BI, businesses can keep up with changes in the industry, monitor seasonal changes in the market, and anticipate customer needs.

2.1.4. BI Strategy for Business

A BI strategy will allow you to address all your data problems and needs, develop a cohesive system, and keep it maintained.

Without a BI strategy	With a BI strategy
Multiple versions of the truth; people refer to different data when making decisions	The single version of the truth that leads to effective business decisions
Unclear names and definitions that get everyone guessing	Consistent definitions
Personnel overhead with different departments having their own BI	BI specialists and analysts maintaining the BI ecosystem
Data quality is an afterthought	Data quality is a priority

Figure 2.2. Life before and after a BI strategy

The BI strategy has three main elements:

- **Vision.** Why are you building the BI practice in your company and what do you want to achieve?
- **People and processes.** Who will define and run the BI strategy? And how?
- **Tools and architecture.** Which dashboards and solutions do we want to build? For which areas? And how will they impact those areas?

Following is a brief of the BI strategy' steps:

- Step 1. Create the vision
- Step 2. Establish BI governance processes: BI governance is about defining and implementing the BI infrastructure (A BI governance team, BI tools, and lifecycle management, user support).
- Step 3. Build a BI roadmap: A roadmap is a visual document demonstrating deliverables at different stages of implementation within the timeline.

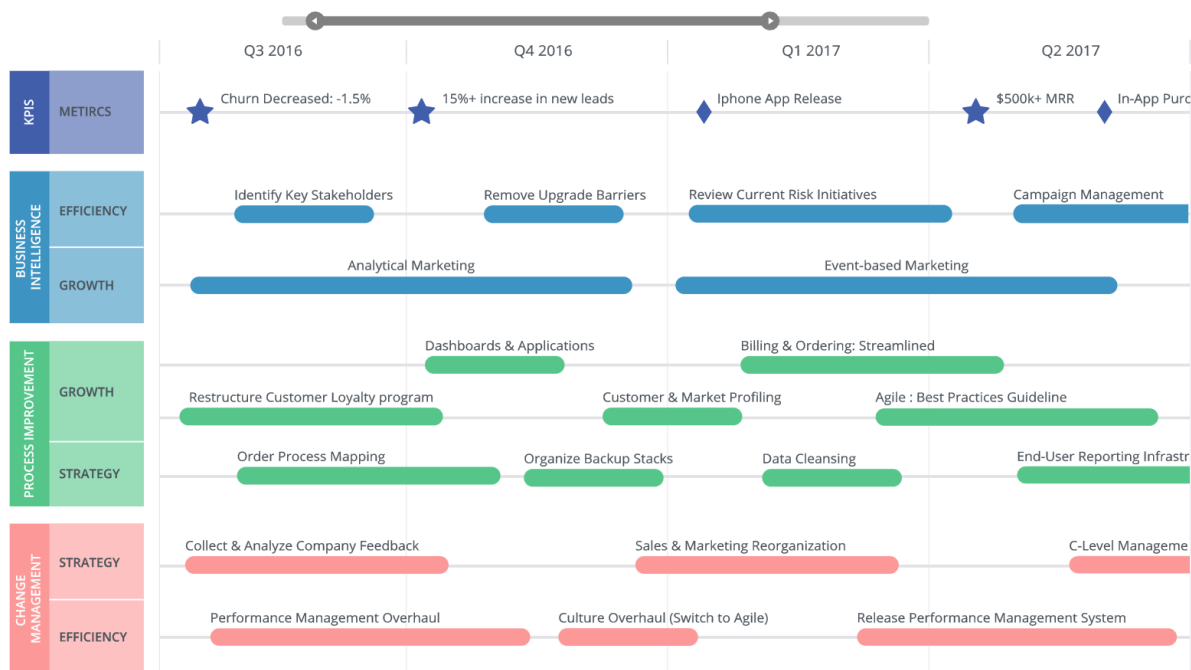


Figure 2.3. An example of such a roadmap spanning three quarters (Source: Roadmunk)

- 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.
- Step 5. Review your BI strategy every year.

2.2. ETL Process

2.2.1. What is ETL?

ETL is a type of data integration process referring to three distinct but interrelated steps (Extract - Transform - Load) and is used to synthesize data from multiple sources many times to build a Data Warehouse, Data Hub, or Data Lake.

2.2.2. Why do we need ETL?

The triple combination of ETL provides crucial functions that are many times combined into a single application or suite of tools that help in the following areas:

- Offers deep historical context for business.
- Enhances Business Intelligence solutions for decision-making.
- Enables context and data aggregations so that businesses can generate higher revenue and/or save money.
- Enables a common data repository.
- Allows verification of data transformation, aggregation, and calculation rules.
- Allows sample data comparison between source and target system.
- Helps to improve productivity as it codifies and reuses without additional technical skills.

2.2.3. ETL Process

ETL is a three steps process:

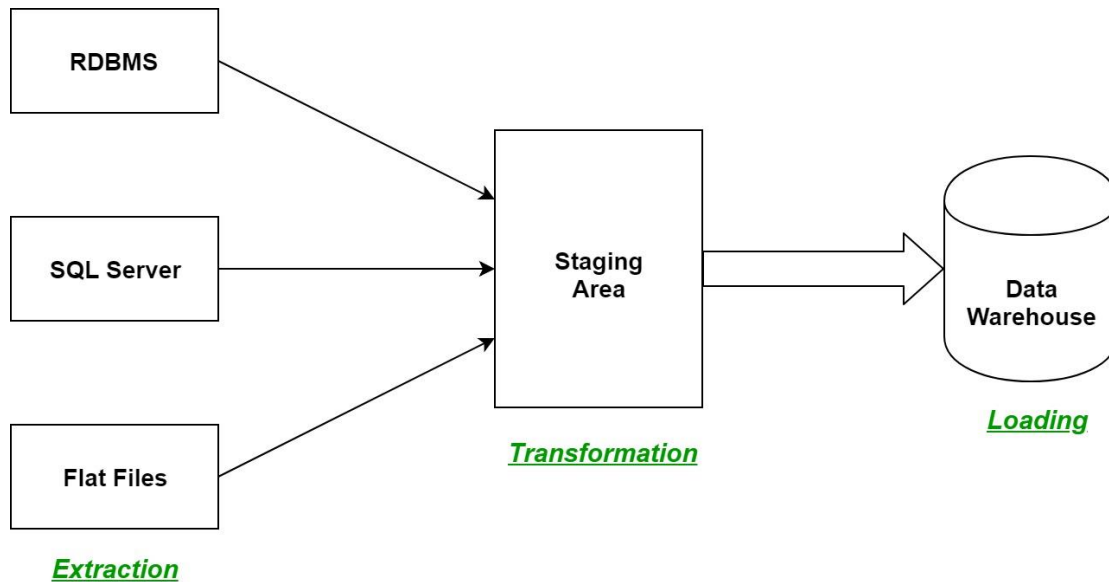


Figure 2.4. ETL Process (Source: [geeksforgeeks.org](http://www.geeksforgeeks.org))

- **Extraction:** 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.
- **Transformation:** In this step, a set of rules or functions are applied to the extracted data to convert it into a single standard format.
- **Loading:** In this step, the transformed data is finally loaded into the data warehouse. The rate and period of loading solely depend on the requirements and vary from system to system.

2.3. Data warehouse and Data mart

2.3.1. What are a Data warehouse and Data mart?

A Data Warehouse is a large centralized repository of data collected from different organizations or departments within a corporation. In Data Warehouse data is stored from a historical perspective.

A Data mart is an only subtype of a Data Warehouse. It is designed to meet the need of a certain user group. Data Mart draws data from only a few sources. These sources may be a central Data warehouse, internal operational systems, or external data sources.

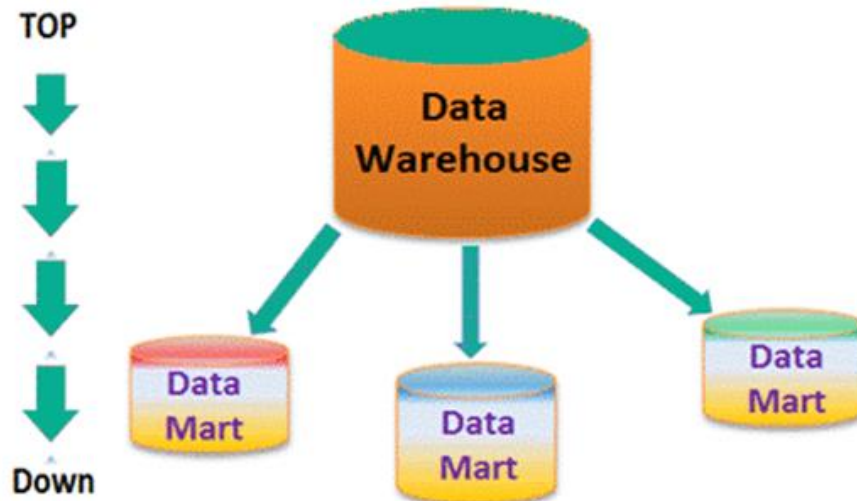


Figure 2.5. Data warehouse and dimension Data mart by Top-Down approach

2.3.2. Who needs a Data warehouse and Data mart?

Data warehouse and Data mart are needed for all types of users like:

- Decision-makers who rely on mass amounts of data.
- Users who use customized, complex processes to obtain information from multiple data sources.
- It is also used by people who want simple technology to access the data.
- It is also essential for those people who want a systematic approach to making decisions.
- If the user wants fast performance on a huge amount of data which is a necessity for reports, grids, or charts, then the Data warehouse proves useful.
- The data warehouse is the first step if someone wants to discover 'hidden patterns' of data-flows and groupings.

2.3.3. Advantages and disadvantages of Data warehouse

2.3.3.1. Advantages of Data warehouse

- Data warehouse allows business users to quickly access critical data from some sources all in one place.

- Data warehouse provides consistent information on various cross-functional activities. It is also supporting ad-hoc reporting and queries.
- Data Warehouse helps to integrate many sources of data to reduce stress on the production system.
- Data warehouse helps to reduce total turnaround time for analysis and reporting.
- Restructuring and Integration make it easier for the user to use for reporting and analysis.
- Data warehouse allows users to access critical data from several sources in a single place. Therefore, it saves the user time retrieving data from multiple sources.
- Data warehouse stores a large amount of historical data. This helps users to analyze different periods and trends to make future predictions.

2.3.3.2. Disadvantages of Data warehouse

- Not an ideal option for unstructured data.
- Creation and Implementation of Data Warehouse is surely a time-consuming affair.
- Data Warehouse can be outdated relatively quickly.
- Difficult to make changes in data types and ranges, data source schema, indexes, and queries.
- The data warehouse may seem easy, but actually, it is too complex for the average user.
- Despite best efforts at project management, data warehousing project scope will always increase.
- Sometimes warehouse users will develop different business rules.
- Organizations need to spend lots of their resources for training and Implementation purposes.

2.3.4. Snowflake and Star schemas

2.3.4.1. Snowflake schema

Snowflake Schema in the data warehouse is a logical arrangement of tables in a multidimensional database such that the ER diagram resembles a snowflake shape. A Snowflake Schema is an extension of a Star Schema, and it adds additional dimensions. The dimension tables are normalized which splits data into additional tables.

In the following Snowflake Schema example, the Country is further normalized into an individual table.

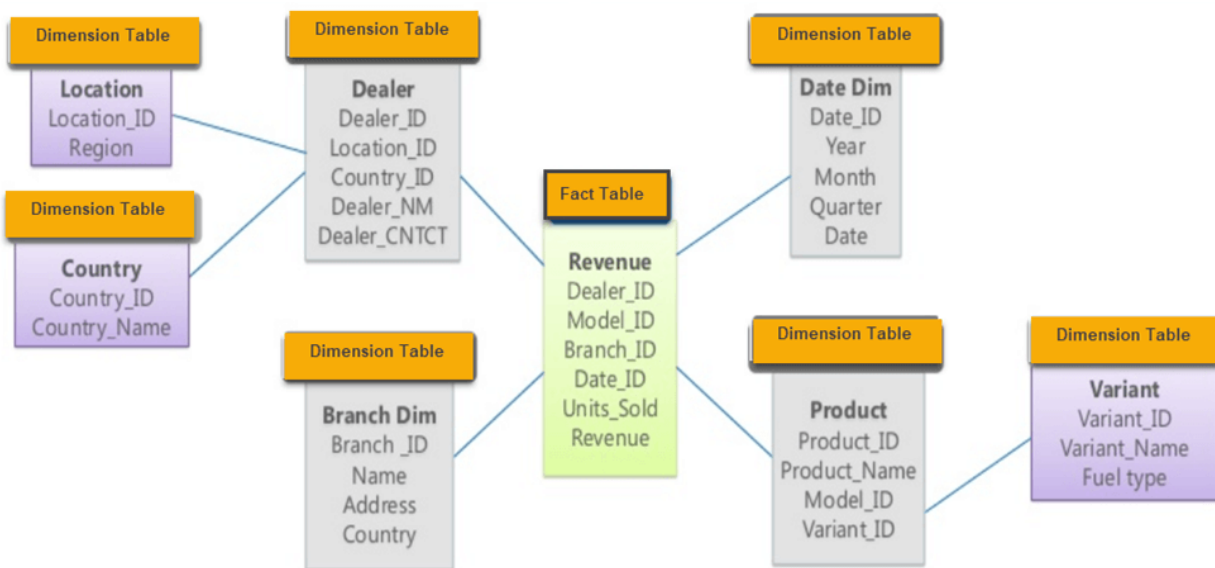


Figure 2.6. Example of Snowflake Schema

2.3.4.2. Star schema

Star Schema in a data warehouse, in which the center of the star can have one fact table and several associated dimension tables. It is known as star schema as its structure resembles a star. The Star Schema data model is the simplest type of Data Warehouse schema. It is also known as Star Join Schema and is optimized for querying large data sets.

In the following Star Schema example, the fact table is at the center which contains keys to every dimension table like Dealer_ID, Model ID, Date_ID, Product_ID, Branch_ID & other attributes like Units sold and revenue.

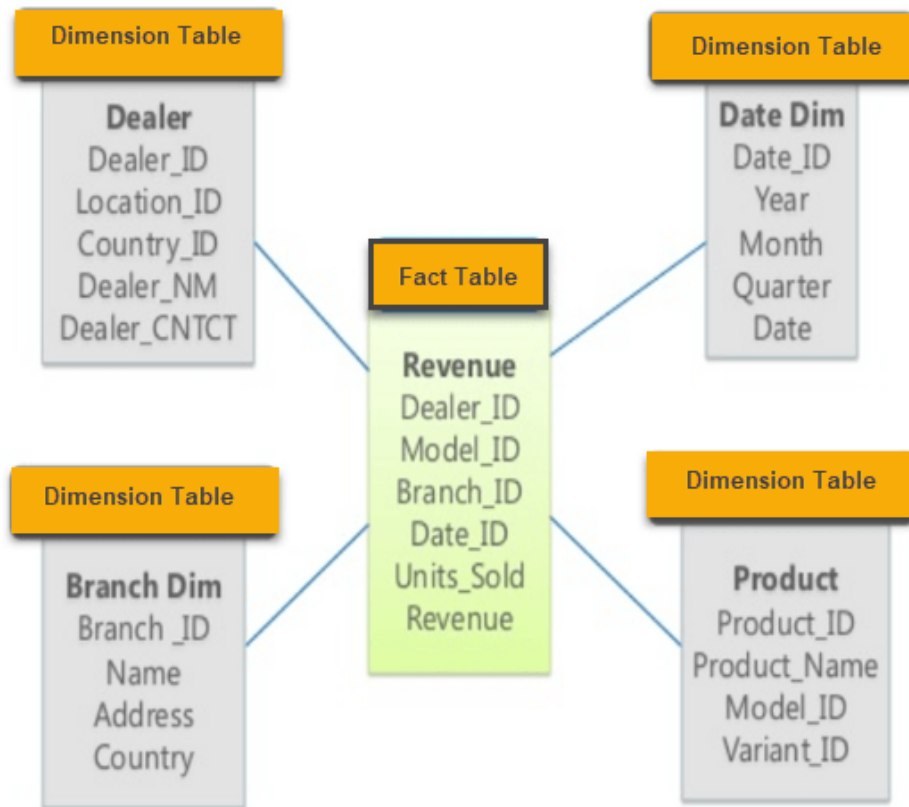


Figure 2.7. Example of Star Schema Diagram

2.4. KPIs

2.4.1. KPIs definition

Key performance indicators (KPIs) refer to a set of quantifiable measurements used to gauge a company's overall long-term performance. KPIs specifically help determine a company's strategic, financial, and operational achievements, especially compared to those of other businesses within the same sector.

2.4.2. The advantages and disadvantages of KPIs

2.4.2.1. Advantages of KPIs

- Close learning gaps: KPIs help you recognize and address learning gaps. If you're not reaching an objective or goal, it may indicate that your employees need further training.
- Empower employees to take action: Clear KPIs drive your employees to action and direct them along the way.

- Measure outcomes and results: KPIs allow you to measure outcomes and results. A good KPI, by definition, should be measurable and trackable. Without a way to measure progress towards your goals, you can't make improvements or adjustments.

2.4.2.2. Disadvantages of KPIs

- Close learning gaps: KPIs help you recognize and address learning gaps. If you're not reaching an objective or goal, it may indicate that your employees need further training.
- Empower employees to take action: Clear KPIs drive your employees to action and direct them along the way.
- Measure outcomes and results: KPIs allow you to measure outcomes and results. A good KPI, by definition, should be measurable and trackable. Without a way to measure progress towards your goals, you can't make improvements or adjustments.

2.4.3. Categories of KPIs of Purchasing department

2.4.3.1. Delivery

This KPI measures how well the purchasing department is when it comes to finding what the organization needs when it needs it. The company should not penalize a supplier for missing delivery dates if the lead time required by the supplier is not compiled by the company or a change was requested at the purchase order. These two situations need to be taken into consideration when calculating this metric.

How to measure: **Number of on-time deliveries / Total number of deliveries per supplier.**

2.4.3.2. Supplier lead time

It's the average amount of time spent from the moment of the order placement until the delivery. This metric is also measured in days and must be measured per supplier. It relates directly to the Delivery KPI.

How to measure: **Moment of delivery – Moment of order.**

2.4.3.3. Quality

It's important to keep track of the quality standards, which means knowing exactly if the goods are purchased to fulfill the needs of the company. If they do, great. If not, a change of supplier may be necessary.

How to measure: **Amount of rejected items / Total amount of items ordered.**

2.4.3.4. Cost

Here, we are looking at 3 metrics.

Number one is Cost Avoidance, which helps the purchasing team find the lowest price for the same good among suppliers. Here's how you calculate it: **Actual Purchasing Price – Lowest Price Quoted.**

Number two, Cost Saving. This indicator differs from the latter as it shows how much the department has been able to save when buying the same good, from the same supplier, for the second time, for a lower price. It demonstrates how well the department is at negotiating. It can be calculated as **Actual Purchasing Price – Last Price Paid.**

Last, but not least, is the well-known ROI, Return over Investment. It shows if investments were made wisely if the return is positive. If it's negative, it means that something went wrong in the process, and the company is losing money.

$$\text{ROI} = (\text{Cost Saving} + \text{Cost Avoidance}) / \text{Cost of Purchasing Operation}$$

2.5. MDX language for analyzing multidimensional data and OLAP

2.5.1. What is MDX language?

Multidimensional Expressions (MDX) is a query language for handling multidimensional data. Microsoft uses this language to work with these types of data sets in server analysis. Multidimensional data is created when the contents of a data set exceed two dimensions, and when traditional Structured Query Language (SQL) no longer serves as a sufficient extractor.

2.5.2. OLAP technique

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.

OLAP databases are divided into one or more cubes. The cubes are designed in such a way that creating and viewing reports become easy. OLAP stands for Online Analytical Processing.

2.5.3. MDX method and structure

As the SELECT statement in MDX specifies a result set that contains a subset of multidimensional data returned from the cube, to define this set an MDX query must contain the following clauses:

- WITH clause: allows to calculate of 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).

CHAPTER 3. REQUIREMENTS ANALYTICS AND INTRODUCTION TO BI SOLUTION

3.1. Business processes of Purchasing

3.1.1. Purchasing department

All businesses need specific goods, materials, and equipment to manufacture products, offer goods for sale to customers, or perform the services they are selling. Someone has to ensure that these goods are bought into the company, in the right volume and at the right time, to meet the company's requirements. That role falls to the purchasing, or purchase, department.

The role itself is a broad one, covering such areas as market analysis, negotiations with suppliers and producers, transport, storage options, procurement technologies, and order times to ensure that goods are bought as economically and time-efficiently as possible.

At Adventure Works Cycles, the Purchasing department buys raw materials and parts used in the manufacture of Adventure Works Cycles bicycles. Adventure Works Cycles also purchases products for resale, such as bicycle apparel and bicycle add-ons like water bottles and pumps. The information about these products and vendors from whom parts are stored in the AdventureWorks database.

3.1.2. The purpose of Purchasing

3.1.2.1. Needs and Supplier analysis

The purchasing department will analyze the supplier's market to see if the company is using the right supplier, at the right price point, to meet its business needs. The team might compare multiple suppliers, including those based in other countries, to prepare a shortlist of possible suppliers.

3.1.2.2. Award supplier contracts

The team will be looking at each supplier's cost, quality, reputation, reliability, production capacity, and delivery schedules before awarding a supplier contract. A

supplier's inability to meet any of these requirements could result in significant losses for the company so it's important to get these decisions right. In large companies, the department might also be making decisions about whether to make the products in-house.

3.1.2.3. Supplier selection and Relationships

It's not unusual for larger companies to have multiple suppliers on their books, and an essential role of the purchasing department is to manage and maintain these relationships. Close cooperation with key suppliers means you can share knowledge about market shifts, new products, and technologies, or other factors that could help you stay ahead of the competition.

3.1.2.4. Ordering and Inventory control

Running out of products means you lose sales and your customers may turn to competitors to get the products they need. Generally, the purchasing department will have systems in place which trigger a stock order whenever a certain quantity of inventory is reached. For those that use a merchandise management system, the minimum stock and the order quantity are generally predefined and are automatically ordered by the software.

3.1.2.5. Compliance and Quality control

One essential role of the purchasing department is to analyze and measure performance data to ensure that suppliers are achieving the desired outcomes, following the company's procurement strategy. For example, the department might measure:

- The percentage of products delivered on time.
- The number of suppliers used and how much product they supply.
- Supplier availability.
- Lead times.
- Product defect rates.

