

# MGI

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## Business Intelligence Tools: overview and comparison study of analytic solutions

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Dissertation

presented as partial requirement for obtaining the Master Degree Program in Information Management

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# **BUSINESS INTELLIGENCE TOOLS: OVERVIEW AND COMPARISON**

## **STUDY OF ANALYTIC SOLUTIONS**

By

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Master Thesis presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management and Business Intelligence

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## **STATEMENT OF INTEGRITY**

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledge the Rules of Conduct and Code of Honor from the NOVA Information Management School.

Ana Sofia Cavaca Martins

Lisboa, 15 de julho de 2023

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## RESEARCH MOTIVATION

Business Intelligence (BI) software market is evolving rapidly, expecting to reach a total revenue of €20.95 billion in the current year of 2022 and €27.69 billions in 2027, corresponding to an annual growth rate of 5,74% (Statista, n.d.). With companies understanding the perks of using such tools the offer is also growing.

In a market with plenty of BI tools to choose from, the selection process can be overwhelming, especially if companies or users don't have defined the main requirements they look for in the software.

The motivation behind this study is to provide future and current users of BI guidance on which software vendors they can rely while choosing BI tools. Through comparative research, it will be possible to contrast tool characteristics, facilitating decision choice.

These characteristics will focus on topics like data visualization, real-time analysis, sources connectivity, security, embedded analytics, adds-on, data mining, and many others, of tools that are part of the four categories of the 2022 Gartner Magic Quadrant for Analytics and Business Intelligence Platforms: challengers, leaders, niche players and visionaries (Kronz et al., 2022).

## ABSTRACT

Business intelligence (BI) proves to bring the companies competitive advantages, providing for an easier and clear decision-making process through the analysis of data. The growth in the BI tools market is clear and can be verified by the increase in tools being offered and the number of users looking for the right system to apply in their companies. However, it can be overwhelming to choose one tool considering the ocean of BI tools available in the market. It is key to understand which tool applies the best to certain business specifications before committing to a sometimes rather considerable investment. This work aims to give business intelligence users proximity to some business specifications and the tools that most apply to them. This is possible through the creation of use cases that exemplify business needs of fictitious companies and by using six BI tools to then test how the tools answer to each business needs. The work carried out holds out a capability matrix as output that compares how each tool works when facing a specific topic, to understand at the end which is the best tool for each use case.

## KEYWORDS

Business Intelligence; BI Tools; Reporting; Dashboards; Comparative Analysis; Analytics; Power BI; Tableau; Qlik.

Sustainable Development Goals (SGD):



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## LIST OF ABBREVIATIONS AND ACRONYMS

<b>AI</b>	Artificial Intelligence
<b>API</b>	Application programming interface
<b>BA</b>	Business Analytics
<b>BI</b>	Business Intelligence
<b>BI&amp;A</b>	Business Intelligence & Analytics
<b>BV</b>	Business Value
<b>DSS</b>	Decision Support System
<b>DW</b>	Data Warehouse
<b>ETL</b>	Extract, transform and load
<b>FAQ</b>	Frequently asked questions
<b>GST</b>	Goods and Services Tax
<b>RLS</b>	Row-level security
<b>SA</b>	Staging Area
<b>SSIS</b>	SQL Server Integration Services
<b>SSMS</b>	SQL Server Management Studio

# **1. INTRODUCTION**

## **1.1 BACKGROUND**

Business Intelligence (BI) is an umbrella term that combines architectures, tools, databases, analytical tools applications and methodologies (Sharda et al., 2015), with the aim of presenting complex and competitive information to planners and decision makers (Negash, 2004).

Nowadays, companies collect big amounts of data from various sources. This data can be customer related information, retail or e-business, inventory tracking, websites tracking, product reviews, and much more. The costs of acquiring and storing this data are one of the motives for the growth of BI products and services (Chaudhuri et al., 2011).

BI systems include multiple software and different authors have their own perspectives of how the software is divided. For example, Gauzelin & Bentz (2017) divide BI systems into four types: reporting, analysis, monitoring and prediction tools. Analysis tools include visualization tools which are software that “accepts raw data and creates visualizations that business leaders can read and understand” (Negash & Gray, 2008). On another hand, monitoring tools allow the study of information and data in real time while supporting timely decision making. This type of tool includes dashboards, where actionable and useful metrics are represented graphically (Gauzelin & Bentz, 2017). In this study, the tools on focus fall into both the categories: visualizations and dashboards. The reason to chose these categories is grounded on the lack of understanding of how effective they can be and how they work for different approaches, users or tasks (Yigitbasioglu & Velcu, 2012).

## **1.2 MASTER THESIS GOALS**

With the increasing supply of business intelligence systems on the market, choosing the right tool for a particular type of business and its needs can be complex but companies consider BI software as leading in implementation project plans (Murugesan & Karthikeyan, 2006).

The purpose behind this thesis is to find an answer to the research questions: how are the leader BI software in the market competing with each other and what is missing in the leader BI tools?

To answer these questions a comparative research is conducted and the output is expressed through a capability matrix where BI software is evaluated against its features and in which companies can rely on when choosing BI platforms.

Throughout the study, twenty-two features will be tested in three BI software divided between three use cases for easier understanding.

## **1.3 MASTER THESIS STRUCTURE**

This master thesis is composed of five sections, structured as follows:

- A. Literature review of business intelligence, business intelligence and analytics and business intelligence tools overall and the tools that will be used in this study;
- B. Research methodology of the study, explaining the method used as well as presenting the use cases and respective data sets;
- C. Empirical study, where is explained the research done and the steps taken to evaluate each tool against the use cases;
- D. Results and discussion of the research, represented with a capability matrix;
- E. Conclusions of the study and future work.

## **2. LITERATURE REVIEW**

This literature review aims to understand what business intelligence is and its evolution until today. There are many tools available on the market for BI purposes, and this will also be the focus of this literature review.

### **2.1 BUSINESS INTELLIGENCE OVERVIEW**

The first time Business Intelligence (BI) was mentioned dates to 1989 in a paper written by H.P. Luhn for the IBM Journal of Research and Development (Grossmann & Rinderle-Ma, 2015). Luhn describes BI with an umbrella term as approaches to improve decision-making in business “by using fact-based support” (Negash & Gray, 2008).

In more recent years, Halpern and Gartner extended BI to a term that includes “applications, tools, infrastructure, and practices to enable access and analysis of information to optimize performance and decision-making” (Larson & Chang, 2016).

On its whole, BI allows the analysis of high volumes of data to generate strategic information for decision-making (Paradza & Daramola, 2021) through a variety of techniques, technologies, systems, and applications (Božič & Dimovski, 2019). It can also be compared to the meaning of decision support systems (DSS) (Negash & Gray, 2008), due to the main output BI tools provide.

Through specific systems and techniques, BI transforms data into useful information, helping businesses gain knowledge about their insights, says Sherman (2015). While gaining knowledge, companies are becoming smarter and making better decisions (Larson & Chang, 2016).

### **2.2 BUSINESS INTELLIGENCE & ANALYTICS (BI&A)**

The BI&A (Business Intelligence & Analytics) has emerged from the large streams of data generate, to what we refer to as big data (Božič & Dimovski, 2019) and highlights the importance of analytics in BI (Ramakrishnan et al., 2020), bringing together BI and BA (business analytics).

Chen et al. (2012), define BI&A as “techniques, technologies, systems, practices, methodologies, and applications that analyse critical business data to help an enterprise better understand its business and market and make timely business decisions”. Plus, BI&A covers “advanced analytic techniques such as data and text mining, forecasting, visualisation, machine learning, network analysis, neural networks, and graph analysis to gain business insights into the competition, market, products and processes” (Božič & Dimovski, 2019).

### **2.3 BUSINESS INTELLIGENCE BENEFITS**

As well as the value it generates, BI advantages can remain undercover for quite some time after the implementation and the most significant benefits can be perceived in other fields of a company besides the monetary sphere (Jalil & Hwang, 2019).

As the adoption of BI takes place over time, the benefits become global and more difficult to quantify. In order of easy to difficult to measure and local to global impact, Jalil & Hwang (2019) established the following benefits:

- Costs savings from data mart consolidation;
- Time savings for data suppliers and users;
- More and better information;
- Better decisions;
- Improvement of business processes;
- Support for the accomplishment of strategic business objectives.

Sherman (2015), adds more to the topic mentioning as BI benefits revenue optimization, cost reductions, risk reduction, regulatory compliance, and the ability to enter new markets and develop new products. Focusing on the ones that are not common to the authors, risk reduction is based on fraud detection and on reducing loan defaults. Whereas regulatory compliance examples follow the adoption of payment terms due to the ability to determine contractual metrics and comply with rules avoiding penalties. Moreover, to conclude, the ability to design new products and define new markets to target specific products.

## 2.4 BUSINESS INTELLIGENCE PROCESS

Business Intelligence follows a general process. According to Zeng et al. (2006), BI development is divided into six phases:

- A. *Locate the business issue:*** identifying the main business needs that will be on focus and converting them into a set of questions. At this point, is crucial to recognize if the data available detains enough information to tackle the issues concerned.
- B. *Create a data model from the business issue:*** the data model is composed of Metadata and data. Many use common data models developed for similar businesses, re-designing them and adapting them to the business variables.
- C. *Data preprocessing phase:*** this procedure should be applied ideally before the data is stored in a data warehouse (DW). The current phase deals with data cleaning and data smoothing.
- D. *Choose suited mining and analysis techniques:*** this step includes the selection of techniques and algorithms to use and the way they should be applied. These techniques are usually descriptive mining or predictive mining.
- E. *Display, interpret, and evaluate results:*** is now time to translate the results achieved into the business circumstances. The results must be presented in a way that makes it easy to understand the information gathered from the original data and is at this point that BI visualization tools take action.

- F. Respond to the mining and analysis results:** at this point is where actions are taken based on what has been applied and the results obtained. This is one of the main goals of BI: transform data into information and generate value from BI-based decisions.

## 2.5 BUSINESS INTELLIGENCE TOOLS

Business Intelligence tools, software, or applications are easy to understand and operate, yet offer a high risk / high return and have a high cost of implementation. BI tools collect data, either structured or unstructured, from multiple sources and offer analytical capabilities to translate data into information in the form of reports, facilitating decision-making across business activities (Chugh & Grandhi, 2013).

For BI tools to meet the aim, there are some key functionalities that they need to provide to users. In a study developed by Chugh and Grandhi (2013), the following features are mentioned as essential. Starting with data consolidation, it is highly required that BI systems can integrate data from different sources, disregarding being internal or external, and that they can simplify the extraction, transformation, and loading (ETL) of such data as well as removing nonessential variables. BI tools need to have functionalities that enable users to ensure data quality.

In the data analysis category, the systems should provide numerous analysis types like what-if analysis, sensitivity analysis, goal seek analysis, and market basket analysis. Forecasting support and modelling are part of these essential categories. As it is highly required for some businesses, BI tools should also provide real-time data tracking (Chugh & Grandhi, 2013).

On another hand, we have reporting and visualization. Reports should contain attractive and easy to comprehend visuals, with filtering features so that data can be analysed on all levels. Reports should be available in standard and personalized models to fit companies' different needs. In addition, it should be possible to share the reports through the most common applications used daily as well as provide integration with other devices such as mobile phones and tablets (Chugh & Grandhi, 2013).

As for the current year, Gartner (2022) stated as critical capabilities of analytics and BI platforms: "cloud-enabled analytics" and "data source connectivity" as the ability to support analytics building, deployment, and management based on cloud data and on-premises data as well as users being able to connect to both of these data sources; "security" as capabilities that permit platform security; "governance" as how information is used, shared and promoted; "data preparation", "data visualization" and "reporting", being the three last already mentioned in the study formerly investigated.

Therefore, choosing a BI application can be overwhelming however it is important to understand if company requirements can be met and which tool offers better long-term effects based on their solutions (Sarode, 2019).

On the current study, three reporting tools will be assessed. The tools choice was based on the 2022 Analytics and BI Platforms Magic Quadrant by Gartner, taking in consideration the quadrant category "Leaders".



With the interest of evaluating the top BI platforms the chosen tools were: Microsoft Power BI, Tableau and Qlik, the three tools from the Leaders quadrant.

In the following chapters, a literature review of each tool is conducted.

### **2.5.1. Power BI**

Microsoft Power BI was created by Ruler and Dhers Netz and was first released in 2015. Originally was an add-on to Excel, but after the launch of several functions in the tool there was a need to separate the application from Excel (Toic et al., 2022).

Power BI can be utilized on premises through the Power BI Desktop application or based on a cloud system through Power BI Service (Sarode, 2019). The data sources for this tool can vary between nearby databases, cloud information and excel, e.g. (Srivastava et al., 2022) and aims to create visualizations and reports.

### **2.5.2. Tableau**

Now owned by Salesforce, Tableau was one of the first platforms created for visual analytics (Toic et al., 2022). Tableau provides three main offers: Tableau desktop, allowing for easy connection to local and external data, Tableau server, ideal for organizations that required analysis at the organizational level, and Tableau online that accommodates the same functions as Tableau server but includes an “on-demand licensing model on a subscription basis” (Bhombe et al., 2019).

### **2.5.3. Qlik**

Qlik was founded in 2003 and offer two tools, Qlik View and Qlik Sense, being the first more traditional and the second more modern and towards data exploration. Qlik suggest that users switch to Qlik Sense since it is a better version of Qlik View, having some more features regarding visualization. It allows to build more “interactive dashboards and reports, extract data from a variety of data sources” and “more efficient data visualizations” (Toic et al., 2022).

### **3. METHODOLOGY**

#### **3.1 RESEARCH METHODOLOGY**

The aim of this study is to present as an output a capability matrix that compares each use case and their main requirements regarding business intelligence tools features within the business intelligence tools.

The methodology associated with the study is comparative research. Comparative research focuses on “similarities and differences between units”, in the current case similarities and difference between reporting tools features, and it includes both quantitative and qualitative methods, being the first one variable-oriented and the second case-oriented (Miri & Dehdashti Shahrokh, 2019).

Comparison research “allows for the testing of theories across diverse settings and for the evaluating of the scope and significance of certain phenomena” and “provides access to a wide range of alternative options and problem solutions that can facilitate or reveal a way out of similar dilemmas” (Esser & Vliegthart, 2017).

In this sense, this thesis was mainly grounded in two studies that use comparative research (Moral-Muñoz et al., 2020; Serrano-Guerrero et al., 2015) to review tools and free access web services.

#### **3.2 BUSINESS INTELLIGENCE TOOLS SUBSCRIPTIONS**

To test each tool features in order to compare which system works better for a specific use case, access to the tools will be subscribed.

Taking into consideration that NOVA IMS University provides Power BI as a tool to be used during the course, there is still the need to obtain access to the remaining tools: Tableau and Qlik.

Tableau offers a free trial to students through the Tableau Academic Program. The program is available for one year and includes Tableau Desktop that will be use to conduct the current study.

Regarding Qlik, there is no special license for students so a one month trial provided by the company will be used during the study, which includes Qlik Cloud.

#### **3.3 USE CASES**

Three use cases were created for the study. Each case has a set of requirements that look forward to being validated by reporting tools features. Tools will be tested accordingly with the trials provided mentioned in the previous chapter and a dashboard was created for each use case in the three BI tools. The dashboard was designed as similar as possible and with the same type of visuals to better evaluate the tools and their features (for more information see Appendix A-I).

### **3.3.1. Use case 1: Data Visualization, Advanced analytics, Schedule reports & Mobile devices**

StayHostels are a hostel company, with facilities all over the world. They need help analyzing booking and customer data. As they are a visually oriented company, there is nothing better than a BI tool to support them.

The company wants to know which are the most common routes for their customers, from where they travel, and which are the facilities they book the most with innovative visuals. They also want to have the possibility to create their own visuals and to have data updated daily.

A tool that provides a scenario analysis is a requirement since StayHostels want to be prepared for any event, either economic, social or natural.

Another requirement of the company is to be able to see the dashboards through other devices than the computer. Since they are not familiarized with coding languages, it would be helpful if the BI tool has an easy-to-understand language.

In this use case the features that will be analyzed and tested are mostly regarding visuals like the variety of visuals, the feature to create own visuals as well as add-ons for visuals, interactive dashboards and making reports. In addition, the use case will also focus on schedule reports, advanced analytics like building scenarios, tool language and mobile apps.

### **3.3.2 Use case 2: Security & Roles, Real-time dashboard & Geospatial and embedded analytics**

GoGo Delivery is a company that connects wholesalers to the marketplaces, by storing and distributing goods from one to another. To improve its services, GoGo Delivery wants to become more efficient when organizing its routes and improving its marketing campaigns, taking advantage of the current marketplace's locations. Each department should have limited access to data, being able to see only what they need.

The company also wants to stand out from the competition by providing a real-time dashboard to the marketplaces showing the state of the order, the estimated and updated delivery time as well as the route from the hub until the marketplace. This dashboard should be available on the GoGo Delivery delivery webpage.

This use case will focus on security and multi users, collaboration, geospatial analytics and embedded analytics and real-time analysis.

### **3.3.3 Use case 3: Data sources, Tool support, AI and New measures**

Your Online Store is an e-commerce platform. The company wants to implement a BI solution that supports the decision-making process, but some requirements need to be fulfilled so that it works for the company.

Due to having more than one data source, Your Online Store wants a tool that allows for data from various sources so that all the data can be analysed without issues. Regarding the dashboard layout, they would like to see some kind of interactive element like buttons and since AI is a current topic, Your Online Store would like to understand if there are any AI features in the tool and how it can be used for their data.

In regard of having any issues with the BI system, the company also leans in for a platform that gives support to their customers as well as training. And since there is no BI expert in the company it would be important that the learning process is easy and steep.

Moreover, they also would like the ability to create new measure from their own data in order to see more different perspectives of the business.

The third use case will focus on data sources, creation of new metrics and buttons, tool support and training, an easy learning process and data lineage.

## **3.4 DATA SOURCES**

For each use case, a different dataset will be used to get as close as possible to the business that is being exemplified. The datasets are in the form of flat files and their sources are open data sites. These datasets were adapted to the use case requirements.

### **3.4.1 Data set I: StayHostels**

The data that will be used for the first use case is a public dataset retrieved from the Festman website, that provides free datasets. It consists of four flat files in csv format that are divided between booking, customer, hotel and payment and represent the bookings done by costumers in any of the StayHostels facilities.

The booking file contains information regarding the check-in, check-out and booking date, time and year as well as the number of days, people and rooms. Each record represents a booking. This dimension also contains the IDs of other dimensions in order to create relationships.

The costumer file has the customers IDs and their information: age, gender, location, state and country.

The hotel file contains the hotel ID and the name, the rating and the hotel location (variables destination city and destination country).

As for the payment file it contains the payment ID and mode, the bank used to process the payment, the booking price and the discount (if there was a discount), the GST (Goods and Services Tax) and the profit margin.



Figure 1. StayHostels Data Schema. Source: Author

### 3.4.2 Data set II: GoGo Delivery

The second dataset of the study was retrieved from Kaggle, a data science community that offers notebooks and datasets. This dataset is from a fictitious delivery center in Brazil that connects wholesalers and marketplaces, and each record contains the information of each order placed by the marketplaces.