These metrics enable the purchasing department to assess how well suppliers are fulfilling the company's requirements, how well they respond to urgent demand, and whether a company is over-relying on just one or two key suppliers which could leave the

company vulnerable if the supplier goes bust. Armed with this data, the purchasing department can then revisit the strategic plan and make adjustments as necessary.

3.1.3. Purchasing process

Every business will have its unique touches to add, but generally speaking, the purchasing process follows a well-established pattern of events.



Figure 3.1. Purchasing process steps (Source: Planergy)

- **Needs analysis**

At this stage, the company recognizes and documents a need for goods or services to solve a particular problem.

- **Purchase Requisition to Purchase Order**

The “purchasing” portion of the purchasing process kicks off with a purchase requisition submitted to the purchasing department or purchasing manager by the individual, team, or department requesting the goods or services.

- **Purchase Order review and approval**

Approved purchase orders are sent to accounting to verify the funds exist in the appropriate budget to cover the requested goods and services.

- **Requests for Proposal**

POs that receive budget approval is returned to the procurement department and, as required, used to create requests for proposal (RFPs), also known as requests for quotation, or RFQs.

- **Contract negotiation and approval**

The vendor with the winning bid is then awarded a contract, which is further refined before signing to ensure optimal terms and conditions and to ensure a mutually satisfactory arrangement for both parties.

- **Shipping and Receiving**

The supplier delivers the goods or services within the agreed-upon timeframe.

- **Three-way matching**

Three-way matching is the comparison of shipping documents/packing slips with the original purchase order and the invoice issued by the supplier. This comparison is used to ensure all the information related to the transaction is accurate.

- **Invoice approval and Payment**

Successfully matched orders are approved for payment. Any modifications or additional charges may require another layer of approvals before payment can be issued.

- **Accounting records update**

Completed orders are recorded in the company's books, and all documents related to the transaction are securely stored in a centralized location.

3.2. Data source and challenges

3.2.1. Data source

The data in the AdventureWorks2014 version of the database pertains to the years 2010-2014. It includes two Microsoft SQL Server databases. The first is an online transaction processing (OLTP) database, which is rich in structure, content, and variety. The second is a data warehouse, which is useful for online analytical processing (OLAP) and data mining, as well as teaching data warehouse concepts and structures.

The OLTP database consists of 71 tables grouped into five schemas related to Adventure Works' business model: Sales, Purchasing, Production, Human Resources, and Person. The database (in its raw state) contains data of almost 20,000 people (employees, customers, store contacts, vendor contacts, and general contacts). It also contains data of over 31,000 sales transactions to customers and over 4000 purchasing transactions from suppliers. Several advanced data types are demonstrated in the AdventureWorks OLTP database, including bitmapped product photographs, XML documents, and hierarchy id fields for representing hierarchical data relationships.

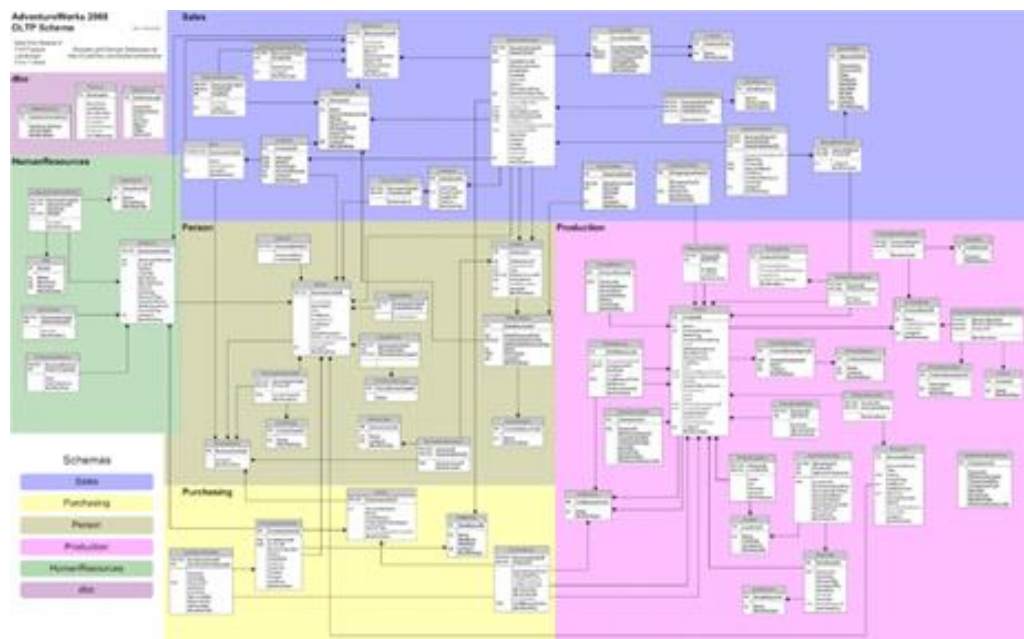


Figure 3.2. AdventureWorks OLTP schema

There are 5 tables in Purchasing module with the description below:

No.	Table Name	Description
1	Purchasing.ProductVendor	Cross-reference table mapping vendors with the products they supply.
2	Purchasing.PurchaseOrderDetail	Individual products are associated with a specific purchase order.
3	Purchasing.PurchaseOrderHeader	General purchase order information.

4	Purchasing.ShipMethod	Shipping company lookup table
5	Purchasing.Vendor	Companies from whom Adventure Works Cycles purchases parts or other goods.

Table 3.1. Table description of Purchasing module in AdventureWorks database

3.2.2. Challenges

- Inconsistent, clear information: information on product status is not circulated seamlessly and lack of information on product quality causes process delays and product quality takes a long time to edit and improve benevolent. The information processing process is cumbersome, time-consuming but inefficient.
- The information is not continuously circulated between departments, for example, lack of production or confusion about sales, material demand, product the demand forecast is not accurate.
- Information is easily lost, poor security: documents and records arising in the processing process are not closely linked, decentralized use and monitoring easily create vulnerabilities and are at risk of being stolen. take advantage of the company.

3.3. Business requirements analysis of Purchasing

3.3.1. Products comparison

Making a decision on which vendor should be chosen is always a pain if there is some lack of information. So, we can create a table where the products can be listed with different vendors and different prices. This can help the selection process to be more efficient as it is informative.

3.3.2. Monthly report of price list

The fact that the sales reps are out in the field most of the time makes it difficult for them to keep their price lists current. The price list changes fairly often, but only a few things on the list change. It would be great to get a report to the sales reps that flagged changes and special offers, and maybe even highlighted the relevant customers.

3.3.3. Actual and standard costs comparison

Standard costs are the estimated costs of labor, material, and other costs of production. Actual Costs, on the other hand, are those realized during the period and compared at the end of the period. By comparing, we can acknowledge the difference between the standard cost vs actual cost is termed as Variance. If the Actual cost is higher than the standard, it creates an unfavorable variance.

3.3.4. Vendor rating

Vendor rating is a system used by buying organizations or industry analysts to record, analyze, rank, and report the performance of a supplier in terms of a range of predefined criteria, which may include such things as the Quality of the product or service.

We know that some factors affect the vendor rating. While evaluating suppliers, buyers usually consider the following things.

- **Quality:** The quality of the products or goods that the vendor supplies are the main factor. The vendor can maintain good quality by improving the process of production, having quality planning in the supply chain.
- **Delivery:** Supplier has to develop the ability to deliver the goods on a scheduled date.
- **Lead time:** It is one of the important criteria for the supplier. Lead time is a period between the actual delivery day and order placement day. The shortest lead time helps to get a good impression on the supplier.
- **Price:** A company always wants to get the materials at less price so that it can reduce its manufacturing cost to increase its profit. Hence the vendor needs to set a competitive price for his products.

3.3.5. Purchase return

A purchase return occurs is when the buyer of merchandise, inventory, fixed assets, or other items sends these goods back to the seller. Excessive purchase returns can

interfere with the profitability of a business, so they should be closely monitored. There are several reasons for purchase returns, such as:

- The buyer initially acquired an excessive quantity and wants to return the remainder
- The buyer acquired the wrong goods
- The seller sent the wrong goods
- The goods have proven to be inadequate in some way.

3.4. IT requirements analysis (IT & Infrastructure)

3.4.1. Availability and Scalability

The solution automatically scales the resources to contain varying throughput at different times a day. The system provided for high availability through means such as redundant backup servers.

3.4.2. Data source and connectivity

The solution connects to popular cloud storage and synchronization systems like Google Drive, OneDrive, Dropbox, etc., and relational databases such as Oracle, SQL Server, MySQL.

3.4.3. Security

The system enables applying object-level security policies and defining which visualizations, reports, dashboards, worksheets, and other objects are revealed to any given user, user groups, or user roles.

3.5. Comparative analysis of BI and Data Visualization Tools

3.5.1. Surveying and evaluation

Software	Price	Features	Time	User	Cloud
MS Excel	+ \$139,99 + \$6,99 <i>(per month</i>	+ Inserting a pivot table + Sorting of tabulated	Lifetime Month	1	Supported

	<i>with Microsoft 365)</i>	data + Adding formulas to the sheet + Calculating large data			
Tableau	+ \$70: Tableau Creator + \$35: Tableau Explorer + \$12: Tableau Viewer	+ Tableau Dashboard + Connect to data on-prem or in the cloud + Quickly build powerful calculations from existing data + Forecasts, and review statistical summaries + Create interactive maps automatically + Analyzing interactive visualizations with fresh data + Big data, live or in-memory + Sharing and collaborating securely + Mobile view	Month	1	Supported
QLik	\$30	+ Shared object library	Month	1	Supported

		<ul style="list-style-type: none"> + Data storytelling functionality + Drag and drop visualizations + Rapid development environment + Powerful open and standard APIs + Self-services simplicity + Smart search feature +Enterprise-level security 			
Power BI	<ul style="list-style-type: none"> + Free: Power BI Desktop + \$9.99: Power BI Pro + \$20: Power BI Premium 	<ul style="list-style-type: none"> + Collaboration and analytics + Build your business on secure data analytics + Unify self-service and enterprise analytics + Accelerate big data prep with Azure + Find answers fast with industry-leading AI + Improve publishing 	Month	1	Supported

		efficiency and accuracy of BI content + Get unparalleled Excel integration + Stream analytics in real-time			
SSAS	Free	+ Tabular model compatibility level + Query interleaving + Calculation groups in tabular models + Governance setting for Power BI cache refreshes + Online attach + Many-to-many relationships in tabular models + Memory settings for resource governance	Lifetime	1	Supported
SAP Business Objects BI	+ \$50.000: Basic implementation + \$104.000: Typical	+ Empower business users to understand trends and root causes with ad hoc queries and BI reporting + Build impactful visualizations,	Year	8-50	Supported

	implementation + \$190.000: Comprehensive implementation	dashboards, and applications to assess risk, improve efficiency, and identify opportunities. + Connect with SAP Business Warehouse and SAP HANA to power real-time analytics. + Analyze large data sets to discover in- depth business insights and forecast business drivers using Microsoft Excel. + Share discoveries by embedding data analytics information into Microsoft PowerPoint presentations.			
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Table 3.2. BI tools survey

3.5.2. Proposing BI solution for the project

Like all organizations, Adventure Works Cycles has massive quantities of raw data that need to be analyzed for trends, associations, predictions, baselining, and so on to give insights and competitive advantage. A business intelligence system not only enables the raw data to be appropriately stored and organized in a suitable data warehouse

environment but also modeled and architected such that the raw data is turned into useful information.

We defined a general structure of a BI solution, existing of five components: data source, integration services, data repositories, data analytics, and data visualization. The BI solution for this project is depicted in the figure below:

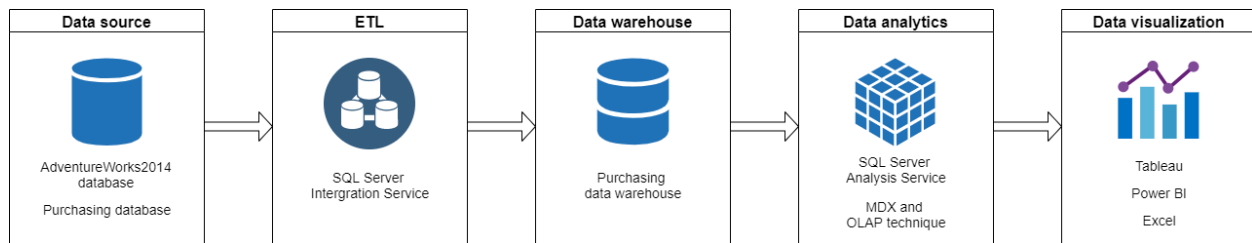


Figure 3.3. BI solution for the project

In this project, we will use a data source named the AdventureWorks2014 database which is created by Microsoft for studying and researching. Our team's function within this project is called “Purchasing” - a department that handles all of the paperwork associated with the purchase and delivery of supplies and materials.

Next, we will integrate data by using the ETL (Extract-Transform-Load) concept to extract data from a database, modify it, and place it into another database. More specifically, we use SQL Server Integration Services which is part of the Microsoft SQL Server data software. It is an ETL tool that is part of Microsoft's Business Intelligence Suite and is used mainly to achieve data integration. After building the data warehouse, we will use the SQL Server Analysis Service, as well as the MDX and OLAP techniques, to create a presentation for the data warehouse's information, visualizing it to assist the manager in making a better decision.

Then, we finally decided to use Tableau as the main BI tool, along with two other tools, Power BI and Excel to visualize appropriate outcome results based on our expected requirements for the project. They are powerful BI tools that help people to be able to view their results practically by visualizing those requirements. We expected that with those tools, we can give the best suitable solutions for solving our given requirements for

the Purchasing module of the AdventureWorks database and give an objective look for people who care about this database to overview and understand it.

CHAPTER 4. BUILDING DATA WAREHOUSE AND INTEGRATING DATA

In this chapter, we will present detail about the building data warehouse process for the purchasing module as well as integrate data from the Adventureworks2014 data sample into our data warehouse.

4.1. Designing data warehouse

4.1.1. Bus matrix

After study about Adventureworks2014 data schema, we use the Bus Matrix to separate the purchasing process into specific tasks and compare them with some common Dimensions.

<div style="text-align: right;">Dimension</div> <div style="text-align: left;">Process</div>	Date	Product	Vendor	ShipMethod	Employee
Issues Purchase Requisition	X	X			X
Receives Quotation	X	X	X		
Issues Purchase Order	X	X	X		
Receives Goods	X	X	X	X	X
Receives Invoice	X	X			
Returns to Vendor	X	X	X		X
Sends Payment	X	X	X		

Table 4.1. Bus Matrix for purchasing module

By analyzing the Bus Matrix table above, we learn that the purchase module interacts with 5 common Dimensions tables such as date, product, vendor, ship method,

and employee. We will detail the data source to build these Dimension tables further in this chapter.

4.1.2. Master data

Master data is data used to build Dimension tables in the Data Warehouse, including tables:

No.	Objects	Description
1	Product	Products information.
2	ShipMethod	Information about shipment methods.
3	Vendor	Suppliers information.
4	Address	Employee's and client's address information.
5	StateProvince	Cities information.
6	Employee	Employee's specific information.
7	Person	Employees' and clients' information.
8	EmailAddress	Employees' and clients' email information.

Table 4.2. Master data table

4.1.3. Transaction data

Transaction data is data used to build Fact tables in the Data Warehouse, including tables:

No.	Objects	Description
1	ProductVendor	Information about supplier's products such as name, price, quantity, cost, etc.
2	UnitMeasure	Information about the unit measure.
3	PurchaseOrderHeader	A detailed description of each purchase order, the transactions are shown by the total cost for products, the total amount of tax value, the employee assign the

		purchase order, product delivery methods, and the shipping cost for that order.
4	PurchaseOrderDetail	A detailed description of each item line in the purchase order such as product name, quantity, product price at a specific time.

Table 4.3 Transaction data table

4.1.4. Fact and dimension tables

With the business requirements mention in chapter 3, information is collected to help the users maintain and compare products from different suppliers, easy to determine the most profitable way to acquire items use for fulfillment and production process. Easily grasping the flow of important factors in several required Dimensions to build the Data Warehouse schema.

AdventureWorks2014		AdventureWorksDW		Data Type
Table	Column	Table	Column	
Product	ProductID	DimProduct	ProductKey	Int
			ProductID	Int
	ProductName		ProductName	Nvarchar(50)
	ProductNumber		ProductNumber	Nvarchar(25)
	Color		Color	Nvarchar(15)
	SafetyStockLevel		SafetyStockLevel	Smallint
	ReorderPoint		ReorderPoint	Smallint
	StandardCost		StandardCost	Money

	ListPrice		ListPrice	Money
	Size		Size	Nvarchar(5)
	Weight		Weight	Decimal(8,2)
	Class		Class	Nchar(2)
	Style		Style	Nchar(2)
		DimShipMethod	ShipMethodKey	Int
ShipMethod	ShipMethodID		ShipMethodID	Int
	Name		Name	Nvarchar(50)
	ShipBase		ShipBase	Money
	ShipRate		ShipRate	Money
		DimVendor	VendorKey	Int
Vendor	VendorID		VendorID	Int
	Name		VendorName	Nvarchar(50)
	PreferredVendorStatus		PreferredVendorStatus	Bit
	CreditRating		CreditRating	Tinyint
Address	AddressLine1		AddressLine1	Nvarchar(60)
	AddressLine2		AddressLine2	Nvarchar(60)
	City		City	Nvarchar(30)

StateProvince	Name		StateName	Nvarchar(50)
			EmployeeKey	Int
	BusinessEntityID		BusinessEntityID	Int
	JobTitle		JobTitle	Nvarchar(8)
Employee	BirthDate		BirthDate	Int
	Gender		Gender	Nchar(1)
	HireDate		HireDate	Int
	Title		Title	Nvarchar(8)
	FirstName		FirstName	Nvarchar(50)
Person	MiddleName	DimEmployee	MiddleName	Nvarchar(50)
	LastName		LastName	Nvarchar(50)
	AddressLine1		AddressLine1	Nvarchar(60)
Address	AddressLine2		AddressLine2	Nvarchar(60)
	City		City	Nvarchar(30)
EmailAddress	EmailAddress		EmailAddress	Nvarchar(50)
		FactProductVendor	FactProductVendorKey	Int

ProductVendor	ProductID		ProductKey	Int
	VendorID		VendorKey	Int
	AvarageLeadTime		AvarageLeadTime	Int
	StandardPrice		StandardPrice	Money
	LastReceiptCost		LastReceiptCost	Money
	LastReceiptDate		LastReceiptDate	Int
	MinOrderQty		MinOrderQty	Int
	MaxOrderQty		MaxOrderQty	Int
	OnOrderQty		OnOrderQty	Int
UnitMeasure	Name		Name	Nvarchar(50)
		FactPurchase	FactPurchaseKey	Int
PurchaseOrderHeader	Status		Status	Tinyint
	EmployeeID		EmployeeKey	Int
	VendorID		VendorKey	Int
	ShipMethodID		ShipMethodKey	Int
	OrderDate		OrderDate	Int
	ShipDate		ShipDate	Int
	Freight		Freight	Money
PurchaseOrderDetail	ProductID		ProductKey	Int
	LineTotal		LineTotal	Money
	Tax		Tax	Numeric(21,5)
	OrderQty		OrderQty	Smallint

	ReceivedQty		ReceivedQty	Decimal(8,2)
	RejectedQty		RejectedQty	Decimal(8,2)
	StockedQty		StockedQty	Decimal(9,2)
	UnitPrice		UnitPrice	Money
	DueDate		DueDate	Int

Table 4.3. Describe data mapping

4.1.5. Data warehouse model

By analyzing and describing the vital data source to build dimensions and morals for Data Warehouse. The recommended Data Warehouse model is the Star model, Fact and Dim tables are clear and easy to understand.

The Fact tables analyze the important factor to help the manager's decision. The FactProductVendor table will help the manager to compare the product from other vendors. The FactPurchase will describe the cost of each purchase order including time, price, and shipping cost.

The Dimension tables offer the manager specific information in the purchasing process such as DimVendor, DimProduct, DimEmployee, DimTime, and DimShipMethod.

All the Dimension and Fact tables will be described in the diagram below:

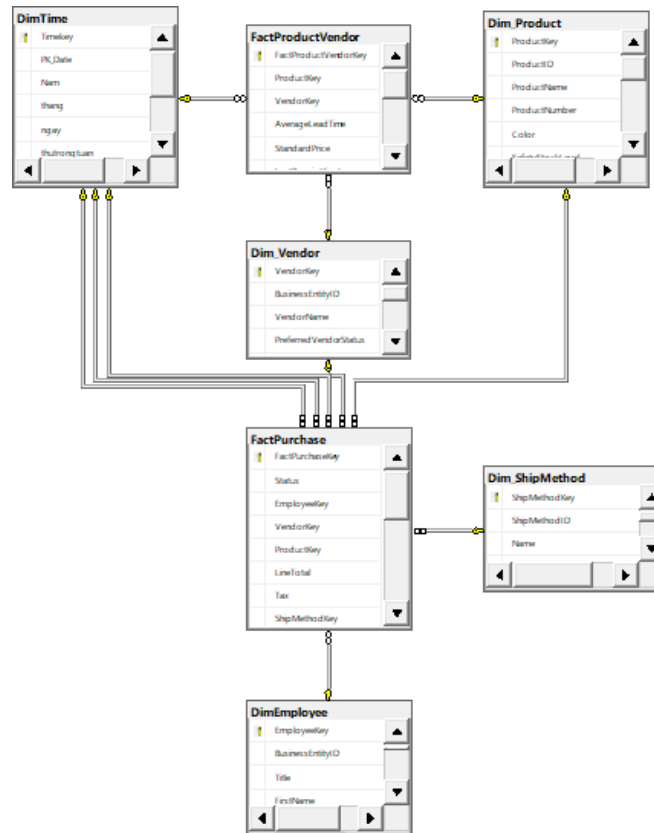


Figure 4.1. Data warehouse diagram

The description of Dimension and Fact tables in the Data warehouse:

No.	Objects	Description
1	DimProduct	Specific information about the product.
2	DimVendor	Specific vendor information.
3	DimShipMethod	Specific information about shipment method.
4	DimTime	Information about time.
5	DimEmployee	Specific employee information.
6	FactPurchase	Summary information about the product in each purchase order.
7	FactProductVendor	Detailed information about each vendor's product.

Figure 4.2. Description of Dimension and Fact tables

Using the described Dimension and Fact tables in the Data Warehouse, the manager can analyze necessary information about the current state of the procurement process to make a better decision to maximize the revenue for the company.