The dataset contains six dimensions and one fact table whose source was seven flat files in csv format: orders, stores, hubs, payments, channels, deliveries, and drivers. Marketplaces are represented as channels and wholesalers as stores.

Orders contains information about purchases made by the marketplaces such as order status, amount, delivery fee and costs and timings of purchase and delivery

The channels, also referred to as marketplaces, have the name and the type (marketplace or own channel).

Stores are the wholesalers and this dimension contains variables as the name, segment (good or food), store plan price and the location (latitude and longitude).

The hubs are the places from which the orders come from and where they are stored. It contains the hub name and location (city, state, latitude and longitude).

Payments has as variables the amount, fee, method and status.

The deliveries have the information about the orders realized with the variables distance and status (delivered or cancelled) the drivers' dimension that contains information about the modal (motoboy or biker) and the driver type (freelance or logistic operator).

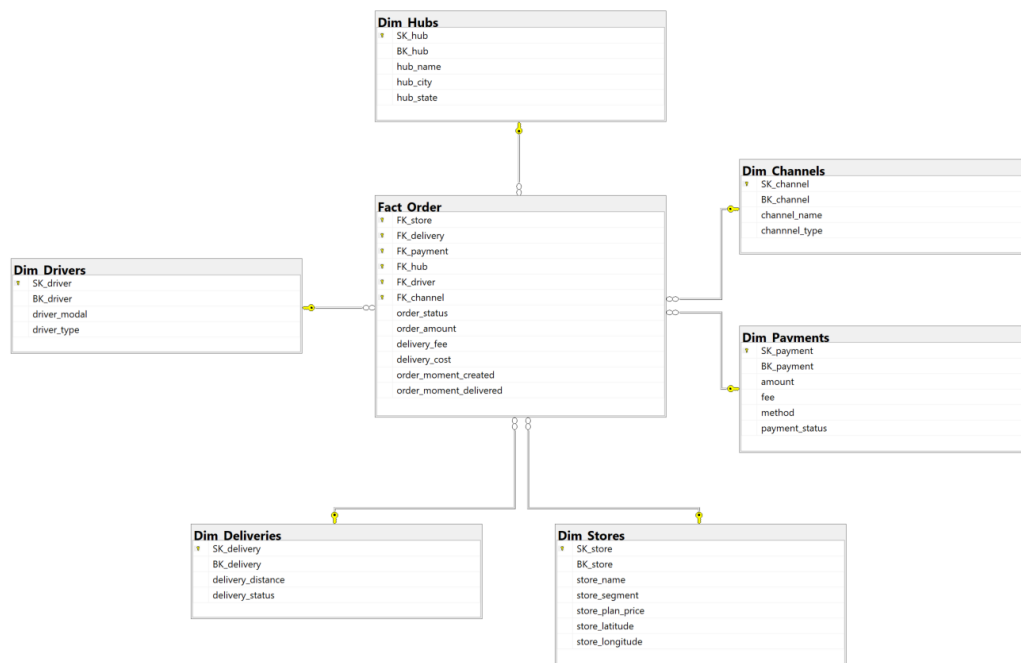


Figure 2. GoGo Delivery Data Schema. Source: Author

### 3.4.3 Data set III: Your Online Store

The last dataset was obtained from Kaggle. The dataset offers data from a fictitious e-commerce platform. The data was divided in four csv files: customer, products, shipping and orders. This consists in one fact table (orders) and three dimensions (customer, products and shipping).

The customer file contains information as the customer's name, segment and their location (city, state, country and region).

The products file regards the product name and category and the shipping file the shipping mode, date and cost.

The orders file contains the sales, quantity, discount, profit, priority and date.

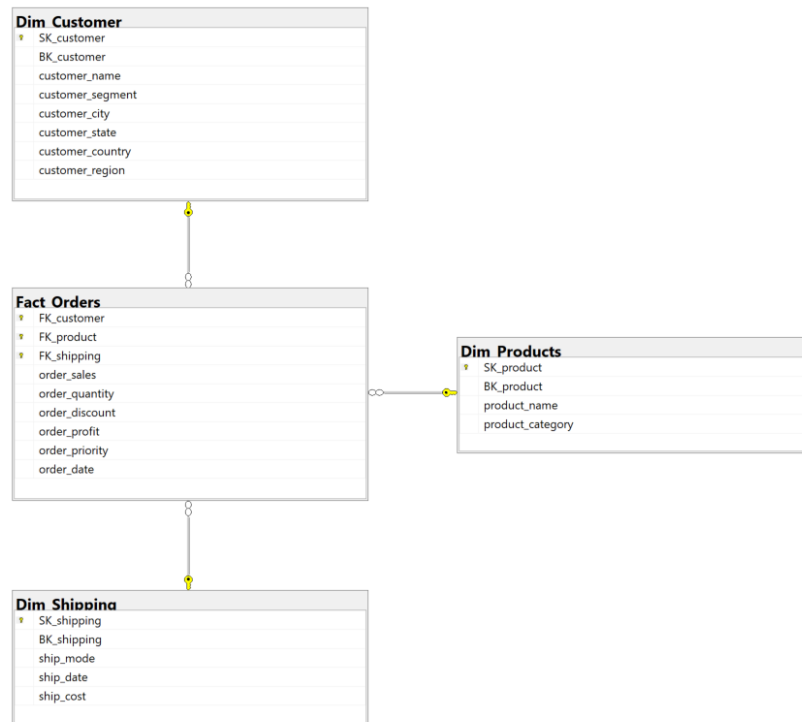


Figure 3. Your Online Store Data Schema. Source: Author

### 3.5 ETL PROCESS

An ETL process for each dataset was conducted through SQL Server Integration Services in order to have a database from each dataset in SQL Server Management Studio, where the data warehouses and staging areas were created.

In SSIS, two packages per dataset were created: one for the SA and the other for DW. On the SA package the connection managers both to the flat files and staging area were added.

The data was first extracted from the flat files, transformed and stored in a staging area.

Afterwards, on the DW package the connection managers for the staging area and data warehouse were created. Data was then loaded from the SA to their ultimate databases in SQL Server Management Studio.

This process was conducted for the three datasets and the databases in SQL Server Management Studio will be the sources for the reporting tools testing.

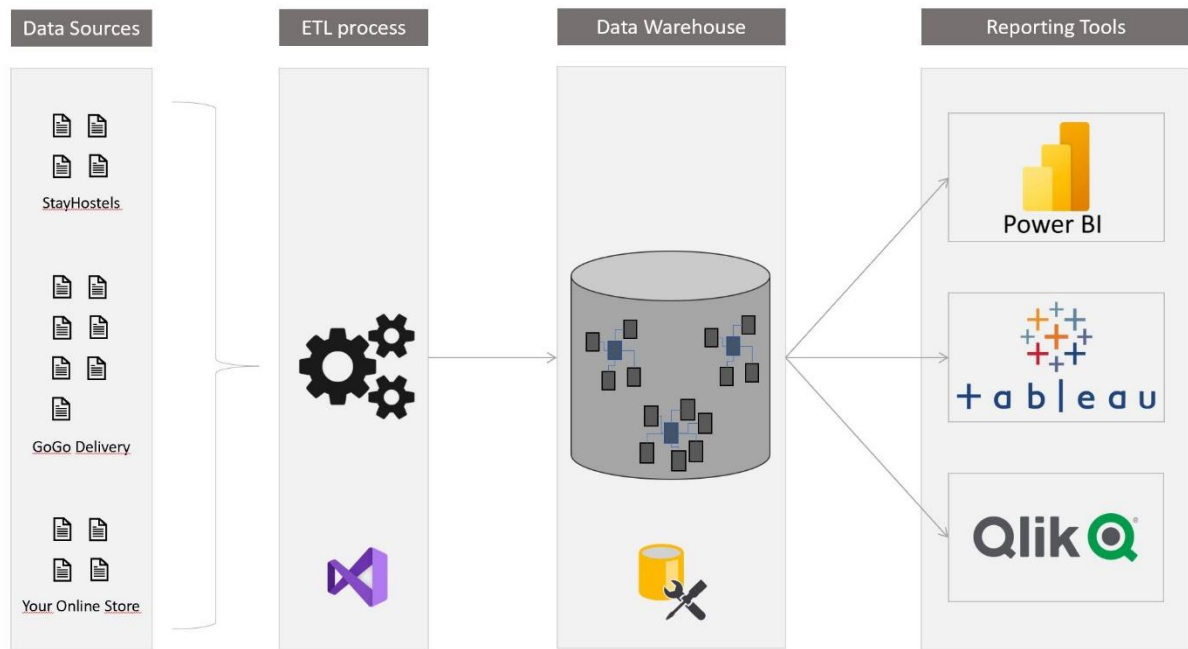


Figure 4. ETL Process. Source: Author



## 4. EMPIRICAL STUDY

### 4.1 POWER BI TESTING

To test this tool was used the version 2.116.884.0 of April 2023 of Power BI and it was provided by NOVA IMS University as part of the course.

#### 4.1.1. Use Case I – StayHostels vs Power BI

The first step was to connect Power BI to the database StayHostels in SQL Server and import the data through DirectQuery. A dashboard was created in Power BI (see Appendix A) to evaluate the features below.

##### Data Visualizations: variety of visuals

Power BI offers 36 different visuals to opt from, including bar charts, pie charts, heat maps, KPI's cards, tables. Besides the most common options, it is also possible to create visuals through R and Python scripts. On a more innovative perspective, Power BI has visuals like Q&A (users ask questions regarding the data and this option retrieves a visual of the answer) and smart narrative (visual that retrieves information from other visualization in the dashboard and creates a summary of all). Variety and unique visuals are a big feature of this tool.

In addition, all visuals have specific setting, make possible to configurate colors, sizes, titles, etc., granting diversification.