The relationships in Data Warehouse schema:

No.	Relationship	Relation type	Description
1	DimProduct – Fact ProductVendor	1 – n	One product can have one or multiple rows in the Fact ProductVendor table, and each row in the Fact ProductVendor table only has one product.
2	DimVendor – FactProductVendor	1 – n	One vendor can have one or multiple rows in the Fact ProductVendor table, and each row in the Fact ProductVendor table only has one vendor.
3	DimProduct – FactPurchase	1 – n	One product can have one or multiple rows in the FactPurchase table, and each row in the FactPurchase table only has one product.
4	DimVendor – FactPurchase	1 – n	One vendor can have one or multiple rows in the FactPurchase table, and each row in the FactPurchase table only has one vendor.
5	DimEmployee – FactPurchase	1 – n	One employee can have one or multiple rows in the FactPurchase table, and each row in the FactPurchase table only has one employee.
6	DimShipMethod –	1 – n	One ship method can have one or multiple

	FactPurchase		rows in the FactPurchase table, and each row in the FactPurchase table only has one ship method.
--	--------------	--	--

Table 4.4. Data Warehouse relationship

4.2. ETL processes

After building the Data Warehouse, we use the SSIS (SQL Server Integration Service) tool to transfer data from the data source into the Data Warehouse. Later in this section, we will present the ETL process for Dimension and Fact tables.

4.2.1. Dimension table's ETL process

In this section, we will present the specific ETL process for Dimension tables by using the DimProduct table as an example:

- Step 1: Setup the data flow task.

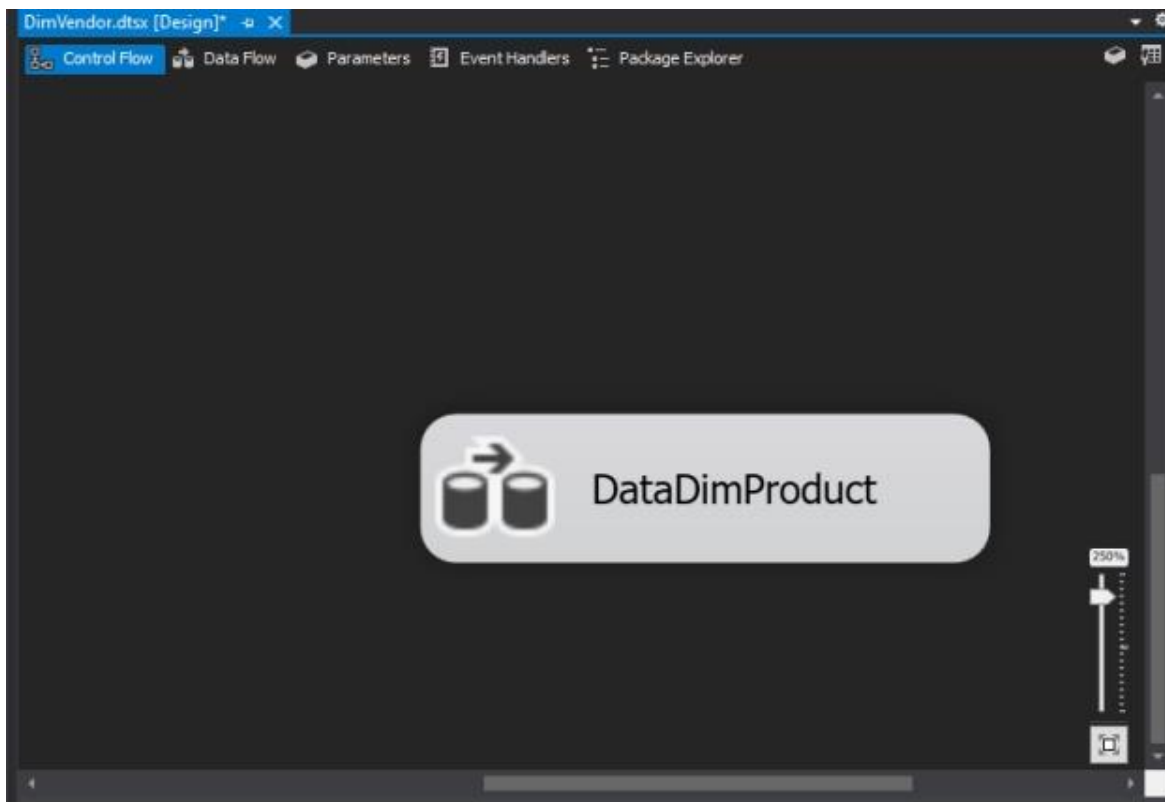


Figure 4.3. Setup the data flow task

- Step 2: Setup the OLE DB source.

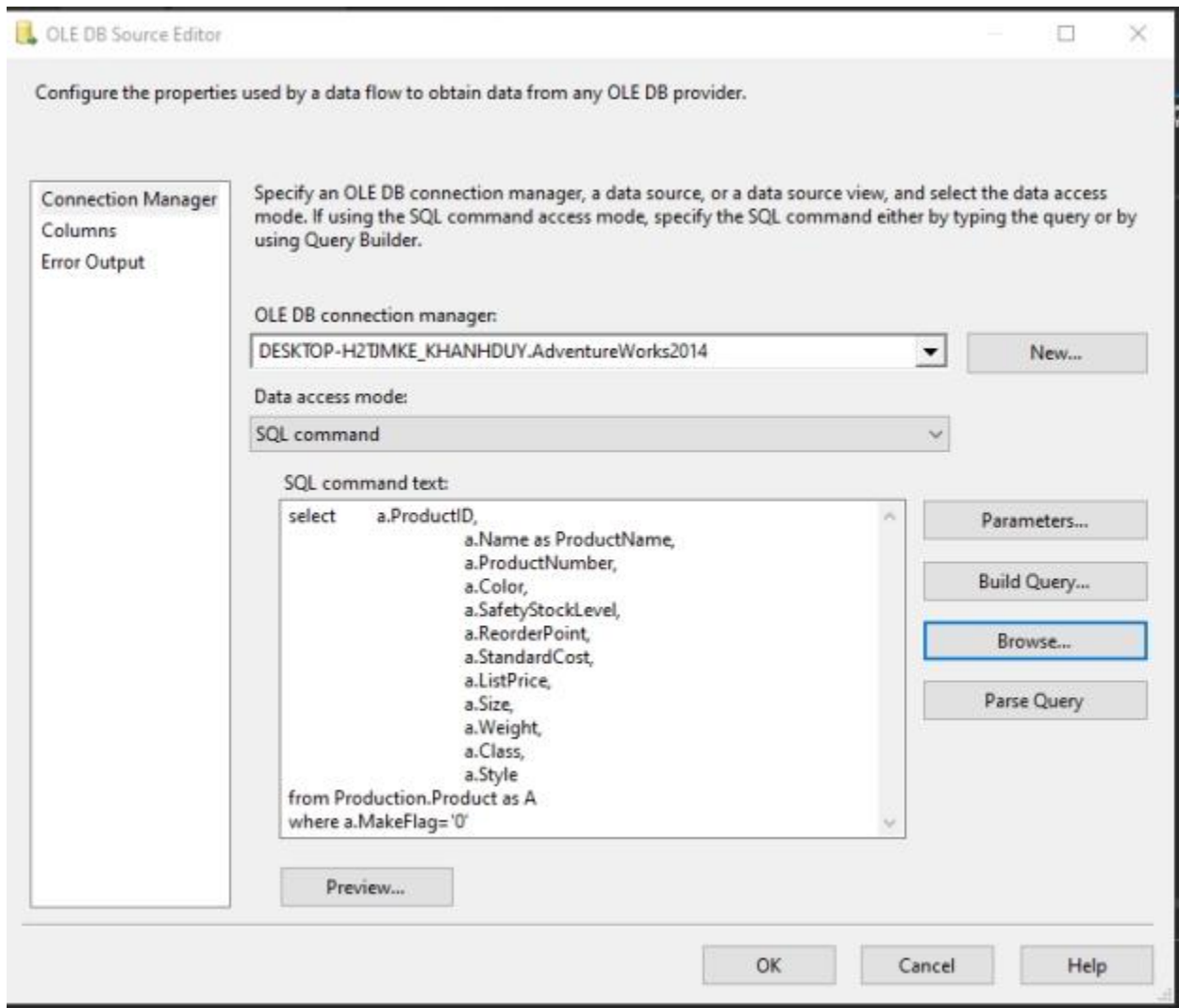


Figure 4.4. Setup the OLE DB source

- Step 3: Select column and business key.

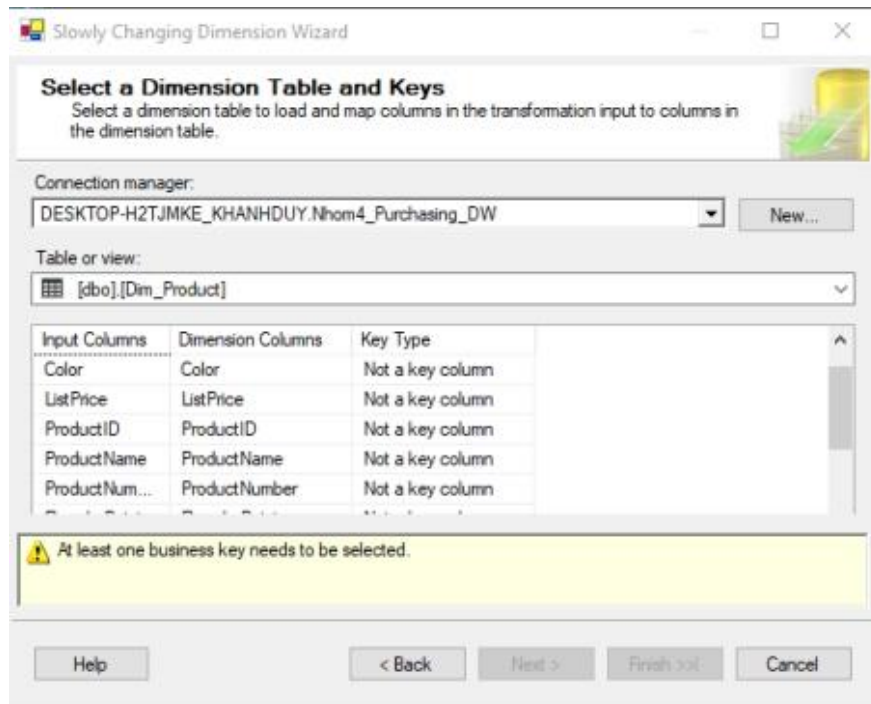


Figure 4.5. Select column and business key

- Step 4: Select column type.

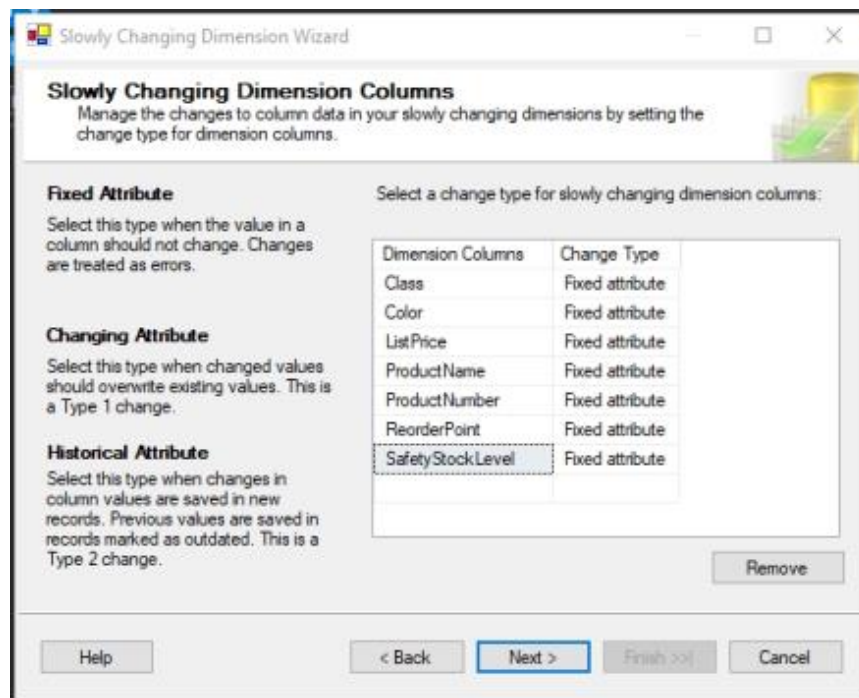


Figure 4.6. Select column type

- Step 5: Select the OLE DB destination.

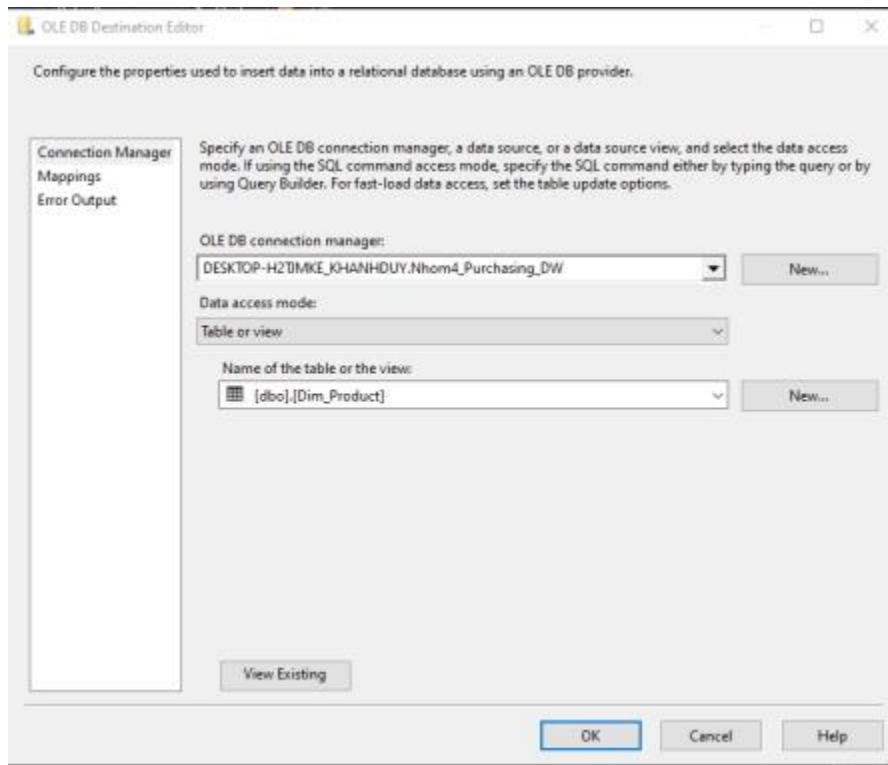


Figure 4.7. Select the OLE DB destination

- Step 6: Complete loading the data into the destination.

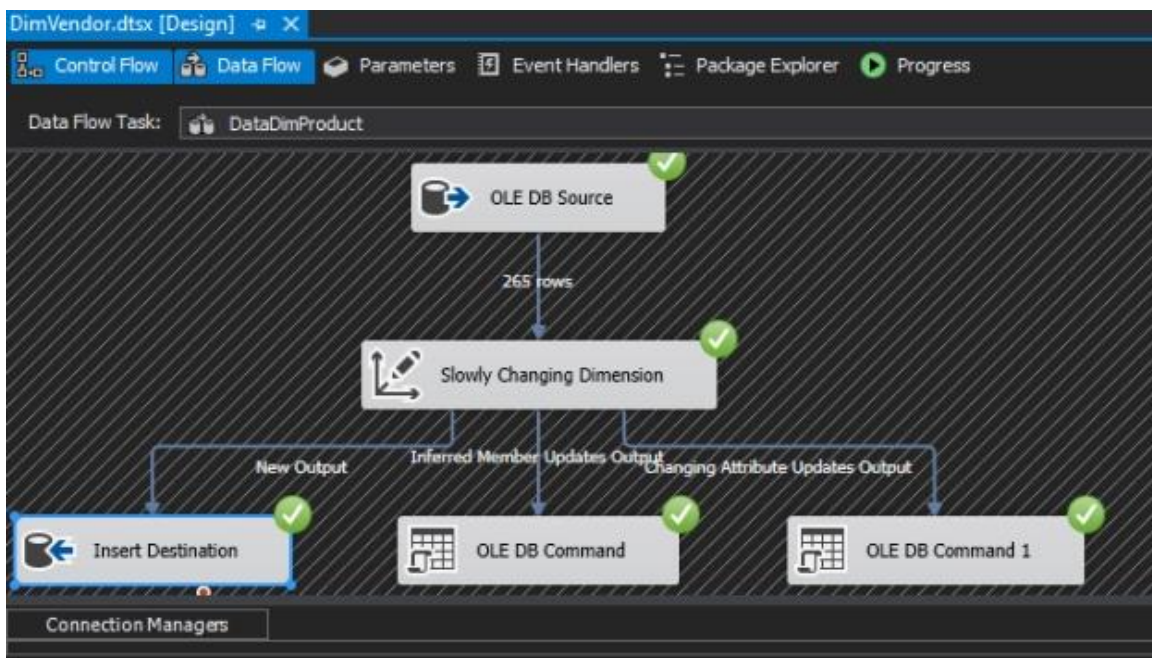


Figure 4.8. Complete loading the data into the destination

4.2.2. Fact table's ETL process

For the Fact table, we will use the FactProductVendor table to present the specific step in the ETL process.

- Step 1: Setup data flow task.

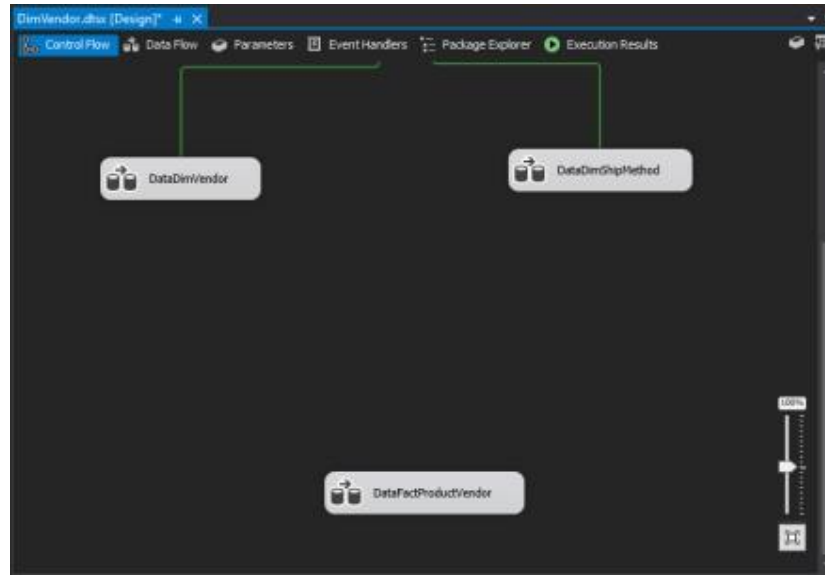


Figure 4.9. Setup data flow task

- Step 2: Setup data warehouse.

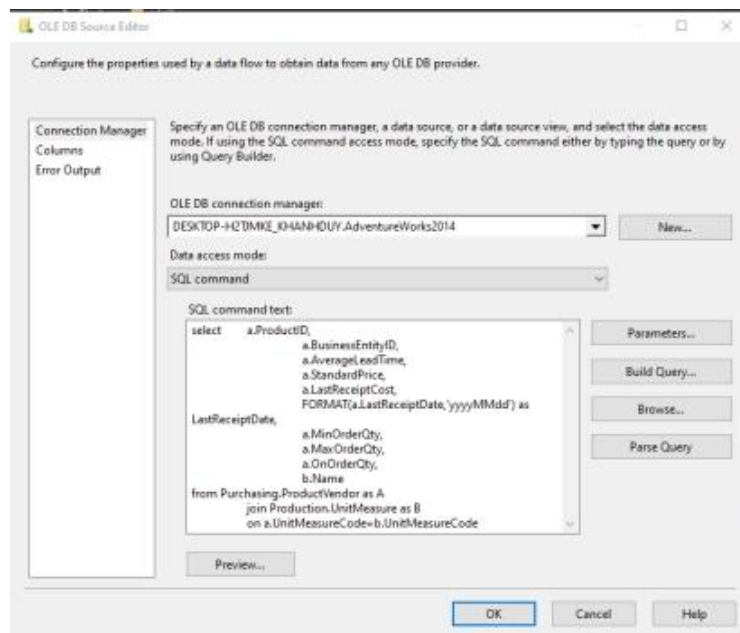


Figure 4.10. Setup data warehouse

- Step 3: Select table lookup.

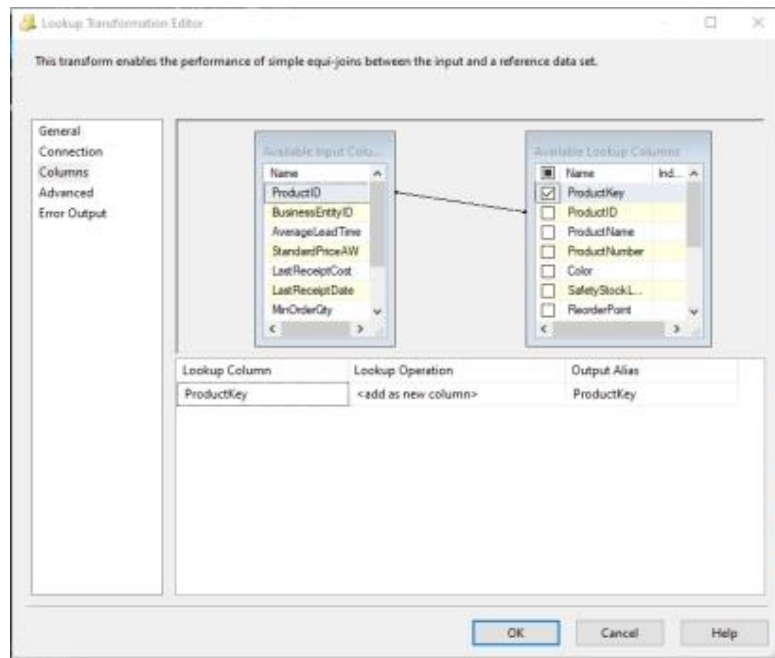


Figure 4.11. Select table lookup

- Step 4: Sort data based on the lookup key.