To test this feature in the tool, a dashboard was built with the following visualizations:

- Card with business revenue
- Card with business profit
- Gauge graphic with the rating average of the establishments
- Multi-row card with customer demographic data
- Column chart with most profitable hostels
- Flow map with customer most common routes

Overall, this BI tool offers a big variety of visuals and it also allows a customization of the visuals.

##### Data Visualization: creation of own visuals

In addition to creating visuals from R or Python scripts, users can create their own visuals for their own use or to share with the PBI community. The visuals need to be packaged to a .pbiviz file to be imported to PBI. Of course, a certain knowledge of code language is required since most visuals are created through code. Besides that, to upload a visual into the PBI community (AppSource) the users need to have a Power BI Pro or Premium Per User account (Main Sources for Acquiring Power BI Custom Visuals - Power BI, 2023).

This feature was not possible to test due to not having the necessary tools and code knowledge to deliver such type of element.

### **Data Visualization: add-ons visuals**

Along with the visuals provided by Power BI and the creation of their own visuals, users can get their hands on a lot more visuals through the AppSource. The AppSource stores a variety of visuals, free or requiring licenses. These visuals are in the format .pbviz and are prepared to be supported by Power BI.

To fulfill one of the needs of the use case (analyze the most common routes of their costumers) and since Power BI doesn't provide a flow map, a research through the Microsoft AppSource website was conducted.

Besides finding an extensive selection of visuals, the exact type of visual needed was found. It is called Flow Map and it was downloaded from the AppSource onto the computer.

The flow map was uploaded onto the Power BI Desktop app by using the option "Import a visual from a file".

The variables used were origin\_country from the Dim\_Customer for the Origin and the variable country from Dim\_Hostel for the Destination. In this way the ten most common routes are analyzed.

### **Data Visualization: interactive dashboards**

Power BI dashboards are interactive by default. Once the data is connected or imported to Power BI, a data model is developed and relationships between tables are visible. This connection between tables makes the interaction possible. After visuals are created and if data is related, when selecting a variable or a value all the related data in other visuals is filtered to what was selected and non-related data is greyed out.

To test this in Power BI, after all visuals were created the data in some visualizations was selected and indeed data related in other visuals was filtered. However, when clicking on a visual a new tab "Format" appears. On the tab there is an option called "Edit interactions" that allows the user to choose the visuals that the current visual can interact with.

The above was tested on the dashboard and it was detected that it was not possible to edit interactions with the add-on visual on the dashboard, but the interaction happens.

### **Ranking reports**

With Power BI, users can filter visuals to rank a certain dimension. In order to achieve a ranking visual, when selecting a visual a tab "Filters" appears on the right side of the screen. There users can chose how to filter the visual: advanced filtering, basic filtering or top N.

To meet StayHostels requirements, a Top N filter was created for the visual that shows the most profitable facilities. The filter was set to show the top 10 hostels with higher profit margin.

### **Schedule Reports**

If the Power BI user is looking for a way to schedule the data in a report on the Power BI Desktop app it is not possible without a third-party application. There are some add-ons in the market that allow for this feature, however it is not a default component in the tool.

Nonetheless, if the report is published or directly created in Power BI Service it is possible to schedule the report for the data to updated daily or weekly in a time schedule of the user's choice.

To be able to schedule reports, when choosing the data source it's imperial to select DirectQuery instead of importing data.

After this mandatory procedure, and using Power BI Service, the connection with SQL Server was created through Windows Authentication.

To implement the schedule report in the current use case, a configuration was made the data to refresh daily at 8h00.

### **Advanced Analytics**

Power BI does not have a What-if analysis feature like Excel, other Microsoft product. However, there is a workaround to simulate scenarios. Besides not giving the same output as a what-if analysis, filters can be used to simulate data scenarios.

Filters regarding the customers were added to test this feature. As mentioned, this does not provide the desired output but still can be used.

### **Tool Language**

Power BI uses DAX (Data Analysis Expressions), a programming language that consists of functions and operators to calculate measures. This language is common to Microsoft SQL Server Analysis Services and Power Pivot. DAX language does not have any similarity with other languages, which can hamper the learning process (Minewiskan, n.d.).

If a user is familiarized with Excel formulas, expect DAX to be different. Besides having similar formulas (like the SUM formula), DAX formulas are a bit more complex but that doesn't mean that they are harder to learn. In Power BI, DAX can be used to create metrics or the create calculated columns.

Both dimensions were tested, and two metrics and one calculated column were developed. The calculated column created was:

- Profit (profit = Dim\_Payment[booking\_price]\*Dim\_Payment[profit\_margin]).

The metrics created were the Total Profit using the new column and Total Discounts:

- Total Profit = SUM(Dim\_Payment[profit])
- Total Discounts = SUMX(Dim\_Payment, Dim\_Payment[booking\_price] \* Dim\_Payment[profit\_margin])

### **Mobile app**

Power BI has its own mobile app whose purpose is to visualize the data in a more flexible way at any time and place. Through the app, users can see the dashboards and interact with visualizations. It does not allow to add or change visuals while accessing Power BI dashboards.

Besides being able to see dashboards in the app, Power BI Desktop and Service provide a mobile layout to adapt the web dashboards to a mobile view.

The Power BI mobile was downloaded and tested. A mobile view of the dashboard was created in Power BI Desktop. The mobile layout is developed with the visuals and other objects that are already present in the dashboard, it is not possible to add other objects besides the ones already created.

After the mobile layout being created and the report published to the service, the mobile view was now available at the Power BI app.

#### **4.1.2. Use Case II – GoGo Delivery vs Power BI**

The data was first imported from GoGo Delivery database in SQL Server to then start the testing phase. A dashboard entitled “GoGo Delivery” was created in Power BI (see Appendix B) considering the features to be evaluated in the current use case. 13928

### **Roles**

In Power BI there are four types of roles:

- Admin: free use of all features;
- Member: cannot update or delete the workspace and add or remove users;
- Contributor: only allowed to create, edit and delete visuals, metrics, dashboards and reports, refresh data and copy and published reports;
- Viewer: permission to view and interact with items.

In Power BI Desktop, through the Manage Roles feature three roles were created regarding the Logistics, Marketing and Finances departments.

The Logistics Department role disables the access to the Payments table. The Marketing Department role disables the access as well to the Payment table but also to the Drivers and Deliveries tables. And the Finance Department role disables access to all tables except for the Payments and Orders tables.

Through the Desktop, users can then select from which role they want to view the dashboard and the data is filtered accordingly with the setup of each role.

### **Multiple users and collaboration**

Sharing dashboards or reports is one of the many features of Power BI Service. Users can share dashboards only for visualization purposes or with building content rights. However, multiple users cannot apply changes at the same time. Permissions can be granted for multiple users to edit a report by adding them to the workspace but if two users try to edit the same report at the same time it will not update the report in real time and will overwrite previous changes (*Ways to Collaborate and Share in Power BI - Power BI, 2023*).

While using Power BI Desktop, only one user is allowed to work on a report at a time.

To test this feature, a link was created in Power BI Service to share with potential users of the dashboard. This link gives permission to read, reshare and build.

### **Security at row level**

In Power BI, row-level security (RLS) works the same way as Roles explained above.

### **Geospatial analytics**

ArcGis maps for Power BI is one of the geospatial visuals in Power BI and probably the most interactive one. This visual allows to see locations and its settings are customizable.

For this feature, two ArcGis maps visuals were created. The first one was built to analyze stores location, created through the latitude and longitude of each store. The second one shows hubs location and it is configured only with the hub city. Both maps were then configured.

### **Embedded analytics**

Power BI offers two solutions for embedded analytics: for customers and organizations.

Embedded solutions for customers do not require Power BI licenses and do not need authentication. On the other hand, Embedded analytics for the organization do require a Power BI and the users' credentials to authenticate.

To develop an embedded solution users should have either Power BI Embedded or Azure and Power BI Premium.

This was not possible to test due to not hold neither the necessary software or knowledge.

### **Real-time analysis**

Real-time dashboards are possible in Power BI Service, however it depends on the dataset used. Real-time data is only possible through the use of push, streaming or PubNub streaming datasets but each of them has its own limitations (*Real-Time Streaming in Power BI - Power BI*, 2023).

Due to this type of data not being available for this use case, this feature was not possible to test. However, it is important to mention that real-time analysis can mean different things in different business perspectives.

### **4.1.3. Use Case III – Your Online Store vs Power BI**

For this dataset and to test one of the features related to multiple data sources, data was both imported to Power BI from the database in SQL Server and from a flat file in .csv format. The dashboard for this use was created in Power BI (see Appendix C).

### **Multiple Data Sources**

Power BI supports many data sources, either on premises and on the web version. The data can be imported, connected through the DirectQuery option or through a data gateway.

Since Power BI allows the merging of different data sources, two data sources were combined in this use case. The Fact\_Order, Dim\_Product and Dim\_Shipping were imported from SQL Server database and DIM\_Customer was imported from csv file. The Dim\_Customer was then connected with the Fact\_Order in the Model view of Power BI.

### **Tool support**

In Power BI Desktop, users find the Support option. This will get to a Power BI support web page with FAQ and additional resources. With Power BI Pro, users can get support by creating a ticket on a link in the support web page.

### **Tool training and learning curve**

Power BI offers guided training on their website on multiple tool features and on procedures, as well as an Youtube channel with videos on procedures and the last system updates. Both the guided training and the Youtube channel are available to everyone, regardless of having a Power BI license or not.

### **AI features**

Power BI has AI features integrated on the tools, both when it comes to data transformation and to visualization. When it comes to data transformation, in the Power Query Editor there are the AI Insights which consist of machine learning models to prepare data which are divided in three categories: text analytics, Vision and Azure Machine Learning. Regarding data visualization, Power BI offers four AI visuals:

- Q&A: natural language visual where users can write questions and a visual is automatically created as result;
- Key influencers: visual that identifies the dimensions that influence the selected KPI;
- Decomposition tree: visuals that analyses data across dimensions like drill down menu;
- Smart narrative: visual that creates a summary of the data displayed in the dashboard visuals.

This feature was used and a decomposition tree was created to analyze sales across countries and customer segment. A Q&A button was added to the top left corner of the dashboard so that users can ask questions regarding data.

### **Buttons**

Buttons are provided by Power BI and can be used to navigate between pages when a report has more than one page or to add a link.

In this case, two buttons were added to the dashboard a "clear all slicers" buttons that clean all the selected filters and, as mentioned previously, a Q&A button that allows users to ask question regarding the data

### **Creating new measures**

Power BI allows the creation of new measures in two ways: from scratch with DAX languages or by using the Quick Measure function that consists of predefined measures. This is possible only with Power BI Desktop.

Considering the above, two simple metrics were created:

- Total Ship Cost = SUM(Dim\_Shipping[ship\_cost])
- Total Sales = SUM(Fact\_Orders[order\_sales])

### **Data lineage**

In Power BI Service, users can get access to the Lineage View where the data flow since the data source and its destination is represented.

After deploying the dashboard to Power BI Service, it was possible to analyze the data lineage through the "View Lineage" feature.

## **4.2 TABLEAU TESTING**

To test this tool was used version 2022.4.0 of Tableau Desktop Professional Edition available for students through university accreditation and a free trial of Tableau Cloud.

### **4.2.1. Use Case I – StayHostels vs Tableau**

Before starting the testing of the tool, the first step needed was to import the data to Tableau from the database StayHostels in SQL Server. After the data was correctly imported to Tableau, the dashboard was created (see Appendix D) in order to be as similar as the one already developed in Power BI.

### **Data Visualizations: variety of visuals**

Tableau offers a wide range of visualizations such as bar and line charts, heat and tree maps, scatter plots and many others. Just like Power BI, Tableau visuals are customizable and users can choose between colors, fonts, sizes, alignments, etc..

Seven visuals were created for this test, four of them of different types:

- Three card visuals to represent the total profit and revenue and the rating average;
- Two tables to show the customers per gender and the age average also per gender;
- One bar chart to analyze the ten most profitable hostels;
- One map to display the countries where the hostels are located.

### **Data Visualization: creation of own visuals**

Tableau users can create their own visuals. These visuals need to be developed throughout other dependencies as Git, Node.js and npm. Such visuals need to be presented in .trex format (*Get Started with Dashboard Extensions*, n.d.).

This feature was not possible to test due to the lack of necessary tools or knowledge.

### **Data Visualization: add-ons visuals**



In Tableau is possible to include add-ons to dashboards. There are different types of add-ons but the ones for visuals are called Extension that in addition to visuals also include filters, natural language generation and parameter tools.

When a dashboard is open on the Tableau Desktop app, on the left bottom corner users will find a tab named "Objects" with an option "Extensions". With a double click, a new window will open and users can search for a specific category or use the filters available. Some visualizations are only available for specific versions of Tableau or require a paid license.

Unfortunately, due to the type of variables available in the use case and the lack of choices between Extensions it was not possible to test this feature.

### **Data Visualization: interactive dashboards**

To create a interactive dashboard, users need to select on the visuals they want to be interactive the option "Use as filter". After this when selecting a variable on a visuals all the other related visuals will be filtered by what was selected.

For this feature to be implemented, all the visuals created were check marked to be used as a filter in order to create an interactive dashboard.

### **Ranking reports**

Tableau dimensions filters have multiple options being one of them the ranking of values. Besides the mentioned one, it is also possible to create custom lists, matching values (wildcard tab) and conditions.

The option to set ranking on visuals can be found by clicking with the right button on top of the dimension in the visual. In the list that appears, the option "Edit filter" should be selected and there users can find the filtering options mentioned above. By selecting the tab "Top" users can than select the top or bottom values or create their own formula.

The visual that shows the most profitable hostels was the one selected for this feature and the filter applied was to visualize the top 10 hostels by total profit.

### **Schedule Reports**

To be able to refresh data on schedules, users must have the Tableau Server version. After being signed into Tableau Server, users can select either if they want to refresh all workbooks or data sources. Users can select which type of schedule wanted and if available also select if they want a full (default option) or incremental refresh (*Refresh Data on a Schedule*, n.d.).

It was not possible to test these features due to not having the version of Tableau that provides such component.

## **Advanced analytics**

Like Power BI, Tableau does not have a what-if or scenario builder feature. Tableau has, however, the possibility to create filters and parameters, being the last more similar to build scenarios. Parameters can be created for the dataset and can be used, for example, to only show periods of time in case of a date variable. It was not possible to test these features due to not being available on the current version of Tableau.

## **Tool Language**

Tableau has its own language to create calculated columns. It doesn't have a specific name but formulas are similar to Excel.

The following calculated field were created:

- Total Profit =  $\text{SUM}([\text{Booking Price}]) * \text{AVG}([\text{Profit Margin}])$
- Profit Rate =  $\text{SUM}([\text{Profit Margin}]) / \text{SUM}([\text{Booking Price}])$

## **Mobile app**

Tableau Mobile is the mobile app of Tableau. Users can define a layout for the mobile app on Tableau Desktop or Cloud and visualize it on the mobile app. Tableau can generate a layout automatically or users can adjust it as preferable. The Tableau Mobile app is only for view purposes but visuals are still interactive.

A mobile layout was created and all visuals used in the dashboard were all implemented in the mobile view.

### **4.2.2. Use Case II – GoGo Delivery vs Tableau**

In order to start the testing, the data was imported from the database GoGo Delivery stored in SQL Server to Tableau. Once in Tableau, a dashboard was created (see Appendix E) evaluating the following features.

## **Roles**

With Tableau Cloud, there are six types of permissions by default:

- View: view and filter the dashboard, view and add comments, download an image or PDF of the dashboard and data summary;
- Explore: in addition to the viewer rights, allows to share, download, to web edit and run explain data;

- Publish - besides the rights mentioned above, it includes the possibility to download or save a copy, to overwrite and to create and refresh metrics;
- Administer – no limitations;
- None - none of the permissions is specified;
- Denied - all the permissions are denied, no permissions are granted.

Besides the templates provided by Tableau Cloud, users can custom create their Permissions rules by adding or removing the rules mentioned above (*Set Users' Site Roles*, n.d.).

After creating the dashboard in Tableau Desktop it was deployed to the Cloud. Once on Tableau Cloud, the Permissions Rules were used to grant permissions to fictitious users. Were created the Publish Rule, the Explore Rule and a Custom rule with permission to view, filter and download an image, being all the other permissions denied.

### **Multiple users and collaboration**

Users are limited in this version of Tableau to 25 creators, however unlimited to explorers and viewers.

Two fictitious users were added: one as Explorer with permission to publish and the other as viewer.

### **Security at row level**

Row level security (RLS) differs from Tableau roles. RLS can be created using user filters. Since some fictitious users were created previously, a user filter was created based on one. For this user was created a filter that only provides access to information of stores located in the cities of Porto Alegre and Rio de Janeiro.

### **Geospatial analytics**

Tableau original visuals include maps. To create maps in Tableau the dataset must have at least one geographical asset as country or region or, to be more precise, longitude and latitude. A map was created to show hostels locations, using only the Country dimension that was then transformed by Tableau into latitude and longitude variables.

### **Embedded analytics**

Tableau offers a paid Embedded Analytics license that allow users to integrate Tableau into their products. This license includes maintenance, support and upgrades to the latest releases (*Embedded Analytics Pricing for Tableau*, n.d.).

This was not possible to test due to not having access to this type of license. However, it is still a feature that the tool offers and that makes it stand out from others in the market.

### **Real-time analysis**

As mentioned previously in this study, the concept of real time analysis can vary from person to person or software to software. In Tableau Desktop and Server is possible to configure an auto-refresh of data that can be consider real-time for some. By using an open-source software, it is possible to refresh the data in Tableau Desktop every 5 minutes automatically which can be consider a real-time approach. With Tableau Server, Tableau JavaScript API can set up an auto-refresh every 3 seconds.

This could not be tested due to not having the required software or version of Tableau.

### **4.2.3. Use Case III – Your Online Store vs Tableau**

For this use case, data was imported from two different data sources in order to test one of the tool features. In Tableau, the dashboard was developed (see Appendix F).

### **Multiple Data Sources**

Data can be imported to or connected with Tableau from numerous sources and it is easy to combine multiple sources. Similarly to the previous tool tested, the data was imported from two different sources: SQL Server and a csv file. From SQL Server was imported the Fact\_Order, Dim\_Product and Dim\_Shipping. The Dim\_Customer table was imported from a csv file.

### **AI features**

Ask Data and Data Story are Tableaus integrated AI features. Ask Data is a visual that allows users to ask questions regarding data and a visual is automatically created to answer the question. Data Story is a feature that adds text fields to the dashboard that explain what is being seen in the dashboard regarding the visuals created. Both features need connection with Tableau Server which means it was not possible to test this feature.

### **Buttons**

Buttons or, as called in Tableau, Objects are a part of Tableau available features. Objects integrate navigation buttons, web links, download functions, images and more but it is quite limited when comparing with other tools.

To test the Objects, and taking in consideration the limitations of the tool, a small download button was added and edit to appear as an icon.

### **Tool support**

While on Tableau Desktop, a Help tab is available with the options "Open Help" and "Get Support". "Open Help" is a web page with help content for Tableau Desktop and Web Authoring. The "Get Support" option opens a web page with support for all Tableau products and FAQ's.