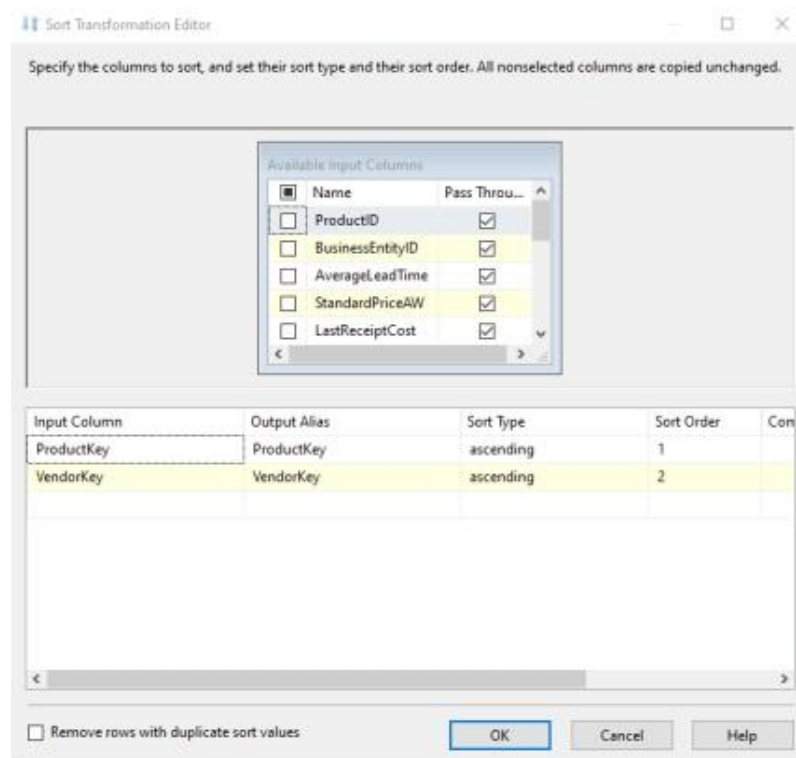


Figure 4.12. Sort data based on the lookup key

- Step 5: Setup OLE DB source.

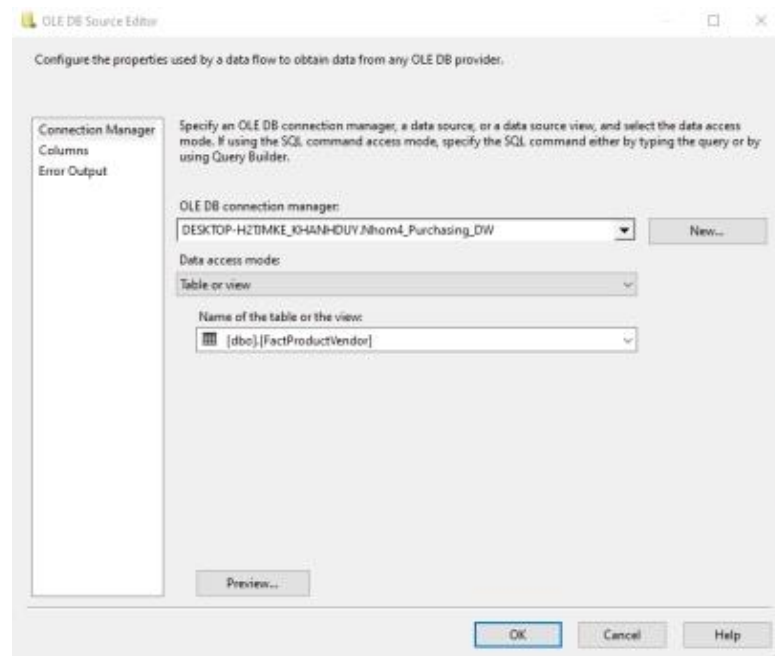


Figure 4.13. Setup OLE DB source

- Step 6: Sort data on DB based on the lookup key.

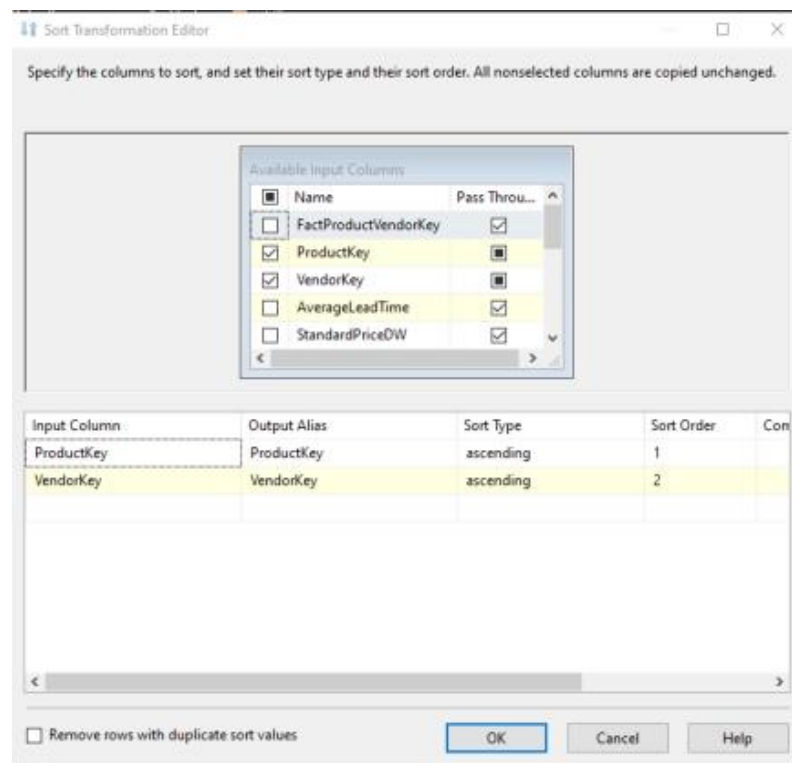


Figure 4.14. Sort data on DB based on the lookup key

- Step 7: Merger – synchronize data.

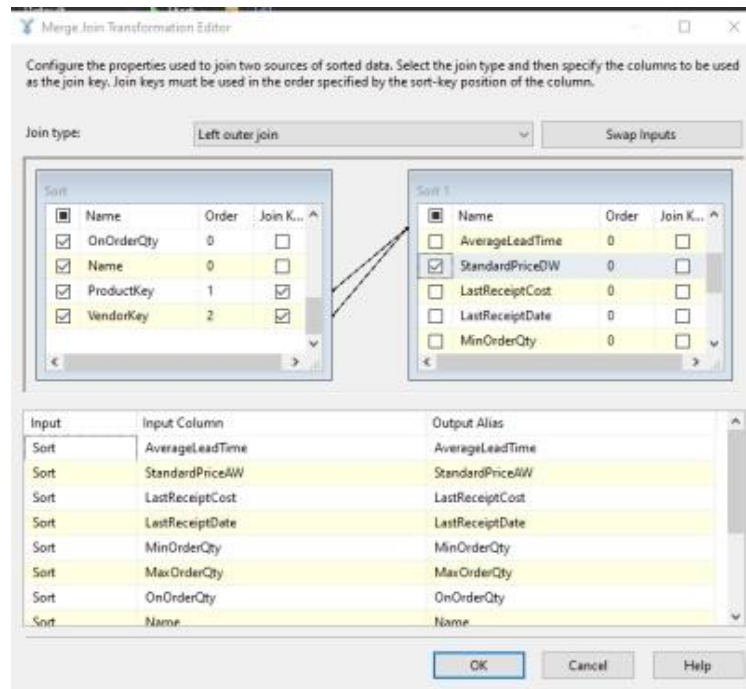


Figure 4.15. Merger – synchronize data

- Step 8: Setup conditional split.

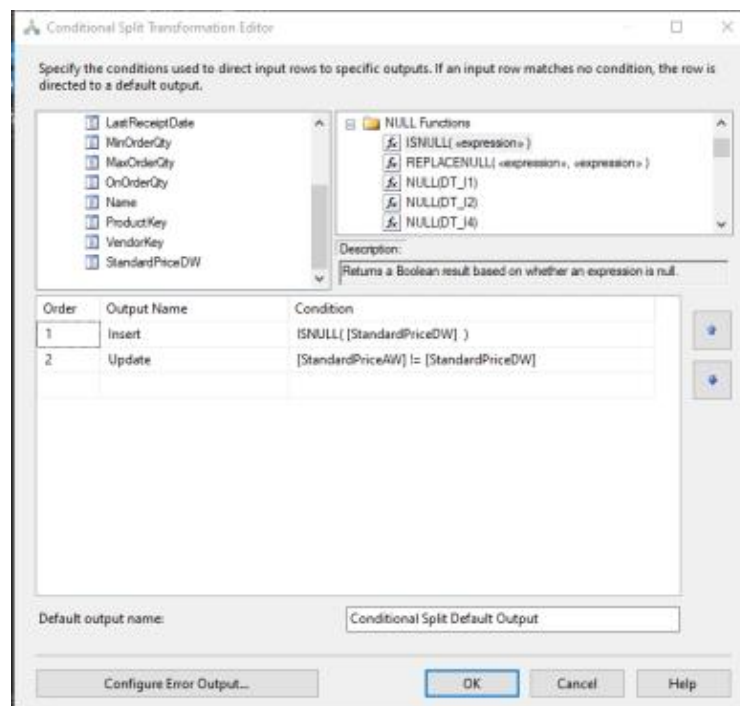


Figure 4.16. Setup conditional split

- Step 9: Setup OLE DB destination.

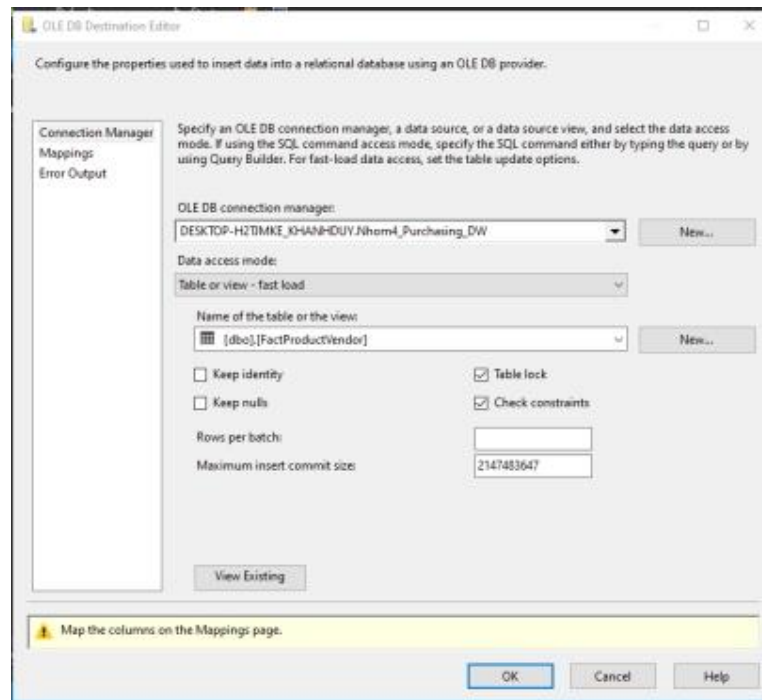


Figure 4.17. Setup OLE DB destination

- Step 10: Setup syntax update function.

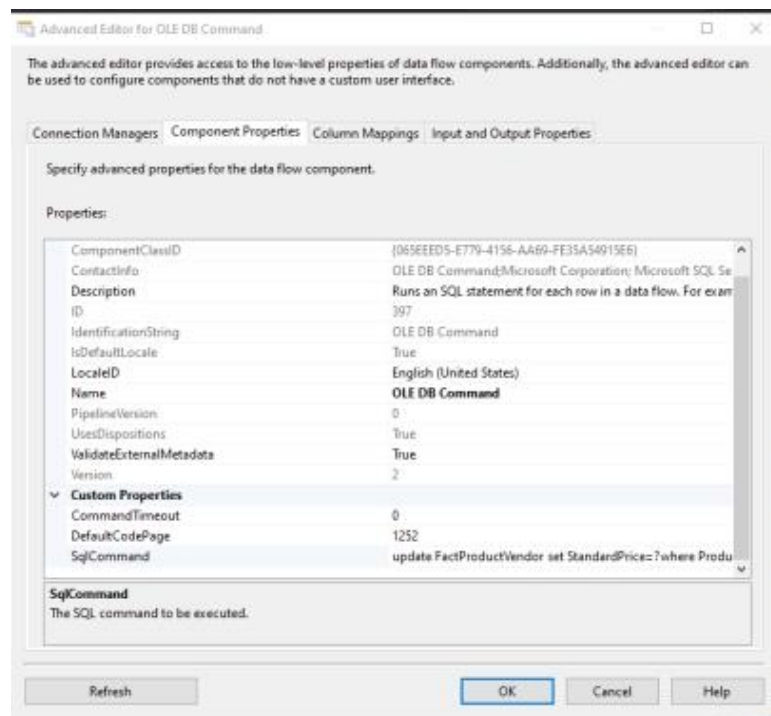


Figure 4.18. Setup syntax update function

- Step 11: Complete load data from the data source into the fact table.

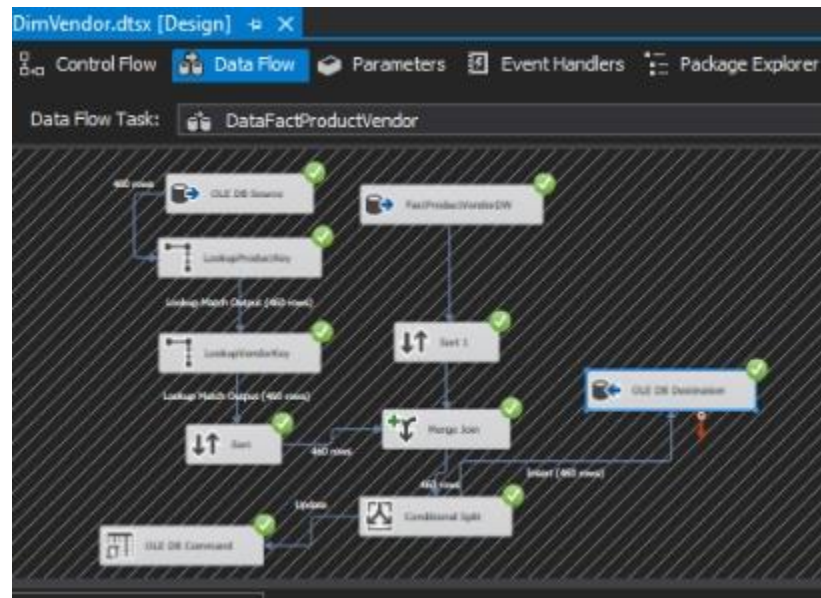


Figure 4.19. Complete load data from the data source into the fact table

After repeat the ETL process for all the Dimension and Fact tables in our Data Warehouse, we complete building and integrating data from the data source into our Data Warehouse to conduct analyst.

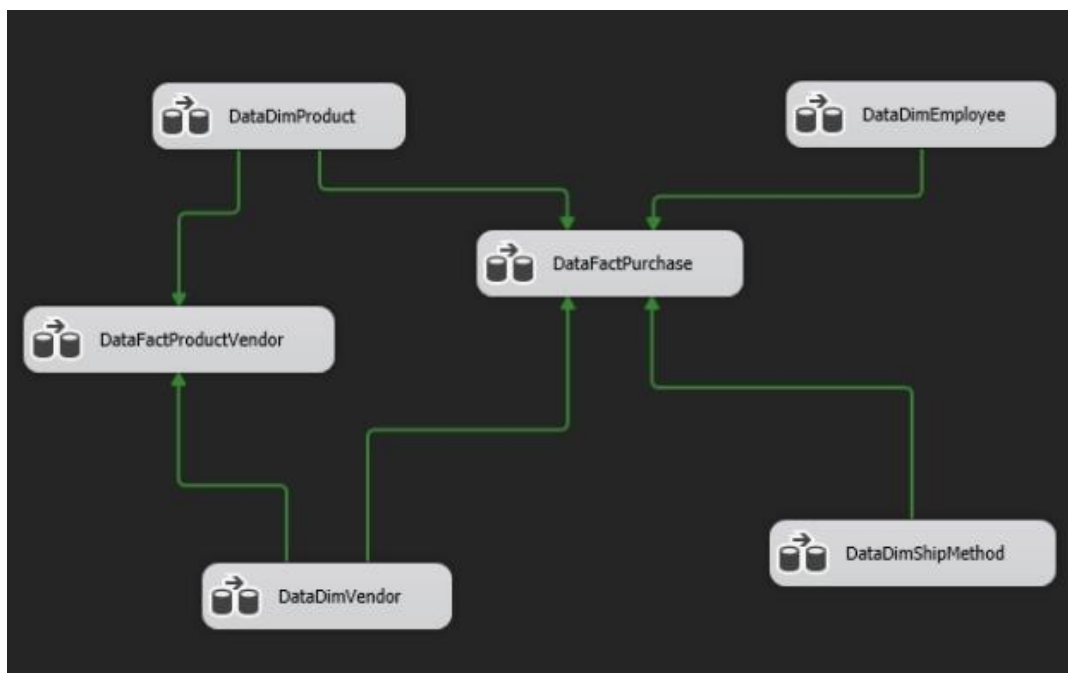


Figure 4.20. The ETL process for Purchasing data warehouse

CHAPTER 5. DATA ANALYTICS

In this chapter, we will use the SSAS technology and the MDX and OLAP technique to make a presentation for the information from the Data Warehouse and visualizing them to help the manager make a better decision.

5.1. Data analytics with SSAS technology

5.1.1. Building the cube

After successfully building the Data Warehouse, we use the SSAS tool (SQL Server Analysis Services) to analyze data in multi-dimension building blocks. The SSAS tool work based on the SSDT (SQL Server Data Tool) environment. We will detail the specific step for building the cube in the following section.

- Step 1: Create Data Sources.

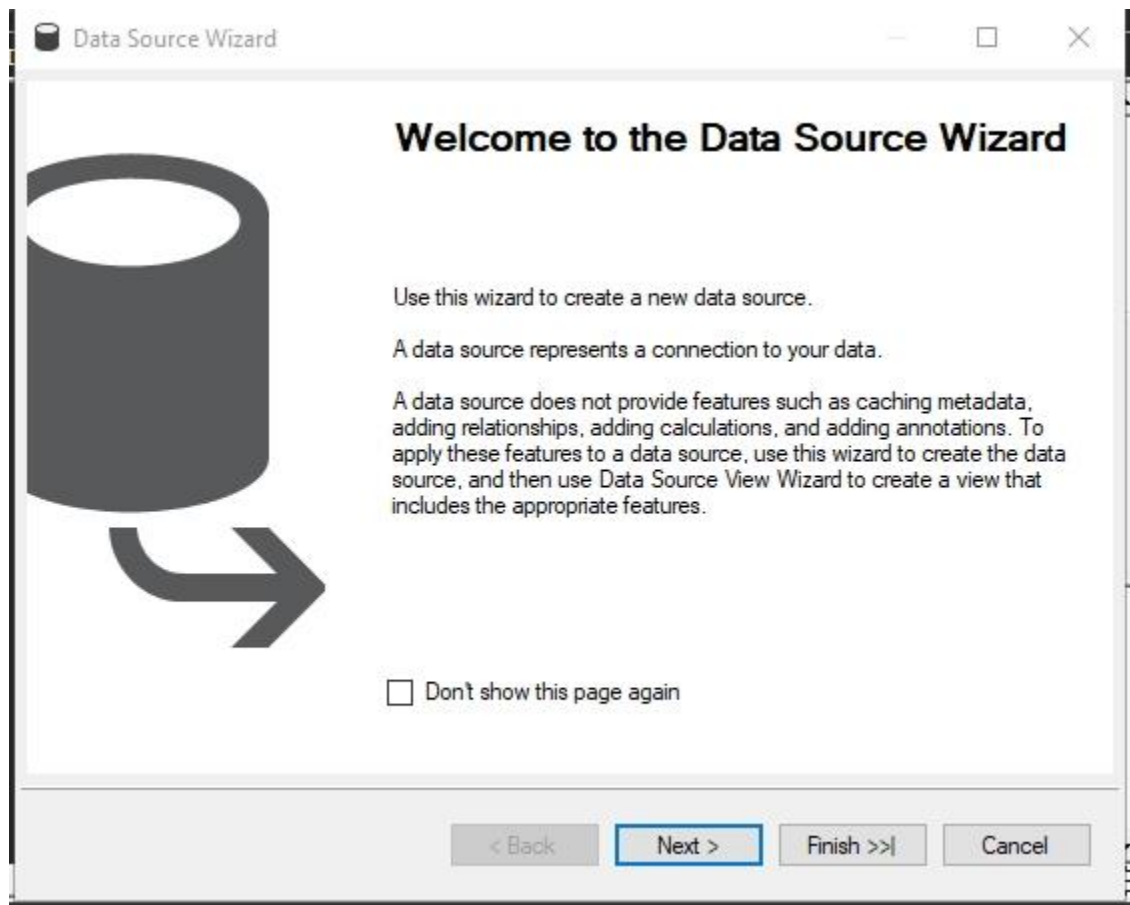


Figure 5.1. Create Data source

- Step 2: Choose your Data Warehouse.

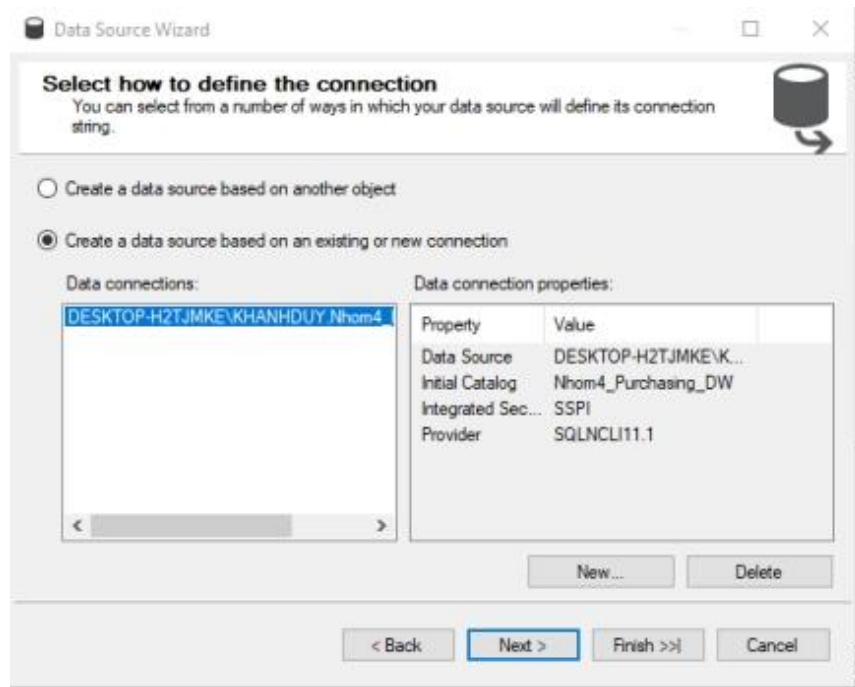


Figure 5.2. Choose your Data Warehouse

- Step 3: Select table and views, except the sysdiagrams table.