### **Tool training and learning curve**

Also on the Help tab, there is an option called "Watch Training Videos". This is a link to a web page with trainings based on the user roles (creator, explorer, viewer and admin) and on the product versions.

### **Creating new measures**

New measures can be created in Tableau through the option "Create Calculated Field". This option was used previously to test the tool language and it is like other methods in different software to create calculations.

The two following simple measures were created:

- Total Sales = SUM([Order Sales])
- Total Ship Cost = SUM([Ship Cost])

### **Data lineage**

Data lineage is available in Tableau Server. After deploying the workbook to the Cloud, the data lineage and a view of the data being analyzed is available in the Lineage tab on Tableau Cloud.

## **4.3 QLIK TESTING**

To test this tool was used the free version of Qlik, Qlik Cloud.

#### **4.3.1. Use Case I – StayHostels vs Qlik**

The data for the testing was imported from StayHostels database stored in SQL Server Management Studios. Once the data was imported, a dashboard entitled “StayHostels” was created (see Appendix G).

##### **Data Visualizations: variety of visuals**

Qlik Cloud has around 30 visuals available. The visuals can be customized however the settings are rather limited.

To test multiple visuals, a dashboard was created with the following visuals:

- One KPI that delivers the revenue;
- A line chart with the revenue per year;
- A bar chart to show the profitability of the hostels;
- A map chart with the hostels locations;
- Two tables for the customers demographics.

##### **Data Visualization: creation of own visuals**

Qlik users can create their own custom objects through the Extension Editor that supports .qext, .js, .html and .css formats. This feature is only available for the Qlik Sense version (*Extending with Custom Visualization Objects*, 2023).

##### **Data Visualization: add-ons visuals**

Extensions can be added to Qlik Cloud if on the formats .qext, .js, .html or .css. There is a community in the Qlik environment that works as a store to get extensions which can be visuals, filters and others. However, this community is not available for the current license being used so this feature was not possible to test but it is available in other versions of the tool (*Managing Extensions*, n.d.).

##### **Data Visualization: interactive dashboards**

In Qlik Cloud, interactivity between visuals is a feature implemented by default. Yet, it is possible to deactivate the interactive using the Alternative State under the Master Items tab.

It is not very clear how this feature works, at least on the current version of Qlik, and Qlik resources also don't have a perceptible guide on how to use it, due to this it was not possible to test this feature.

### **Ranking reports**

Qlik Cloud features do not include ranking reports, nonetheless this feature is available in Qlik Sense.

### **Schedule Reports**

Before opening the folder on Qlik Cloud, there are three dots where the settings of the app can be found. In the settings there is an option to program the reload of the data. Users can choose how they want to update their data: daily, weekly, monthly or once a year. It is also possible to choose the time schedule and if the reload should happen continuously or between dates.

To test this feature, it was implemented a reload schedule happening on hourly on working days from 7h00 until 20h00.

### **Advanced analytics**

Equally to the ranking reports, Qlik Cloud does not have any advanced analytics features build it, still they are available in other versions of the tools.

### **Tool Language**

Qlik uses QlikScript as their coding language. This language can be applied to build expressions, metrics, scripting data and others. A simple metric was created to retrieve the total revenue:

- `=sum("Booking Price[SGD]")`

### **Mobile app**

The Qlik mobile app is called Qlik Sense SaaS and it displays the dashboards created on Qlik Cloud. Just like the previous tools, Qlik Sense SaaS does not allow to add or change the visuals.

By default, the dashboard will appear in list view which means that all the visuals will appear in a list order without being possible to change the order.

However, it is possible to change to grid view, that allows the users to see the dashboard as it was created on the Cloud. To perform this change, once on the Sheet properties in the Cloud, users should change the small screen layout from List view to Grid view.

This was tested and the grid view was implemented for the mobile app.

#### **4.3.2. Use Case II – GoGo Delivery vs Qlik**

The GoGo Delivery data was imported from its database in SQL Server Management Studios to Qlik Cloud and the dashboard was created (see Appendix H).

##### **Roles**

In Qlik Cloud there are seven different roles divided between two main categories: users and admins (*Assigning Security Roles*, n.d.). The users' roles are composed by:

- Developer - "can generate API keys"
- Private Analytics Content Creator - " can create analytics content in their personal space, create alerts and subscription reports"
- Shared Space Creator - " can create shared spaces"
- Steward - " can create, update, and delete a glossary, and approve, edit, and delete terms"

And the admins by:

- Analytics Admin - "has access to the Management Console, but only to the areas of governance and content"
- Audit Admin - " has access to the Management Console, but only to events"
- Tenant Admin - "has complete access to the Management Console to manage and administer the tenant"

To test this features, two fictitious were created and one was registered with Analytics Admin rights and the second one with Steward rights.

##### **Multiple users and collaboration**

When it comes to the number of users accessing one Qlik folder there is no evident limit in the version of Qlik Cloud being tested and, as per the test of the previous feature, two roles were created.

##### **Security at row level**

Security at row or column level is not a feature provided by Qlik Cloud, however it is available for the Qlik Sense version.

##### **Geospatial analytics**

Qlik Cloud has a map visual that shows limitations. This map can only be created if there are latitude and longitude variables in the dataset. Furthermore, these variables cannot simply be added to the visual, it is necessary to create an expression. The expression is the GeoMakePoint and the two geographical variables need to be added to it.



The following expression was built: GeoMakePoint(store\_latitude,store\_longitude). This retrieved the stores locations on the map. For the hubs, since there were not variables with latitude and longitude data it was not possible to develop the visual.

### **Embedded analytics**

A specific license and Qlik Sense are the requirements to be able to set embedded analytics. Since Qlik Sense is not being tested in the current study it was not possible to test this feature.

### **Real-time analysis**

As already mentioned, real-time analytics depends on how the user sees its concept. For some real-time analytics means tracking data to the second and to others tracking data to the hour. If not done manually, Qlik Cloud data refresh can be set to reload data every hour and this is the minimum time span.

#### **4.3.3. Use Case III – Your Online Store vs Qlik**

To start the testing, the data was imported from the database Your Online Store in SQL Server to Qlik and the last dashboard of the study was created (see Appendix I).

### **Multiple Data Sources**

Qlik Cloud allows the connection to more than 80 data sources, plus the upload of files. To test this feature it was used a connection with Microsoft SQL Server and a .csv file. The connection with SQL Server was made to import the tables Fact\_Order, Dim\_Product and Dim\_Shipping. The Dim\_Customer table was imported from a csv file.

### **AI features**

Qlik offers a lot of AI analytics but none is available for Qlik Cloud, meaning it was not possible to test this feature.

### **Buttons**

Buttons are available in Qlik Cloud and come by default with a very bug list of options and are customizable being the user able to choose the color, title or icon. Two buttons were created for the dashboard: one button to refresh the data and other to clear all filtering selections.

### **Tool support**

On the Launcher Menu in Qlik Cloud, there is Help tab. This will bring users to the Qlik Help portal with articles and web pages dedicated to the different versions of Qlik (Qlik Cloud, Qlik View and Qlik Sense) and data integration. On the Launcher Menu, users can also find the Qlik Community where users can post their question regarding Qlik and search topics posted by other members.

### **Tool training and learning curve**

As well on the Launcher Menu, there is a link to the Learning Portal in which users can find quick guides, video tutorials, self-paced learning, classroom training and even assessments. This provides for a faster learning process.

### **Creating new measures**

Depending on the chart selected, metrics or measures can be added. Once a chart is added, Qlik shows the user the most common calculations (sum, count, average, minimum and maximum) however it is also possible to open the Expression editor, represented by the fx symbol, for more complex calculations.

For this feature, three measures were created and represented in the dashboard:

- Sum of sales
- Count of products
- Sum of sales per month

### **Data lineage**




When on the Home page of Qlik Cloud, users can find their apps where the dashboards for each project are inserted. Without opening the so-called app, in each project there are three dots located on the bottom right corner of the square. Clicking on the three dots, there is a line called Lineage. This will open a window with the data lineage for the current app.

## 5. RESULTS AND DISCUSSION

While testing the features of each use case in the three BI tools, a score on a numerical scale was assigned to the corresponding feature.

The numerical scale runs from 1 to 4. The lowest number is the scale, number 1, is set for a feature that is not available in the version of the tool being tested. So if a tool does not have the feature being tested, the feature will be scored with a 1. The second number on the scale, number 2, represents a feature that is available on the tool but overall is week, meaning that somehow it is limited either on settings or on what the feature should present. The number 3 in the scale, represents a feature that overall is good and that performs how expected by users. The last number on the scale, the number 4, is for a feature that performs very well, with multiple settings and provides more than the usual.

Considering the features and scores assigned, a capability matrix was build displaying the features tested per use case and per tool. Scores assigned to each feature can be consulted in Table 1.

		 Power BI	 + a b l e a u	
<b>Use case 1</b> <b>StayHostels</b>	Data Visualization - visuals variety	4	4	3
	Data Visualization - creation of own visuals	3	3	1
	Data Visualization - add-ons visuals	4	3	1
	Data Visualization - interactive dashboards	4	4	2
	Ranking reports	4	4	1
	Schedule reports	3	1	4
	Advanced analytics	2	1	1
	Tool language	3	4	3
	Mobile app	3	3	3
<b>Use case 2</b> <b>GoGo Delivery</b>	Multiple users and coloboration	3	3	4
	Roles	4	4	3
	Security at row level	-	4	1
	Geospatial analytics	4	3	2
	Embedded analytics	1	1	1
	Real-time analysis	3	1	2
<b>Use case 3</b> <b>Your Online Store</b>	Multiple data sources	4	4	4
	Tool support	4	4	4
	Tool training and learning curve	4	4	4
	AI features	4	1	1
	Buttons	4	2	4
	Creation of new measures	4	4	3
	Data lineage	4	4	4

Legend:

1. Not available      2. Week      3. Suficient      4. Good

Table 1. Capability matrix

### Data visualization: visuals variety




	BI System	Description
Winners	 Power BI	In this topic, Power BI and Tableau appear as winners for the quantity, variety and customization options.
		
Lower performer		Qlik stands out in the negative when it comes to the variety of visuals compared to Power BI and Tableau. Qlik visuals are limited in number but also by their settings, not having as many customization options as the other two tools.

Table 2. Data visualization: variety of visuals

### Data visualization: creation of own visuals




	BI System	Description
Winners	 Power BI	Both Power BI and Tableau allow users to create their own visuals. However, both tools require additional knowledge of code and other software to create the visuals, which makes the process more difficult.
		
Lower performer		The Qlik version being tested does not allow the creation of its own visuals.

Table 3. Data visualization: creation of own visuals

### Data visualization: add-ons visuals




	BI System	Description
Winner	 Power BI	In this topic, Power BI stands out for the ease of searching and adding external visuals to the program and for the number of available visuals. AppSource, the resource shop for PowerBI, offers a wide range of free and paid visuals. Besides resources from the AppSource, it is also possible to add external visuals to PowerBI if they meet the required formats.
Lower performers		Tableau shop has a much smaller selection of graphic elements but just like Power BI allows the addition of external visuals if if the correct format.
		Qlik does not support the addition of visual add-ons.

Table 4. Data visualization: add-ons visuals

## Data visualization: interactive dashboards




	BI System	Description
Winners	 Power BI	Interactive dashboards make data segmentation easier by just clicking on a variable. Power BI and Tableau's definitions of interactivity are broad, giving the user the option to choose which visuals should influence the segmentation of data in others.
	 + a b l e a u	
Lower performer	 Qlik	Qlik also allows for dashboard interactivity but does not allow the user to choose the interactivity settings, limiting the creativity of the dashboard creation process.

Table 5. Data visualization: interactive dashboards

## Ranking reports




	BI System	Description
Winners	 Power BI	Sometimes, when creating a graph, users only want to look at the top or bottom of the given dimension or look at the values starting at a certain number. Ranking reports support this creation and are available in both Power BI and Tableau and allow users to create tops or conditions to rank the visual data.
	 + a b l e a u	
Lower performer	 Qlik	Qlik fails on this topic by not having this feature available when creating visuals.

Table 6. Ranking reports

## Schedule reports




	BI System	Description
Winner	 Qlik	When it comes to schedule reports, Qlik has more alternatives than its competitors. This BI tool allows the automatic refresh of data 24 times a day, one every hour.
Lower performers	 Power BI	Power BI only allows a total of eight automatic data refreshes per day.
	 + a b l e a u	Here Tableau weakens by not having available the option to automatically refresh the data.

Table 7. Schedule reports

## Advanced analytics




	BI System	Description
Winner	 Power BI	Advanced analytics encompass several techniques, which in BI tools may include the creation of scenarios or what-if analysis. However, none of the tools to be evaluated present advanced analytics methods other than Power BI but in the data transformation part and not in the visualization.
Lower performers		
		

Table 8. Advanced analytics

## Tool language




	BI System	Description
Winner		All three tools have their own languages for creating metrics or calculated fields. However, Tableau stands out as having a language that is similar to Excel.
Lower performers		Power BI and Qlik languages have their own characteristics and are therefore more difficult to learn.
		

Table 9. Tool language

## Mobile app




	BI System	Description
Winners		All three tools have their applications for mobile devices with modern and user-friendly layouts, simply by logging in to the tool's online service. In this aspect, Power BI and Tableau present similarities in the construction of a mobile layout having distinguished a page in their online services for the creation of the same layout. In Qlik, there is no creation of the layout for mobile and the dashboard appears in the app as in the Cloud which causes some asymmetries due to the resolution of the screens of mobile devices.
		
		

Table 10. Mobile app

## Roles




	BI System	Description
Winners	 Power BI	The Roles functionality is identical in all three tools, with various options for source roles. In Power BI and Tableau it is even possible to mix permissions and create unique roles.
	 + a b l e a u	
Lower performer	 Qlik	However, in Qlik, and besides also having a weird range of roles it is not possible to create unique roles and it does not have a role with only view rights.

Table 11. Roles

## Multiple users and collaboration




	BI System	Description
Winner	 Qlik	Neither tool allows more than one user to work on a dashboard at a time, but users can change, remove or add new views depending on their role and Qlik has no restrictions on the number of users.
Lower performers	 Power BI	Both Power BI and Tableau have user limits for some roles.
	 + a b l e a u	

Table 12. Multiple users and collaboration

## Security at row level




	BI System	Description
Winners	 Power BI	In Power BI, roles also provide the same that is meant by row level security which makes this tool one of winners due to the many possibilities of creating roles and restricting those based on data accessibility.
	 + a b l e a u	In Tableau there is specific SRL, where users can be set to have limitations to the access to data and filter data based on the variables of the dataset.
Lower performer	 Qlik	Qlik, on the other hand, does not provide such features.

Table 13. Security at row level

## Geospatial analytics




	BI System	Description
Winner	 Power BI	Geospatial analytics are available in all three tools, with Power BI being the most developed one. By default, Power BI has more geospatial visuals integrated than the other two tools and by provided the ArcGIS maps integrated it's a bigger plus.
Lower performers	 + a b l e a u	Tableau provides geospatial features but in only two different formats.
	 Qlik	Qlik's biggest limitation compared to other tools is that it requires latitude and longitude coordinates to create maps.

Table 14. Geospatial analytics

## Embedded analytics




	BI System	Description
Lower performers	 Power BI	All tools allow for embedded analytics but require either an upgraded version of the tool or other software.
	 + a b l e a u	
	 Qlik	

Table 15. Embedded analytics

## Real-time analysis




	BI System	Description
Winner	 Power BI	Power BI allows the connection to three different data types that are indicated for data being updated on the minute and changes are visible automatically on the dashboard.
Lower performers	 Qlik	Tableau an Qlik also provide this type of data but not in the versions being tested.
	 + a b l e a u	

Table 16. Real-time analysis



## Multiple data sources




	BI System	Description
Winners		Power BI, Tableau and Qlik are really leaders when it comes to data sources, having as many data sources as possible. They also allow for the merging of data from different sources in one dataset.
		
		

Table 17. Multiple data sources

## Tool support




	BI System	Description
Winners		All the tools provide online web pages with support for the tool usage as well as a community to ask questions and see the most asked questions, all highly structured.
		
		

Table 18. Tool support

## Tool training and learning curve




	BI System	Description
Winners		The tools provide training contents like webpages, videos and even courses for free making it easier for users to get to know the system.
		
		

Table 19. Tool training and learning curve

## AI features




	BI System	Description
Winner	 Power BI	As far as artificial intelligence is concerned, only Power BI gives its users features integrated into the tool and even with some variety.
Lower performers	 + a b l e a u	The two tools fall short by not having anything related to AI.
	 Qlik	

Table 20. AI features

## Buttons

	BI System	Description
Winners	 Power BI	Power BI and Qlik have a very big variety of buttons to be added to dashboards. The only difference between the two tools is that in Power BI buttons are more customizable but still buttons in Qlik are pretty good.
	 Qlik	
Lower performer	 + a b l e a u	Tableau has a very short range of functions for buttons which limits the activity in the dashboards.

Table 21. Buttons

## Creation of new measures




	BI System	Description
Winners	 Power BI	Adding new measures to the dashboard is possible in all three tools, however Power BI and Tableau make it easier by having a set of built-in measures ready to be used.
	 + a b l e a u	
Lower performer	 Qlik	Qlik, besides not having the built-in measures, when it comes to create more complex expressions is harder compared to the other tools.

Table 22. Creation of new measures

## Data lineage




	BI System	Description
Winners		On the last feature being tested, Power BI, Tableau and Qlik proved once again why they are leaders and provide their users a very straight-forward data lineage tab where users can follow the path that the data follows until arriving to the tool.
		
		

Table 23. Data lineage

The results indicate that, overall, Power BI wins on all topics except for the language of the tool and schedule reports. This result is aligned with the 2022 Analytics and BI Platforms Magic Quadrant by Gartner that shows between the leaders Microsoft Power BI as the top platform in the area. Power BI language proves to be more complex compared to Tableau's since it bears less resemblance to other languages. On schedule reports, Qlik proves to be the most advanced, giving the user more options to choose from. Nonetheless there is still plenty of room for Power BI to grow specially when it comes to advanced analytics.

Despite the results presented, there are still weighing factors when it comes to choosing the ideal BI tool based on features.

No matter how good a certain tool is, if a dashboard is not properly designed it won't have the desired outcome and what it aims to communicate will fail (Smuts et al., 2015). On that note, it is strongly recommended that professionals working with BI tools have training on how to take the most out of the tool to present efficient designs.

Nonetheless, companies value their own design guidelines so when investing in a BI tool should be taken into consideration a tool that allows for the implementation of companies own designs, colors, or formats.

The initial stage of using a new BI platform can be challenging. AI services can minimize the difficulty of the process by automating the transformation of unstructured data into meaningful visualizations (Edge et al., 2018).

When it comes to security, companies should be aware that it goes beyond the IT departments. BI tools can help companies develop a security-aware culture which is nowadays a conversation topic globally (Paulsen & Coulson, 2014). BI tools can restrict the information that each user should have access to it or not.

Overall, this study helps companies choose their main BI software supplier based on what the company is looking for in a tool. Companies can make a value calculation taking into consideration the score of

each feature or even analyze how each feature works through the research done and presented in chapter 4.