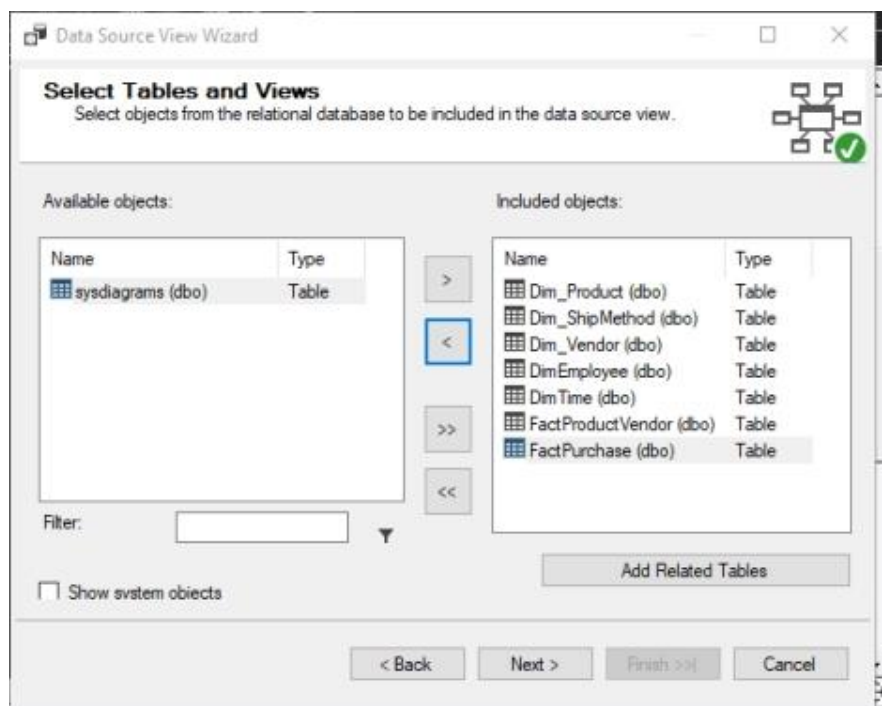


Figure 5.3. Select table and views, except the sysdiagrams table

- Step 4: Confirm the Data source view and click “Finish” to create the Data Source View.

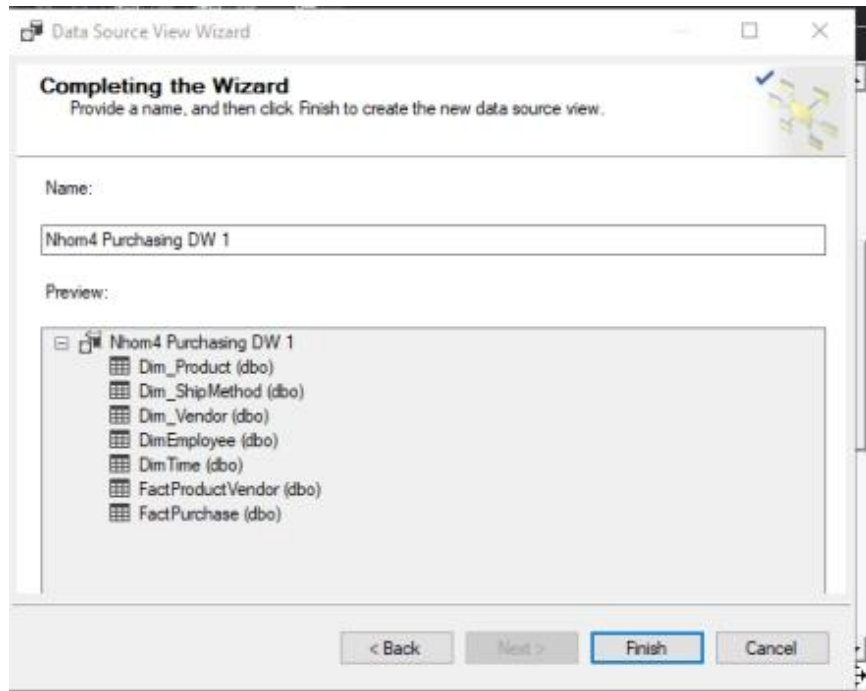


Figure 5.4. Confirm the Data source view

- Step 5: Create a Cube from the data source view.

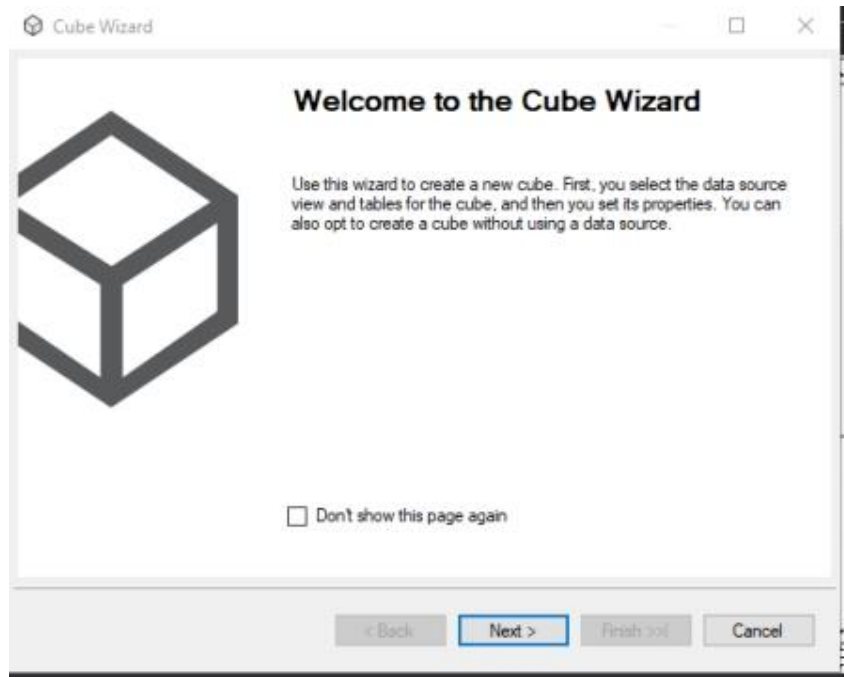


Figure 5.5. Create a Cube from the data source view

- Step 6: Select the measure you want to present in the Cube (mostly Fact table).

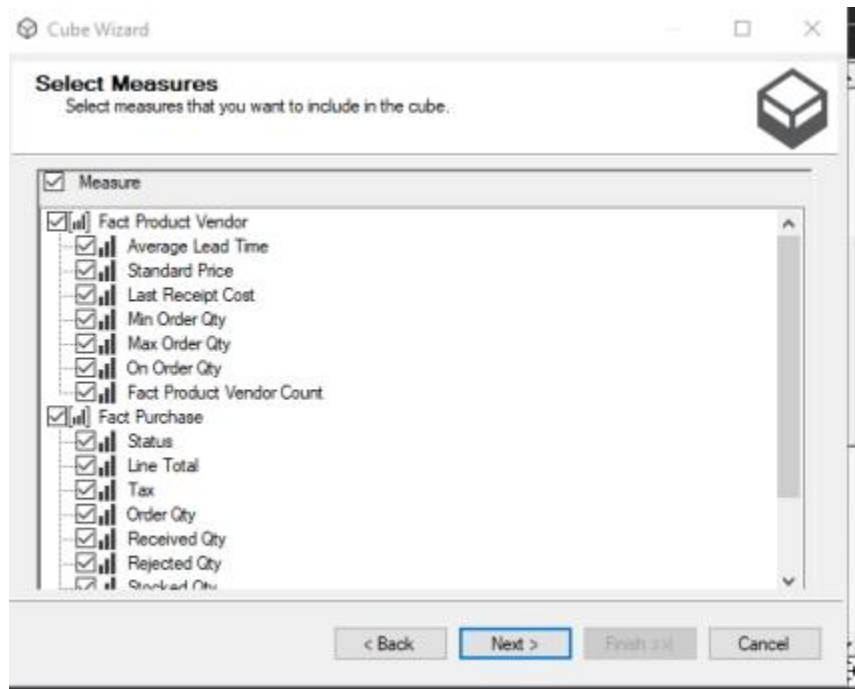


Figure 5.6. Select the measure

- Step 7: Select the dimension in the Cube.

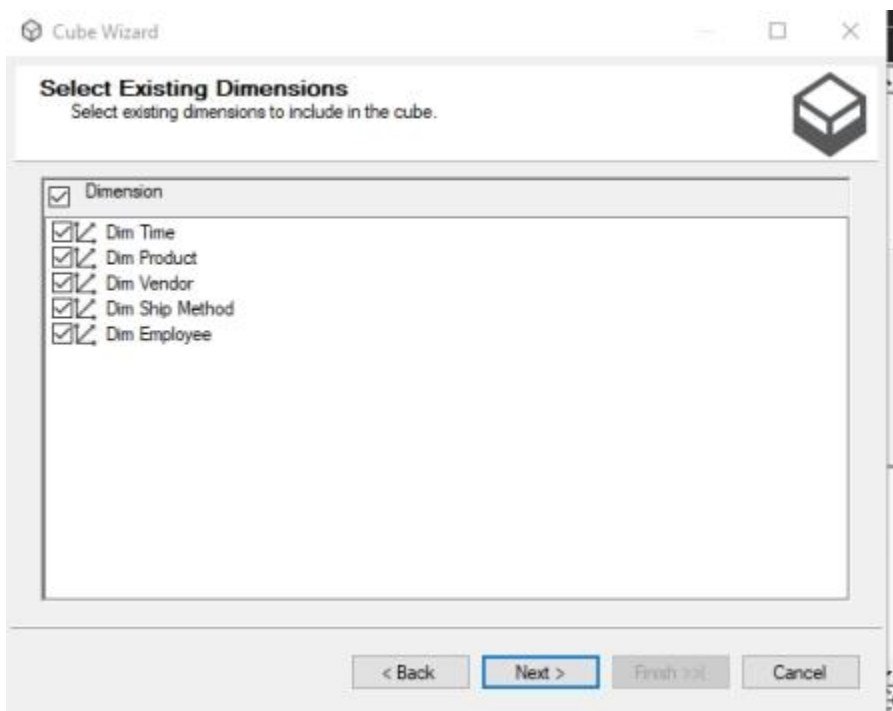


Figure 5.7. Select the dimension in the Cube

- Step 8: Confirm all the measures and dimensions in the Cube, and then click “Finish”.

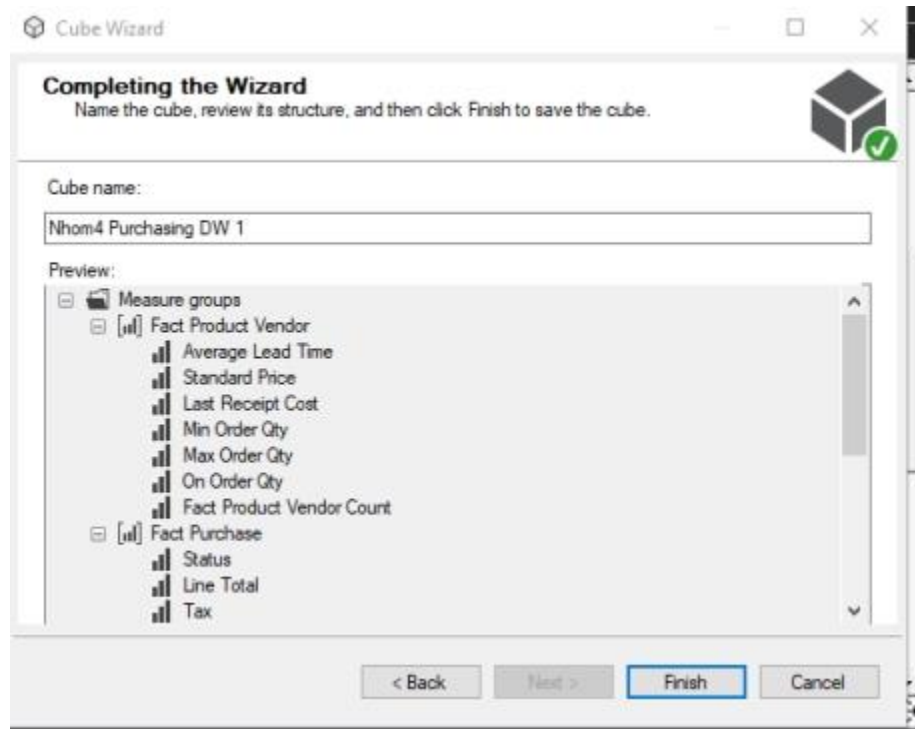


Figure 5.8. Confirm all the measures and dimensions

Completing all the steps above and is the menu you receive in the SSAS tool.

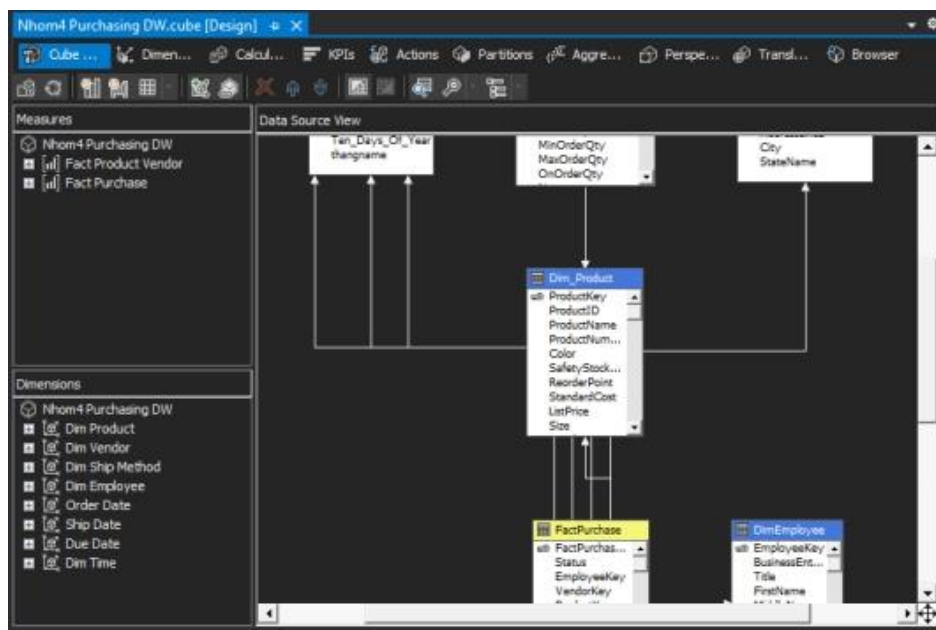


Figure 5.9. SSAS tool

5.1.2. Analysis with SSAS

5.1.2.1. Compare the average lead time the company received products from different vendors

Product Name	Vendor Name	Average Lead Time
Bike Wash - ...	Green Lake Bike Co...	45
Cable Lock	International Trek ...	10
Chain	Varsity Sport Co.	19
Chainring	Beaumont Bikes	17
Chainring	Bike Satellite Inc.	17
Chainring	Training Systems	19
Chainring Bolts	Beaumont Bikes	17
Chainring Bolts	Bike Satellite Inc.	17
Chainring Bolts	Training Systems	19
Chainring Nut	Beaumont Bikes	17
Chainring Nut	Bike Satellite Inc.	17
Chainring Nut	Training Systems	19
Classic Vest, L	Team Athletic Co.	35

Figure 5.10. The average lead time the company received products from different vendors

From the analysis of the average lead time, the company may receive the products from different vendors, the manager can choose the vendors that provided the products with the most efficient time for the company. In this case, we will choose the “Chainring” as our example, there are three different vendors that provide this product: Beaumont Bikes, Bike Satellite Inc., and Training Systems, if the company is needing the product as soon as possible the company may choose to order from Beaumont Bikes or Bike Satellite Inc. since their average lead time only 17 compared to 19 from Training System.

5.1.2.2. Compare the price of the products from different vendors

Product Name	Vendor Name	Standard Price
Adjustable R...	Litware, Inc.	47.87
All-Purpose B...	Green Lake ...	49
AWC Logo Cap	Integrated S...	6.55
Bearing Ball	Wood Fitness	39.92
Bike Wash - ...	Green Lake ...	3
Cable Lock	Internationa...	8.5
Chain	Varsity Spor...	14.99
Chainring	Beaumont Bi...	24.21
Chainring	Bike Satellite...	25.11
Chainring	Training Sys...	27.33
Chainring Bolts	Beaumont Bi...	45.21
Chainring Bolts	Bike Satellite...	43.21
Chainring Bolts	Training Sys...	47.28

Figure 5.11. The price of the products from different vendors

Continue with the analysis about “Chainring”, from figure 5.1-11 we can see that the standard price from Beaumont Bikes is 24.21 have 0.9 lower than Bike Satellite Inc. which is 25.11, so the manager can easily choose Beaumont Bikes for the order about “Chainring” in the future.

5.1.2.3. List of order quantity based on vendors

Vendor Name	Max Order Qty	Min Order Qty	On Order Qty
Advanced Bicycles	80	16	33
Allenson Cycles	1000	100	0
American Bicycles and Wheels	5	1	0
American Bikes	1000	100	0
Anderson's Custom Bikes	1000	100	0
Aurora Bike Center	95	19	45
Australia Bike Retailer	80	16	0
Beaumont Bikes	110	22	0
Bergeron Off-Roads	120	24	0
Bicycle Specialists	1000	100	0
Bike Satellite Inc.	110	22	0
Bloomington Multisport	5	1	3
Burnett Road Warriors	5	1	3

Figure 5.12. List of order quantity based on vendors

By analyzing the order quantity from each vendor, the manager can identify whether that vendor is reliable enough or not, and can control the number of products that have been ordered to that vendor.

5.1.2.4. List of purchase orders based on ship method

Name	Ship Base	Fact Purchase Count
CARGO TRANSPORT 5	8.99	3225
OVERNIGHT J-FAST	21.95	2985
OVERSEAS - DELUXE	29.95	344
XRQ - TRUCK GROUND	3.95	1017
ZY - EXPRESS	9.95	1274

Figure 5.13. List of purchase orders based on ship method

One of the key requirements in the purchasing department is choosing the most efficient and effective ship method, to ensure the company can have the cost as lowest as possible. In figure 5.1-13, cargo transport 5 have an 8.99 ship base the second-lowest in the list, but it has the highest number of the purchase order that using it, meanwhile overseas – deluxe have the highest ship base (29.95) and the lowest number of the purchase order which mean the manager may try to limit the using of this method.

5.1.2.5. List of vendors and the number of purchase orders the company send

State Name	City	Vendor Name	Fact Purchase C...
Arizona	Lemon Grove	Greenwood Athletic Company	102
California	Altadena	Allenson Cycles	51
California	Altadena	Gardner Touring Cycles	102
California	Berkeley	Cruger Bike Company	226
California	Berkeley	Trikes, Inc.	100
California	Burbank	Anderson's Custom Bikes	51
California	Burbank	Professional Athletic Consultants	142
California	Burlingame	Federal Sport	51
California	Chula Vista	Integrated Sport Products	10
California	Concord	Inline Accessories	51
California	Concord	Wide World Importers	51
California	Coronado	Pro Sport Industries	201
California	Coronado	Signature Cycles	100

Figure 5.14. List of vendors and the number of purchase orders the company send

From the statistic, the manager can know the vendor where the company orders the most so that the manager can try to sign a contract with that specific vendor to gain some special offers and profit for the company.

5.1.3. Building KPIs system

In addition to analyzing data, we also provide two KPIs (Key performance indicators) such as Employee Learning – used to assess how much the employee has performed in the purchasing department, so that the manager can decide to increase their salary; Quality Check – used to evaluate the percentage of the rejected products from each vendor.

5.1.3.1. KPIs Employee Learning

This metric should be used more by all companies, big and small. The purchasing manager must verify if the personnel is striving to deliver more quality and efficiency at work. This is a very good way to find out if the team feels motivated and driven, and also to reward the employees who show the biggest efforts of improvement.

Code:

Value Expression:

[Measures].[Fact Purchase Count]

Goal Expression:

case

when [Dim Employee].[Job Title]

is [Dim Employee].[Job Title].&[Buyer] then 2000

when [Dim Employee].[Job Title]

is [Dim Employee].[Job Title].&[Purchasing Assistant] then 100

else 125

end

Status Expression:

case

when KPIVALUE("Employee")/KPIGOAL("Employee")>0.8 then 1

when KPIVALUE("Employee")/KPIGOAL("Employee") <=0.8

and KPIVALUE("Employee")/KPIGOAL("Employee")>0.6 then 0

else -1

end

Trend Expression:

case

when ISEMPTY(PARALLELPERIOD([Due Date].[Nam].[Nam],1, [Due Date].[Nam])) then 0

when [Measures].[Fact Purchase Count] > (PARALLELPERIOD([Due Date].[Nam].[Nam],1, [Due Date].[Nam]), [Measures].[Fact Purchase Count]) then 1

when [Measures].[Fact Purchase Count] = (PARALLELPERIOD([Due Date].[Nam].[Nam],1, [Due Date].[Nam]), [Measures].[Fact Purchase Count]) then 0

else -1

end

5.1.3.2. KPIs Quality

This metric is usually calculated every month. If the percentage is too high, an analysis must be held to determine why the items are being rejected, if it's due to problems with the supplier, with the purchasing orders, or something else.

Calculation:

[Measures].[QualityCheck] = [Measures].[Rejected Qty]/[Measures].[Order Qty]

Code:

Value Expression:

[Measures].[QualityCheck]

Goal Expression:

0.1

Status Expression:

case

when KPIVALUE("QualityCheck")/KPIGOAL("QualityCheck") >0.9 then -1

when KPIVALUE("QualityCheck")/KPIGOAL("QualityCheck") <=0.9

and KPIVALUE("QualityCheck")/KPIGOAL("QualityCheck") >0.8 then 0

else 1

end

Trend Expression:

case

when ISEMPTY(PARALLELPERIOD([Due Date].[Nam].[Nam],1, [Due Date].[Nam])) then 0

when [Measures].[QualityCheck] > (PARALLELPERIOD([Due Date].[Nam].[Nam],1, [Due Date].[Nam]),[Measures].[QualityCheck]) then -1

when [Measures].[QualityCheck] = (PARALLELPERIOD([Due Date].[Nam].[Nam],1, [Due Date].[Nam]),[Measures].[QualityCheck]) then 0

else 1

end

5.2. Data analytics with MDX and OLAP technique

5.2.1. Compare the standard price with the latest purchase price of Chainring between vendors

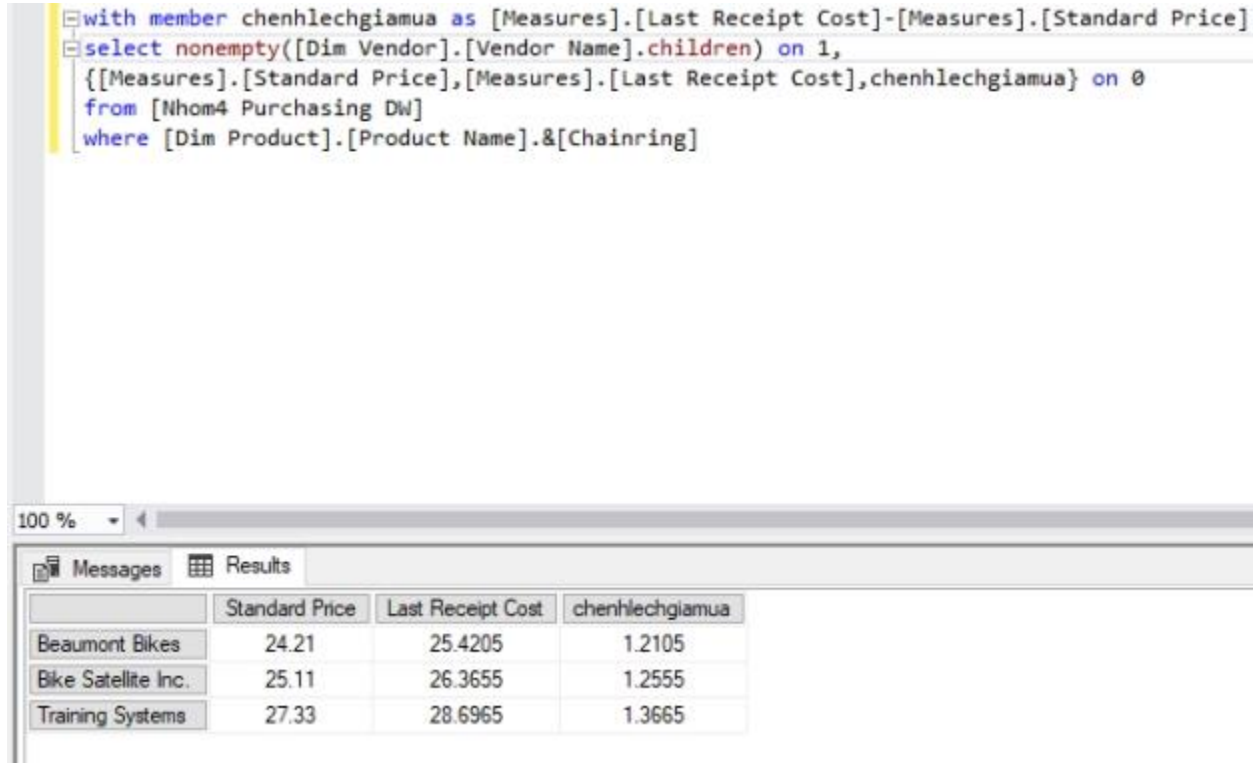


Figure 5.15. The latest selling price and the standard price from vendors

Even though the manager can analyze the standard price and the average lead time to determine the vendor they send the purchase order, they still need to evaluate the last receipt cost after each transaction to maintain the change in the price. In this case, the last receipt cost for “Chainring” from Beaumont Bikes increase by 1.2105 from 24.21 to 25.4205, but from Bike Satellite Inc. is 1.2555, and from Training System is 1.3665. So the manager can still choose Beaumont Bikes next time if they need “Chainring”.

5.2.2. Top 5 ordered products in 2014

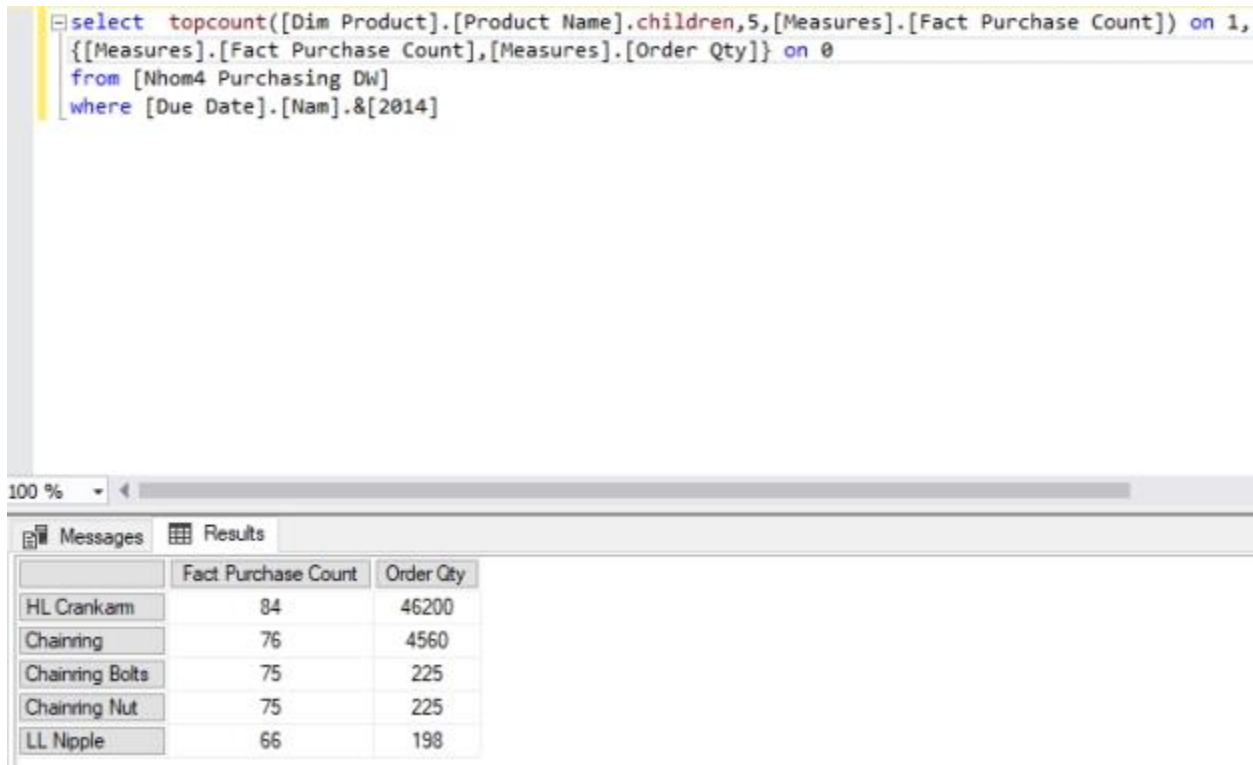


Figure 5.16. Top 5 ordered products in 2014

After each year, the manager can make this analysis to identify what and how many products, the company will need to purchase during their last year. By doing so, the company can make a specific contract with the vendors offered these so that they can increase the maximum order quantity or have a special price when sending the purchase orders.

5.2.3. List of line total based on each month and the difference between the current month with the previous month in 2014

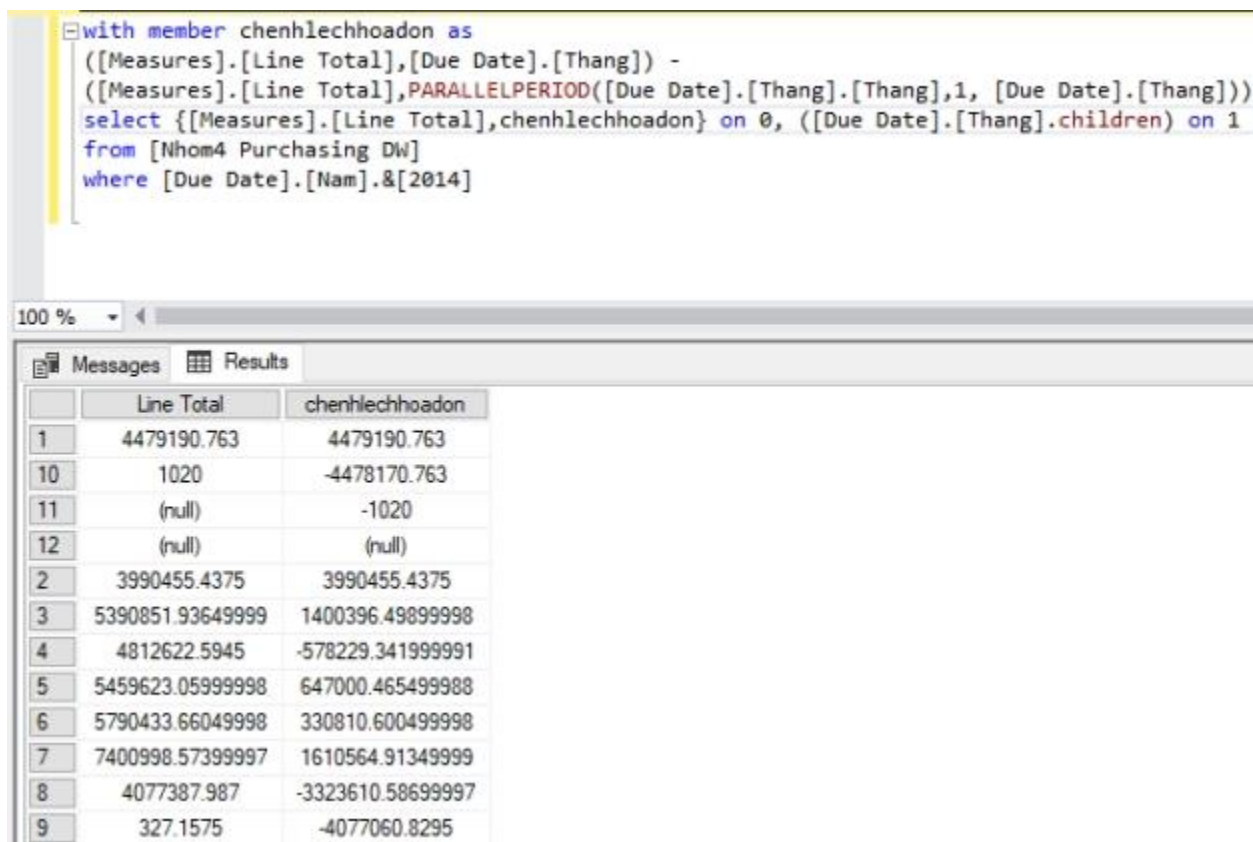
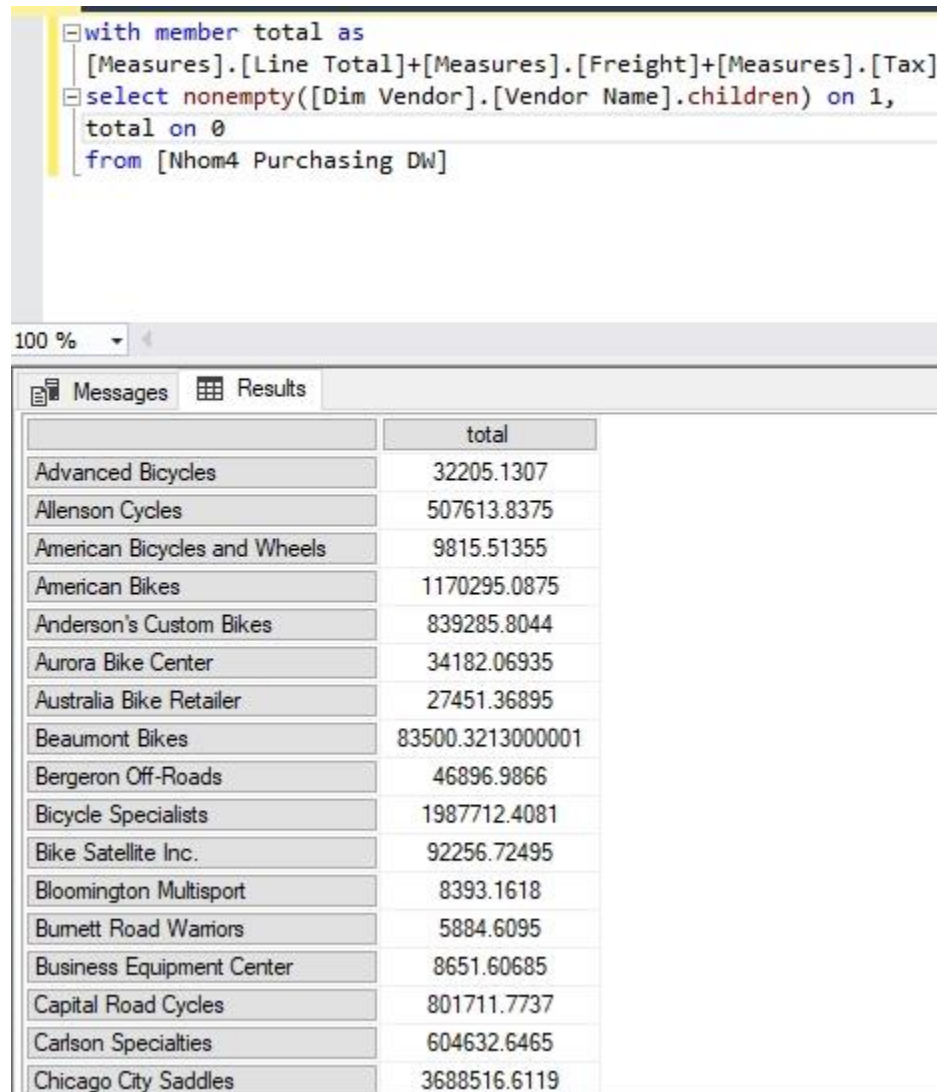


Figure 5.17. List of line total based on each month and the difference between the current month with the previous month in 2014

From the statistic in figure 5.17, we can see that the company will purchase a lot of products in March, May, June, and July. With this information, we can know that the company may prepare to mass-produce and big sales in these specific periods. But from September to December, the company less likely to buy products, because it's close to the closing periods, and the company doesn't want to exceed its inventory since it will cost a lot.

5.2.4. List of the total purchase price for each vendor



```
with member total as
[Measures].[Line Total]+[Measures].[Freight]+[Measures].[Tax]
select nonempty([Dim Vendor].[Vendor Name].children) on 1,
total on 0
from [Nhom4 Purchasing DW]
```

	total
Advanced Bicycles	32205.1307
Allenson Cycles	507613.8375
American Bicycles and Wheels	9815.51355
American Bikes	1170295.0875
Anderson's Custom Bikes	839285.8044
Aurora Bike Center	34182.06935
Australia Bike Retailer	27451.36895
Beaumont Bikes	83500.3213000001
Bergeron Off-Roads	46896.9866
Bicycle Specialists	1987712.4081
Bike Satellite Inc.	92256.72495
Bloomington Multisport	8393.1618
Burnett Road Warriors	5884.6095
Business Equipment Center	8651.60685
Capital Road Cycles	801711.7737
Carlson Specialties	604632.6465
Chicago City Saddles	3688561.6119

Figure 5.18. List of the total purchase price for each vendor

From figure 5.5-4, Chicago City Saddles have the highest total which is 3688561.6119. With this list, the manager can identify the important vendor of their company, and prepare a long-term contract so that they can cooperate better in the future.

CHAPTER 6. VISUALIZATION AND FORECASTING

In this chapter, we will visualize the requirements and significations of the report according to data in the data warehouse we built and using some BI tools to conclude statistical reports.

6.1. Report and dashboard systems

At the beginning of the project and after the data warehouse was completely created, we discussed what tools should we choose for visualization and had some decisions, they are Excel, PowerBI, and, of course, Tableau, a quite well-known BI tool. Down here is the visualization report structure.

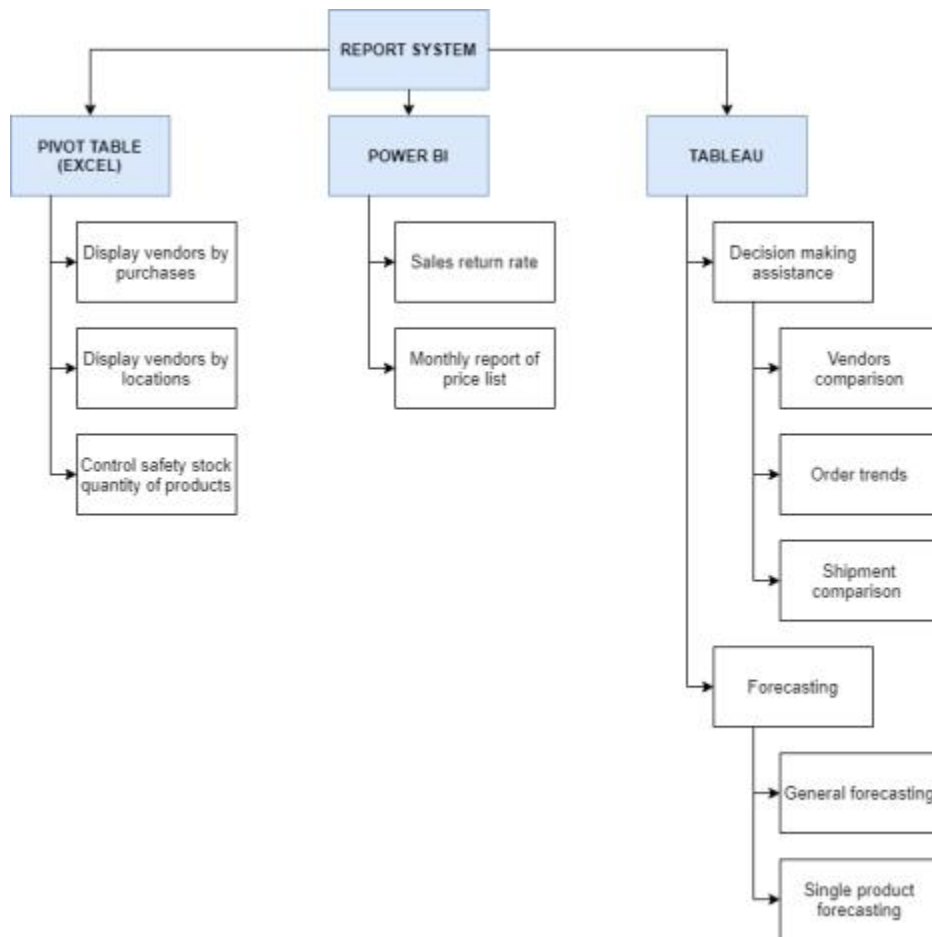


Figure 6.1. The reporting system

6.2. Data analysis with Power BI

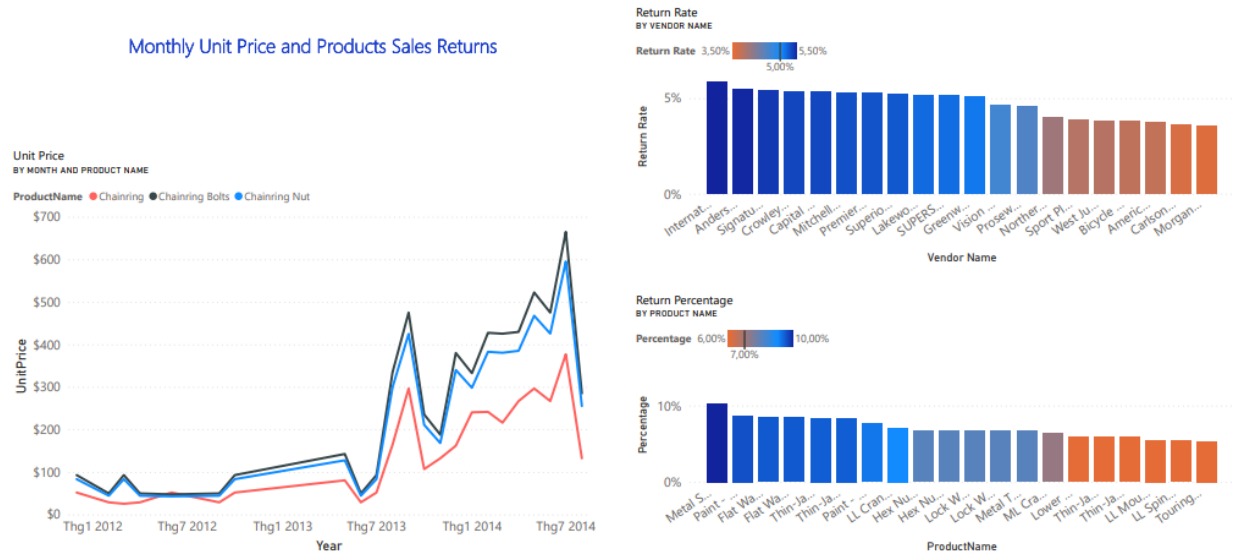


Figure 6.2. Monthly unit price and purchase return dashboard

In general, the dashboard will contain 2 parts: Monthly unit price and Purchasing return which help AWC making better decisions in choosing the best product and vendor for their company. Let's take a closer look at each of them.

6.2.1. Purchase return

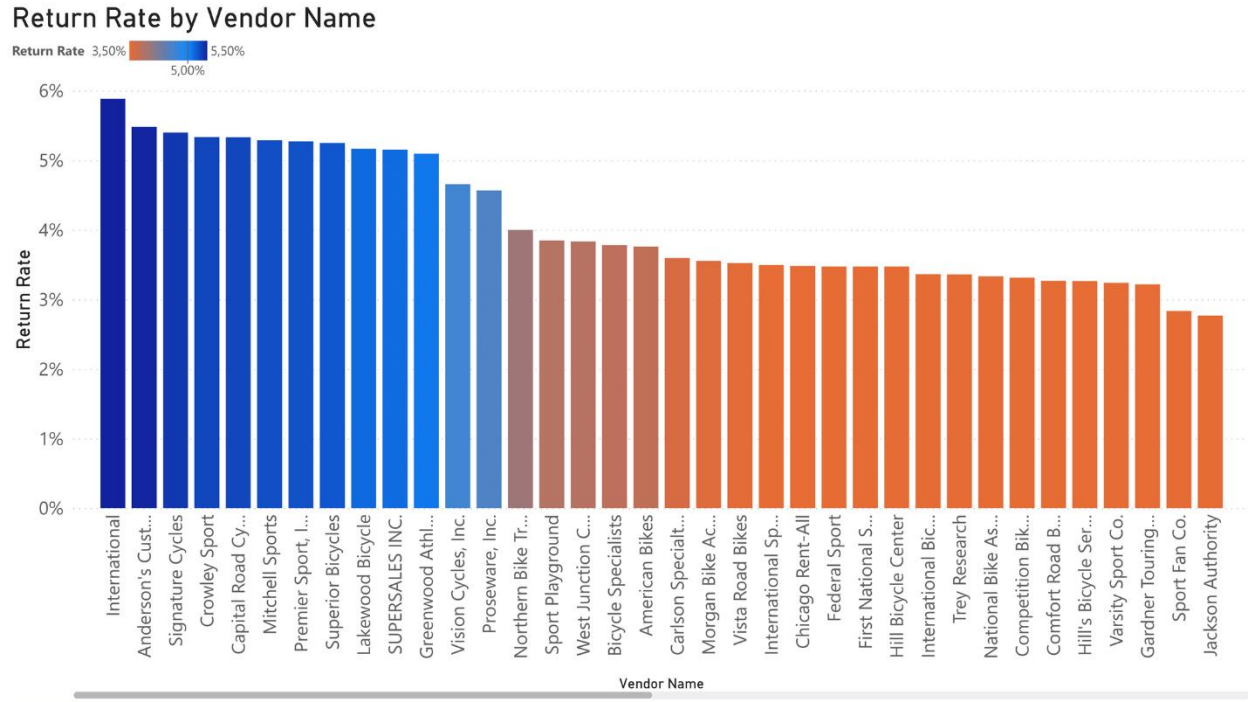


Figure 6.3. The chart illustrates the Purchase return by Vendor

The chart gives information about the quantity of rejected products and received products of each vendor. The light blue represents the quantity of the received products and the other represents the quantity of the rejected products – the products that were returned to the organization by vendors because of some particular issues. The amount of products that were returned by vendors, overall, is proportional to the number of products that were sold, but they only took up a small amount of the total sales.

To begin with, vendor International has the most ordered products, with the highest return rate at 5.88%. On the other hand, Beaumont Bikes has the least return rate, which is 0.23%. Besides, there are some vendors whose return rate is 0% (which means these vendors didn't have any rejected products) such as Jeff's Sporting Goods and Green Lake Bike Company.

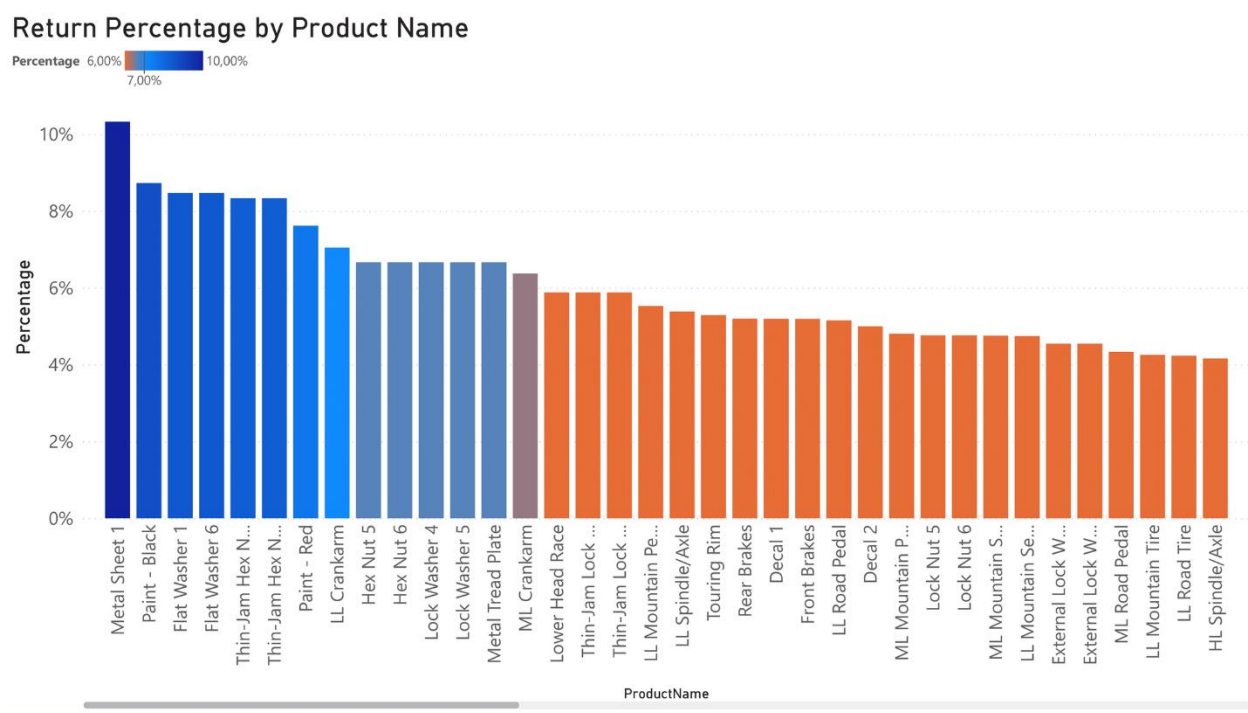


Figure 6.4. The chart illustrates the Purchase return by Product

Besides, it was also essential for managers to review which products were returned, and Figure 2 helps managers to keep track of them. Figure 2 illustrated the return percentage of the rejected products. The chart was sorted descending based on how much percentage each rejected product had. It is observed that Metal Sheet 1 had the highest percentage, which is 10.33%, which means that this product was rejected most by vendors. On the other hand, Paint-Silver had the smallest proportion, which is 0.08% was returned to the organization by vendors.

In conclusion. with this chart, managers can manage to visualize and keep track of the purchase return of the products, therefore deploying suitable solutions to deal with the returned products and maintain a good relationship with vendors.

6.2.2. Monthly report of price list

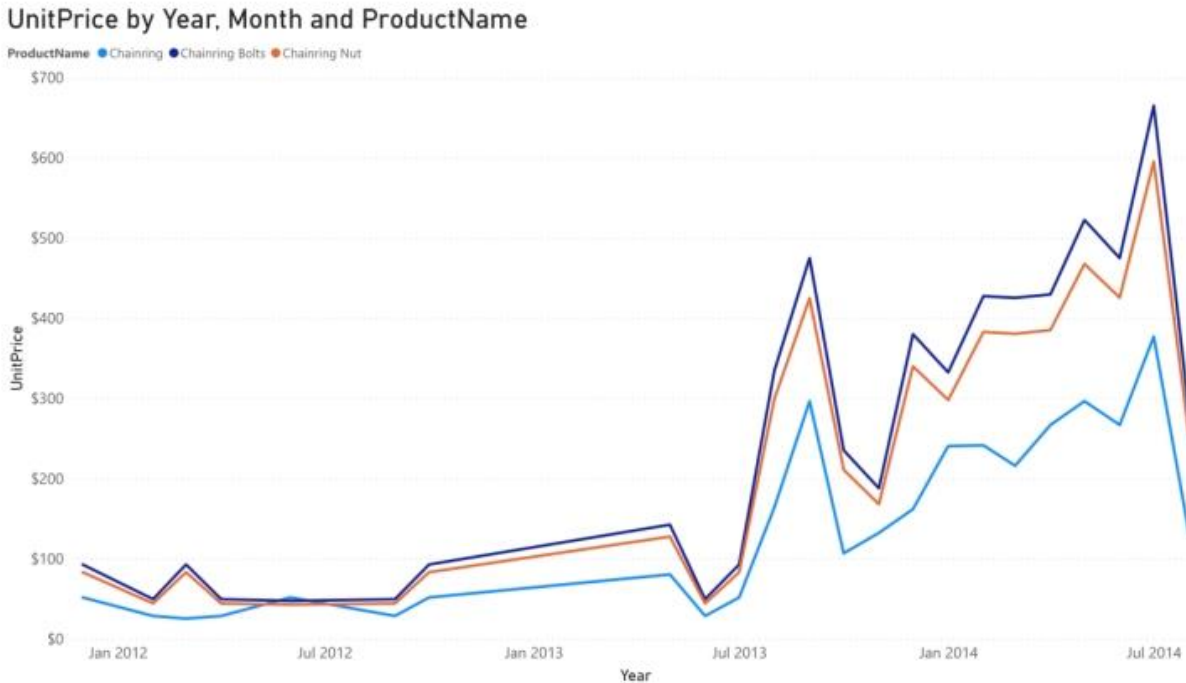


Figure 6.5. Chart about the monthly report of price list

The chart illustrates the monthly unit price of products. There are 265 products in total, and the chart above gives information about the monthly price of some products, which are Chainring, Chainring Bolts, and Chainring Nut. Overall, there are many fluctuations in the price of these products. However, these three products shared the same trends of increasing and decreasing from September 2012.

In more detail, in the first few months of the recorded period, all of the products except Chainring share a similar shape to the graph. Not until September 2012 did these three products mentioned above have the same trend of price. In September 2013, Chainring peaked at \$296.5095, while Chainring Bolts and Chainring Nuts are \$474.999 and \$424.83, respectively. After that, the figures fluctuated but then increased continuously and reach the highest peaks, which are 132.2685 for Chainring, \$284.97 for Chainring Bolts, and \$255.213 for Chainting Nut in August 2014.

In conclusion, with this chart, the manager can manage the price change of products in each month, therefore maintaining the financial balance, the sales cost, and imported materials for production.

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

6.3.1. Stock management

Stock management involves ordering, storing, tracking, and monitoring stock levels. It applies to every item that your business uses to produce its products from raw materials to finished goods. The aim is to have the right amount of stock for sale at all times. Good stock management can help business owners know when it's time to reorder materials and minimize costs at the same time.

Based on Figure 6.6, we can see that the number of safety and unsafety stock product are quite equal.

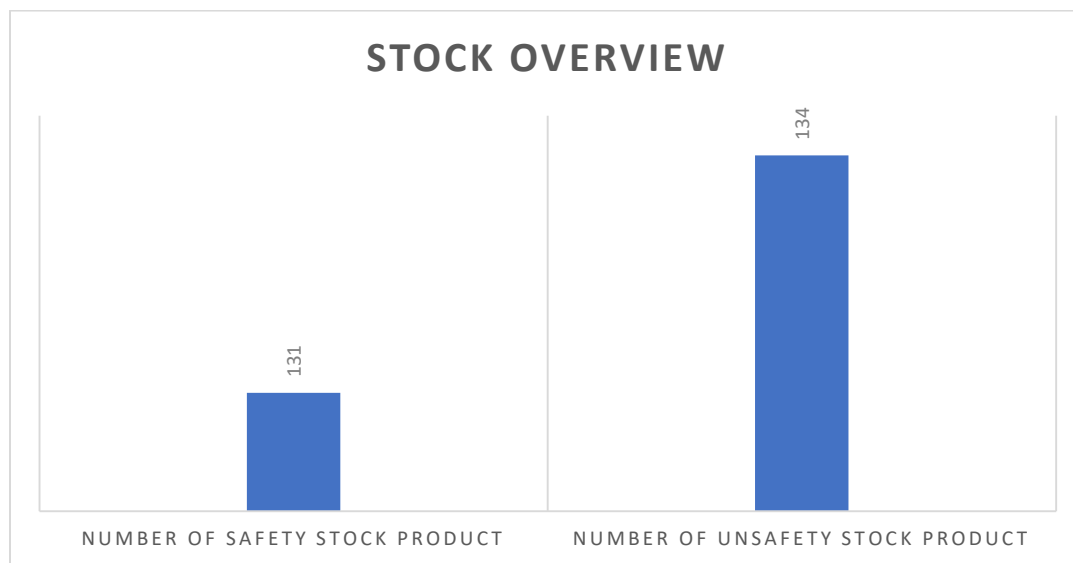


Figure 6.6. Number of safety and unsafety stock product

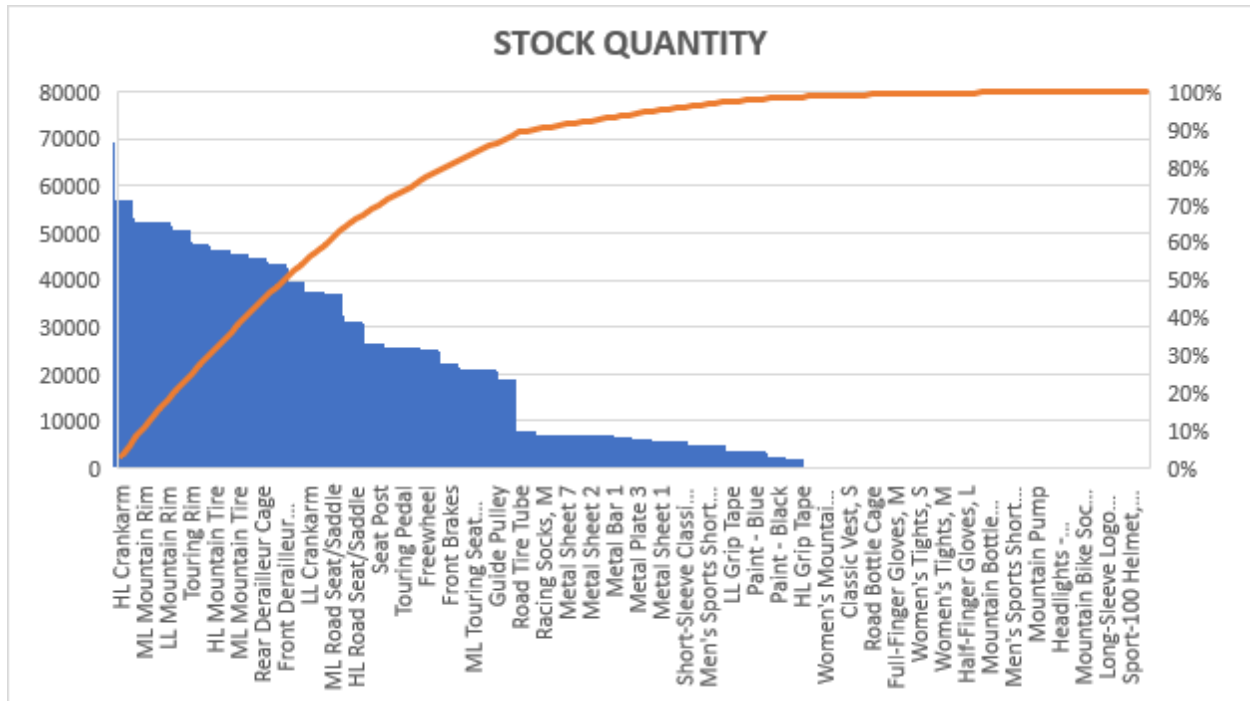


Figure 6.7. Stock quantity of each product

In figure 6.7, we combined bar with line charts to figure out specifically the product's stock in inventory. Through this chart, also adds information so that business users can perform data exploration and make informed decisions about filling in missing products. The chart in figure 6.6 lets you know if there are products needed to re-order, and as you can realize, the answer is yes. Then, in figure 6.7, the bar chart shows the physical quantity of all products in units. The line chart, on the other hand, shows the percentage of the missing units which we have to reorder to ensure the quantity is above the safety level. The more we go to the right side of the chart, the missing rate is higher and reaches 100% on the right vertical axis, which means the products on the right side urgently need to get a "refill" right away.

6.3.2. Vendors by location

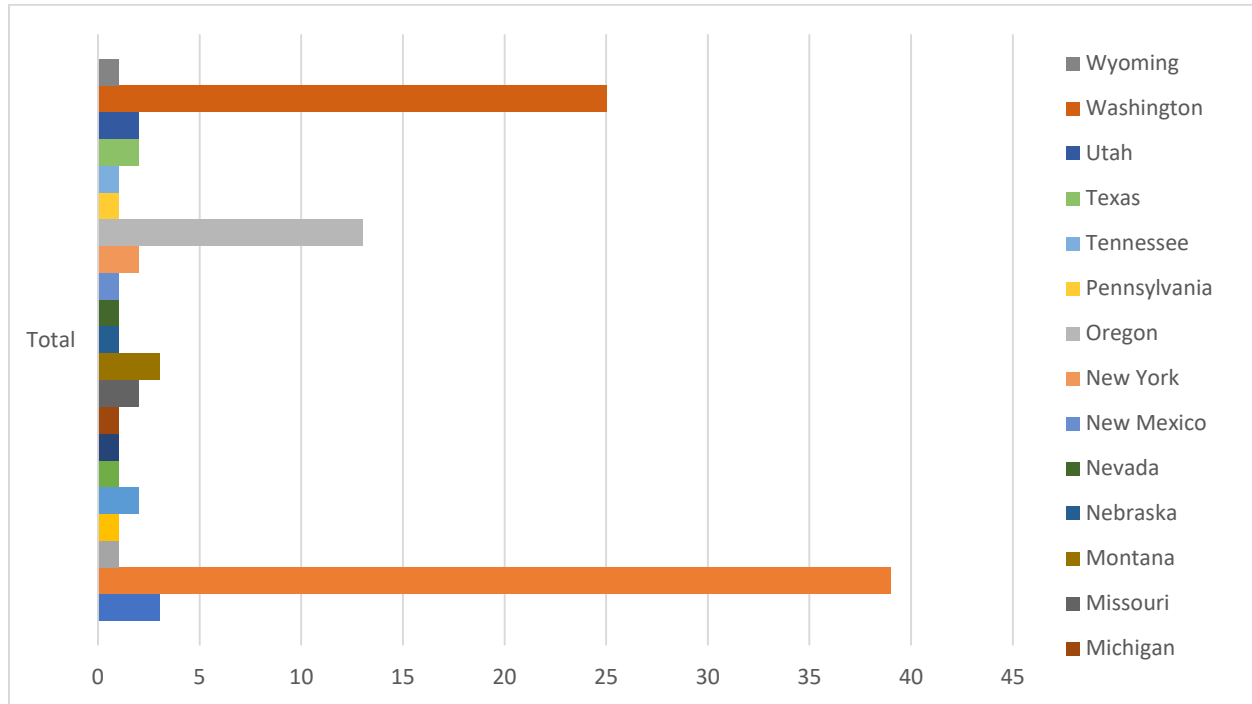


Figure 6.8. Vendors by location

The chart above shows the numbers of vendors analyzed by location. This figure will be used to explore the data visualization by geographical locations. We find this chart best use in choosing vendors with criteria if they are near the point needed material or not. In some cases when you require specific materials right away, a list of vendors by locations can help you handle the urgent lack of stock quite well. Base on the chart, we can see that California has the most vendor with 39 vendors.

6.4. Data analysis with Tableau

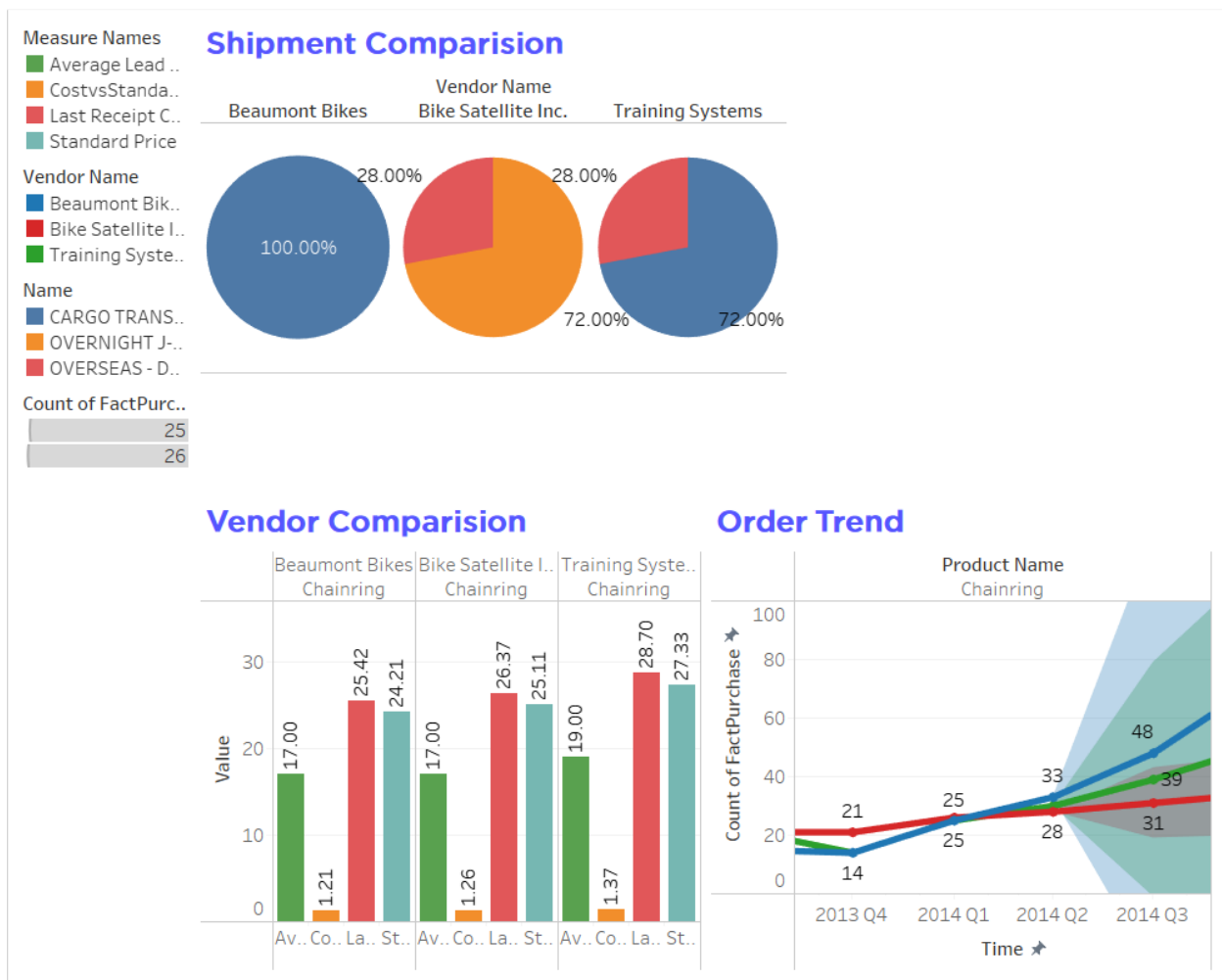


Figure 6.9. Chainring's procurement comparison dashboard

The main purpose of the Tableau section is to help the company can generate a better decision when they need to consider which materials to buy, which vendor to get supplies...From the dashboard, you can realize that we gathered data and make it into 3 charts which are Vendor comparison, Order trend, and Shipment method comparison. The product we will take as the example is called “Chainring”, the component of a bicycle drivetrain that converts the reciprocating motion of the rider's legs into rotational motion used to drive the chain or belt. Now let's take a closer look at each one of them.

6.4.1. Vendor comparison

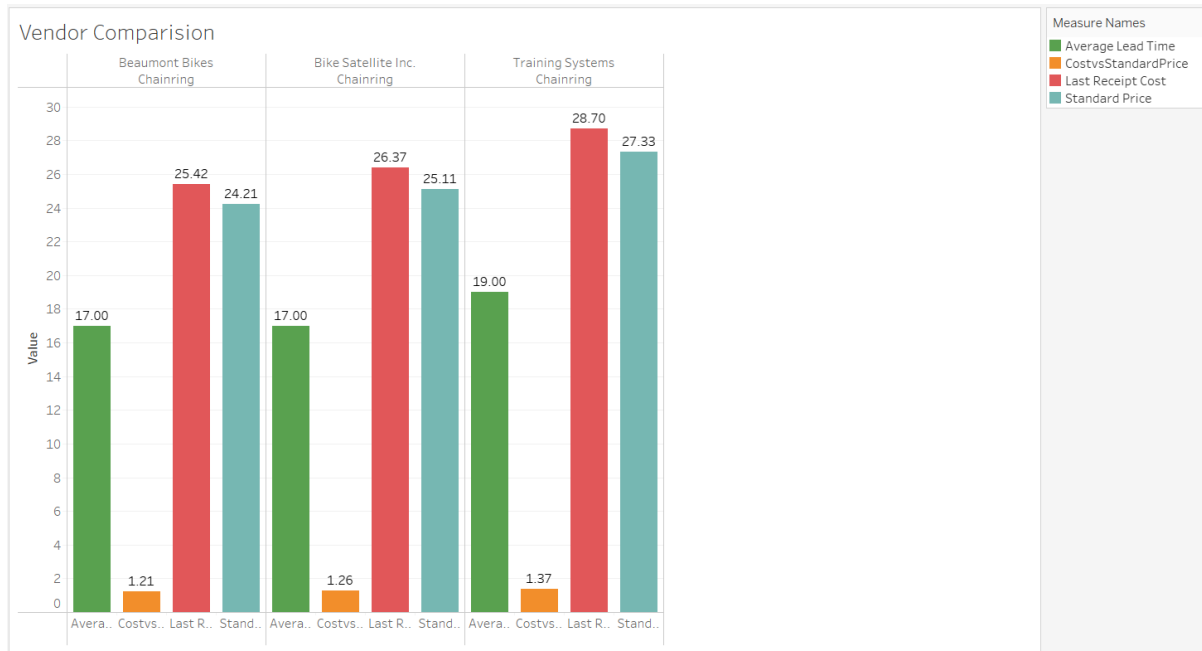


Figure 6.10. Vendor comparison

Starting with the Vendor comparison chart. For the chainring product, we have 3 suppliers which have done business with AWC before and their data is marked in our database. Beaumont Bikes, Bike Satellite Inc., and Training Systems are the 3 options for us. We do compare according to 4 attributes.

- Average lead time: the amount of time that passes from the start of the procurement process until its conclusion. Here, the lead time is counted as days. Like what you see, there is not much difference between 3 candidates except Training Systems will have 2 more days than others which we will consider this supplier in case we need this material urgently.
- Last receipt cost: the selling price when last purchase.
- Standard cost: The vendor's usual selling price.
- Cost vs Standard price: The difference amount between the last receipt cost and standard cost.

The last 3 attributes will help you have a proper viewpoint about the cost for each vendor. Here, Beaumont Bikes will take advantage of their cost for each unit of the chainring, and their average lead time is the cheapest and fastest one. A sure thing, we can base on the result to say Beaumont would be the “chosen one” for supplying this item.

6.4.2. Order trend

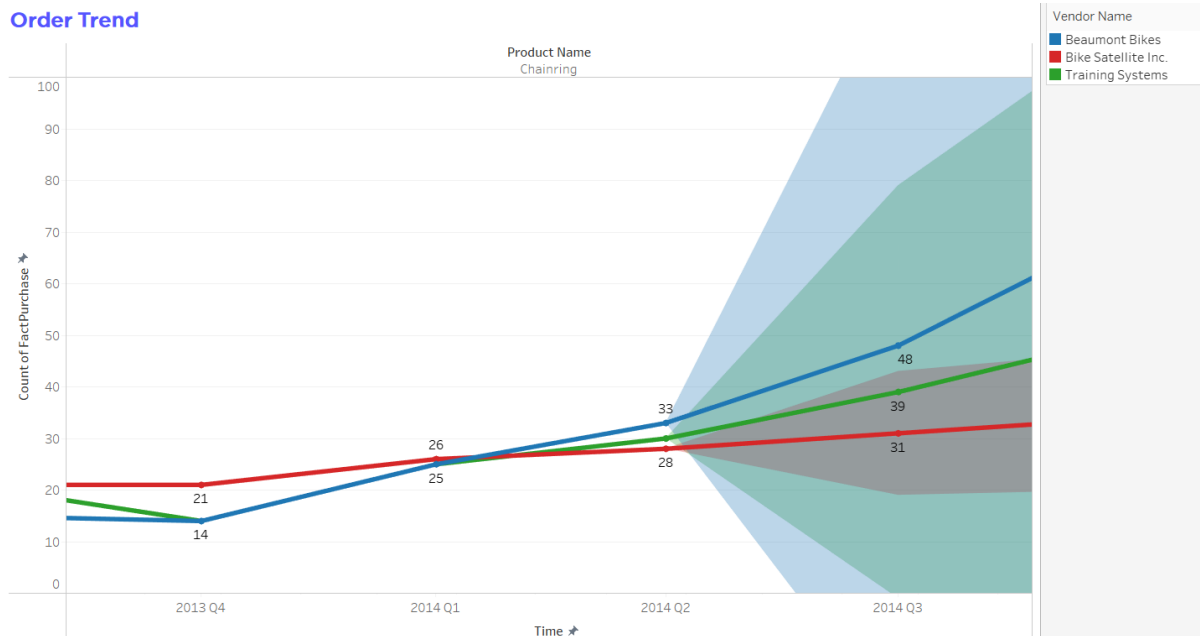


Figure 6.11. Chainring's Order Trend

The order trend chart has proven our inference was right. From the beginning, Bike Satellite was the main vendor for AWC providing chainrings. However, since quarter 1 of 2014, Beaumont Bikes slowly take the lead role and become the main vendor for chainrings. The reason for this may come from their pricing strategy as their shipping process was also more professional than before.

6.4.3. Shipment comparison

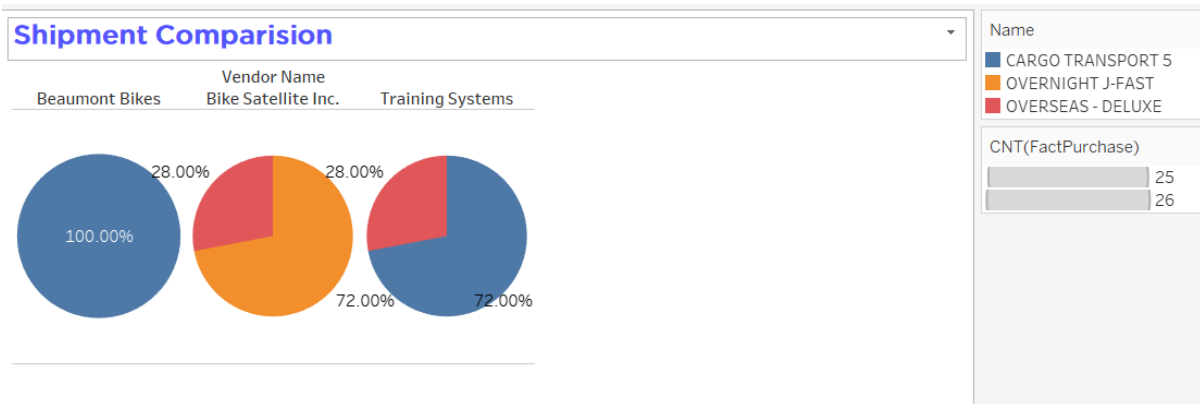


Figure 6.12.Chainring's Shipment comparison

Finally, the last chart is to compare the shipping method between 3 suppliers in the most recent year, 2014. The most important point in this chart is the middle circle. Bike Satellite Inc. as we mentioned above, didn't get ordered the most chainring like before. However, they have the Overnight J-Fast shipment which is super ideal for urgent needs. As if the company requires chainring as soon as possible, Bike Satellite is a promising candidate they would consider for.

6.5. Time series and Forecasting with Tableau

6.5.1. General forecasting

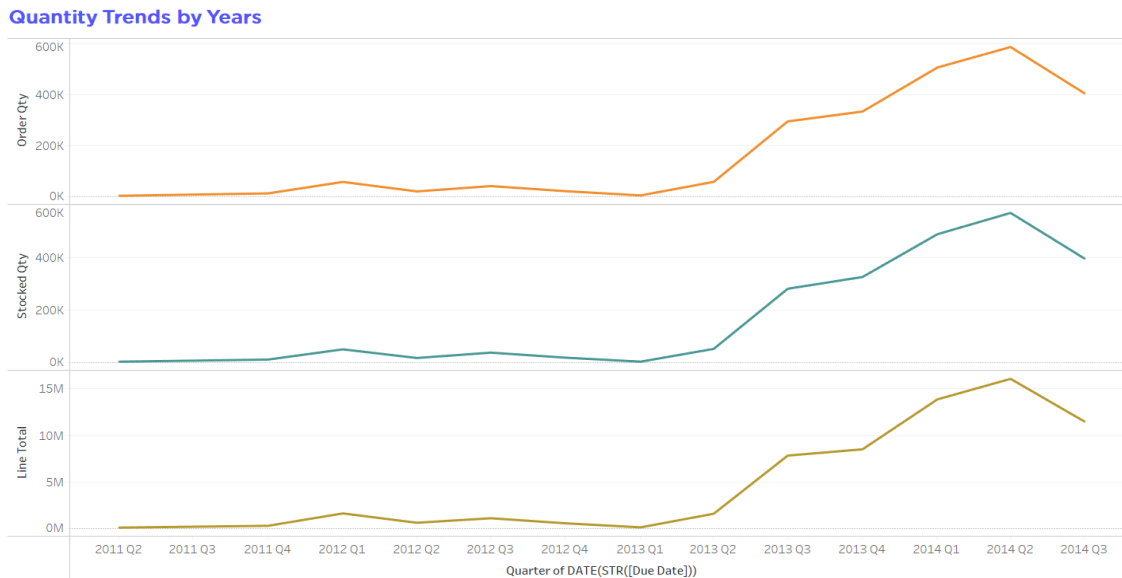


Figure 6.13. Quantity trends by years

According to the above line chart, we can see that:

- Order quantity, Stocked quantity, and Line total always have the same ratio between them.
- The difference between order and stocked quantity is not much which means AWC now has a reselling-oriented than a manufacturing company.
- Another proof is that after Q1 2013, there is a dramatic change in the figure, it is a burst for the reselling department.
- This indicates the shifting in the business goals, they no longer focus so much on the manufactured products and shifted their focus to other trading goods.

Let's take another chart to know which products make a large part in all these mutations of a burst.

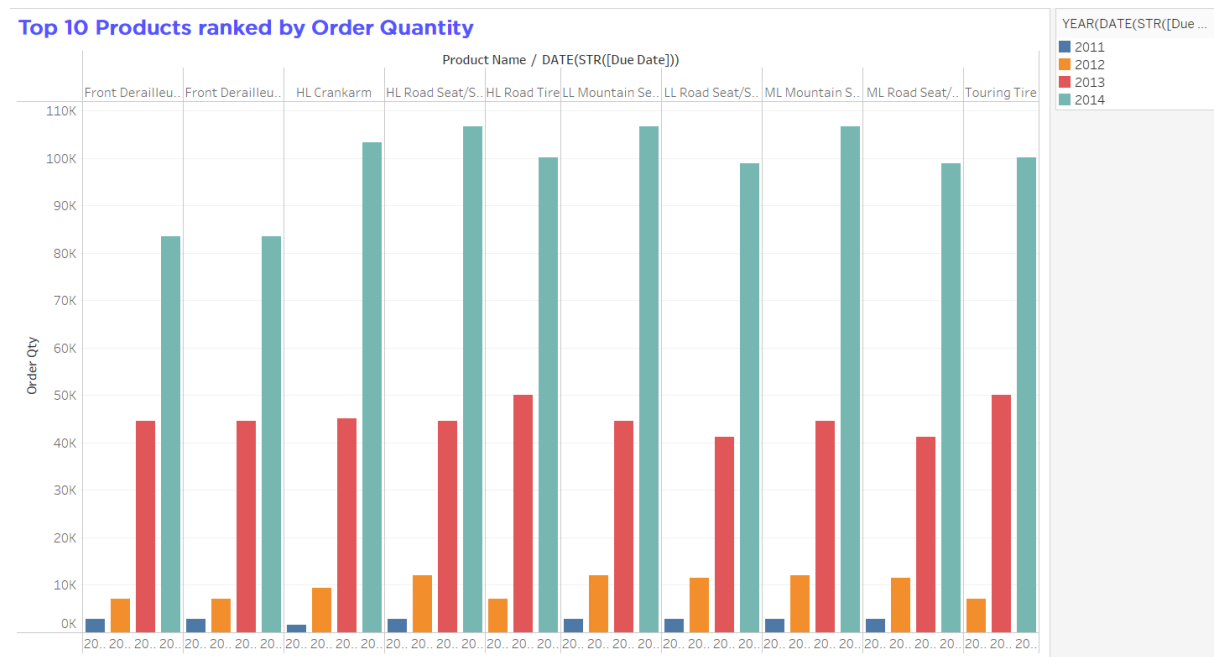


Figure 6.14. Top 10 Products ranked by Order Quantity

We had known AWC Trading goods procurement had made impressive growth since 2013. And from the chart above, the changes are proved that mostly come from accessories. Especially from 2013 to 2014, the order quantity of 2014 seems to be double the 2013's.

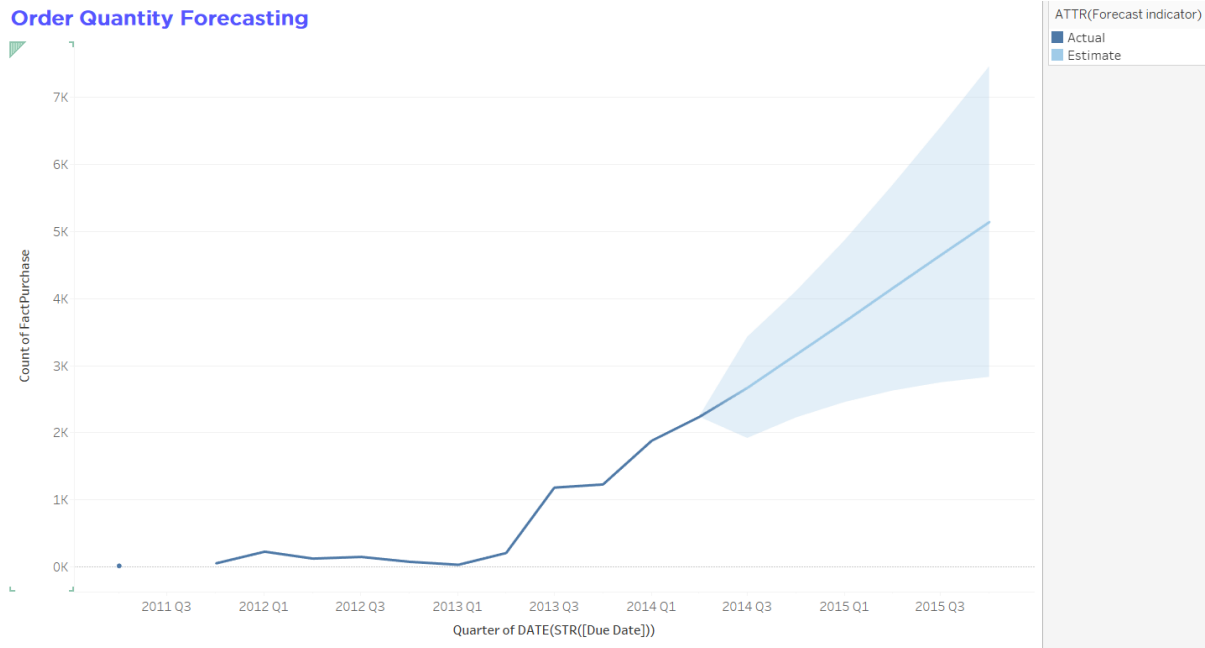


Figure 6.15. Order quantity forecasting

In at least one year later, AWC might still keep itself procurement-oriented. In our most optimistic view, the estimated field is telling the growth potential of order quantity can triple in the next year. Even if there may be some decrease, the estimated field shows that it will keep the order quantity in a “safe and sound” amount.

6.5.2. Single product forecasting

That’s for the big picture, now let’s get to the detail. Like the last part, we also build a forecast section for every single product. However, understanding which kind of products need to be analyzed depends on the data analysis results from the Sales and Production department. Hence, in this project, we will take a specified product called “Chainring”, the component of a bicycle drivetrain that converts the reciprocating motion of the rider's legs into rotational motion used to drive the chain or belt.

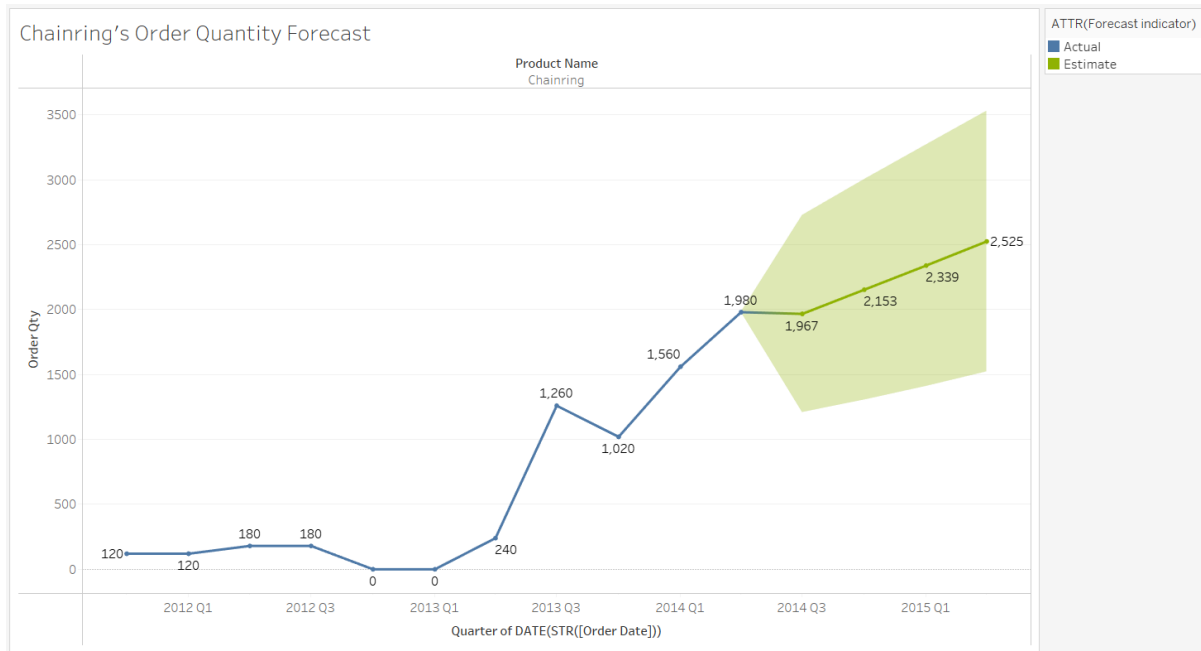


Figure 6.16. Chainring's order trend

Here, we use the line chart to forecast what will happen to the procurement situation of the chainring. With the prediction intervals of 95%, which means there will be 95% that the count of fact purchase will be in the blur blue area.

By observing the charts, we can see that it has the same ratio as the general order quantity forecasting chart above. There's still a burst stage from quarter 1 2013. For 2 years, the chainrings order quantity has gained from 120 to 1980, which is 16.5 multiplied times. Though there is still a decrease in late 2013 it's not a real deal with this product growth. According to the forecast, this product still plays a main role in the next one.

In conclusion, we will need more information about sales and production to know which materials need to buy the most, and which materials need to be lowered. From that, we can build a proper strategy for the procurement process.

6.6. Evaluation and Discussion

In conclusion, we hope our visualization section would be helpful to the company when they want to generate qualified decisions and wise moves when it comes to procurement. We also hope with data from the sales and production department to decide

which material is needed to buy, the 6.1 section will be a powerful support for the next steps. Furthermore, in the future, we can integrate the “Trinity” includes Sales, Production and Purchasing department to build a big data warehouse, then, with a large amount of data will help procurement to know what, when, who to buy the suitable materials to help sustain the company retail and manufacturing.

CHAPTER 7. CONCLUSION AND FUTURE WORKS

7.1. Results

- Survey and propose BI solution data analytics models, which help companies develop smart reporting and decide based on multidimensional information.
- Acting as a reference for subjects related to data, accounting, management and decision science.
- Propose solutions for data warehousing and business decision support systems. The support solution for decision-making comprises three main elements: source data, data store, and data mining.
- The report utilizes data storage and data analysis tools, creates intelligent reports to assist students to choose the right learning and research tool. PowerBI, Panel, SSIS, SSAS, MDX,...
- Research reports of KPIs - indicators of business performance evaluation and included in business performance analysis of enterprises. This is also an important factor in data analysis and business decision-making.

7.2. Limitations

This is a new approach to the group so it is difficult in the way of project development. In addition, the implementation time is quite short when there is a lot of expected work in the development of the project, so the project is only limited to the extent of creating general management reports with the objects, yet intervene deeply in data analysis.

7.3. Future works

- Expanding the construction of the business situation report set of the entire module of the enterprise's business system on the AdventureWorks database.
- Examine more practical needs from customers to have specific requirements, accumulate knowledge to develop, support ERP projects that need to use BI reports at work.

- Further processing and intervention in the research of source data and ETL for better data quality and more reliable results.
- Extend interactive features in reports and nested reports.

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