## 6. CONCLUSIONS AND FUTURE WORKS

This study aimed to understand which BI software is more developed regarding certain features, helping companies when making the decision of choosing a software. The three tools evaluated are the leaders of the 2022 Gartner Magic Quadrant for Analytics and BI platforms and this is evident in their abilities. However, throughout the study one tool stood out from the others by scoring the highest score in almost every item.

It is important to stress that all tools have their qualities and weaknesses and much can depend on the users' knowledge of tool. With that said, is recommended that some level of knowledge of the software is required before using it, in order to speed up the process of working with the tool.

As the study progressed, some limitations emerged which leaves room for more research to be done in the future. During the development of the thesis, the main limitation was not having the same version of each tool. This meaning that by having a version of Power BI that is much more advanced than the version of Qlik it creates some disparities in the study and the comparison is not as accurate as if the most advanced version of all tools was being used. It should also be noted that the lack of knowledge or not having access to additional tools needed to test topics like embedded analytics were also limitations.

Another limitation was the fact that other tools, besides the leaders in the Gartner quadrant, did not provide free trials and only demos where available not making it possible to be part of the study. This ended with the initial idea of the study: evaluating the three leaders' tools in the quadrant and one more tool from the other quadrants (challengers, niche players and visionaries).

Facing the limitations identified, it should be considered for future work to test more tools that cover the full Gartner quadrant and that are all at the same version level, preferably the most advanced one. In addition, more features such as cost and licensing models, big data, self-service BI and others may also be considered in the future research.

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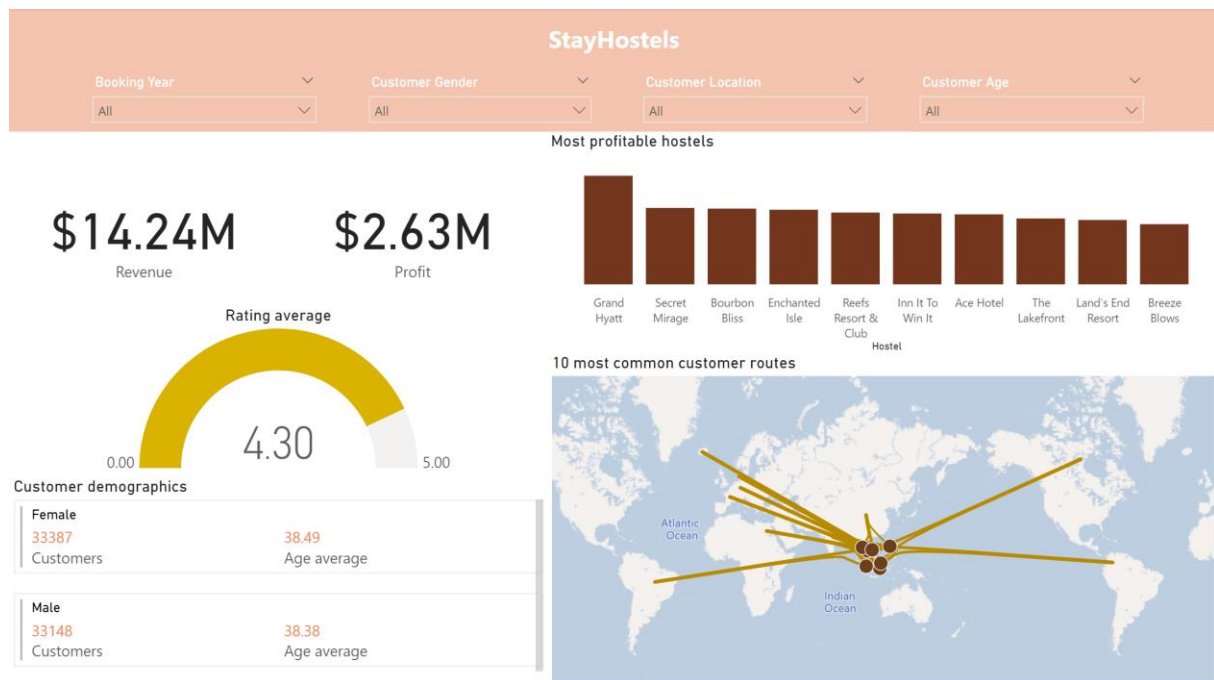
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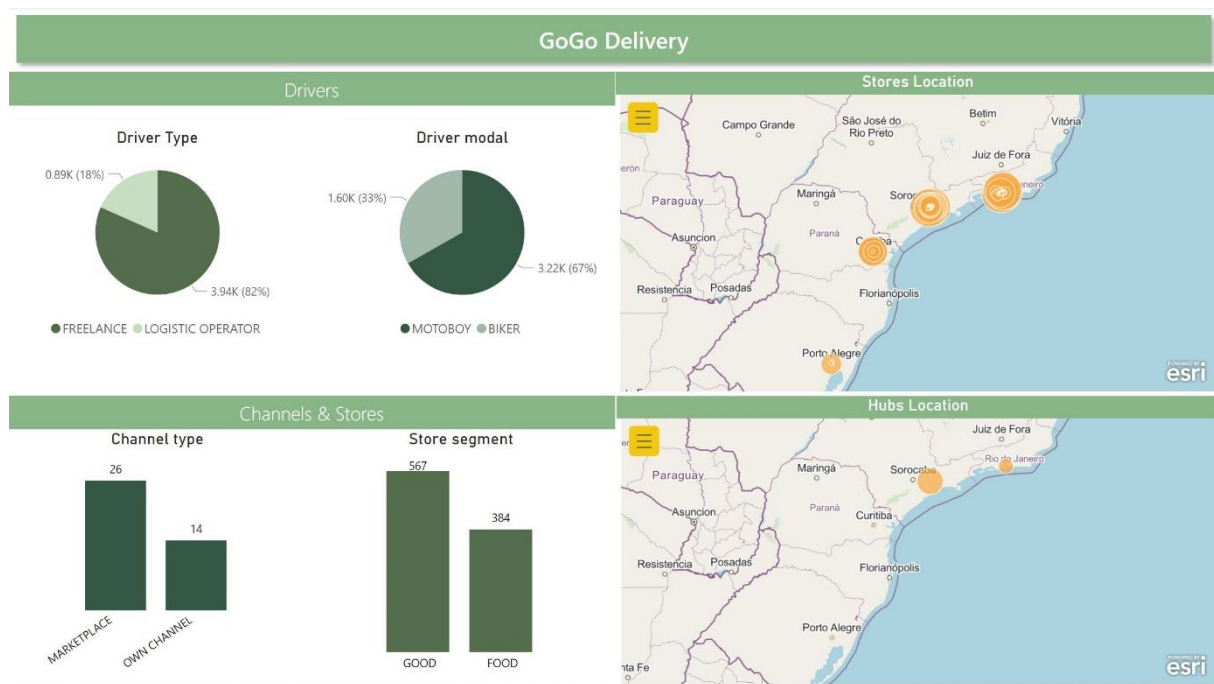
## APPENDIX A

### Use Case I: StayHostels Dashboard in Power BI



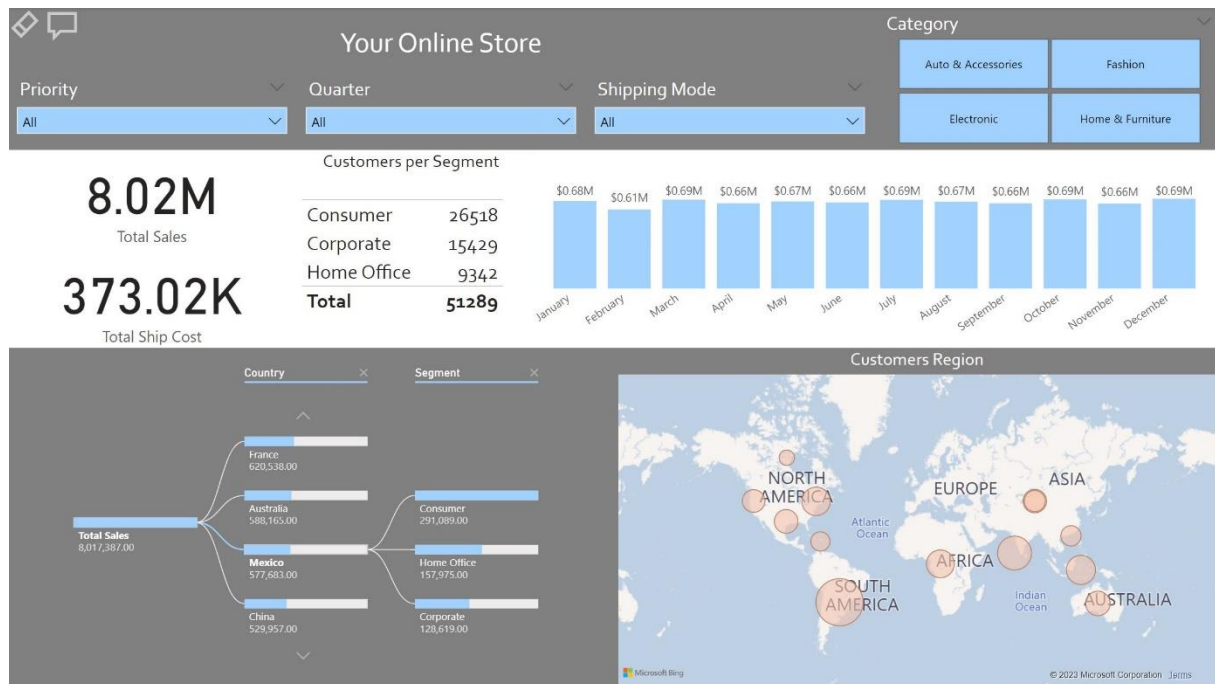
## APPENDIX B

### Use Case II: GoGo Delivery Dashboard in Power BI



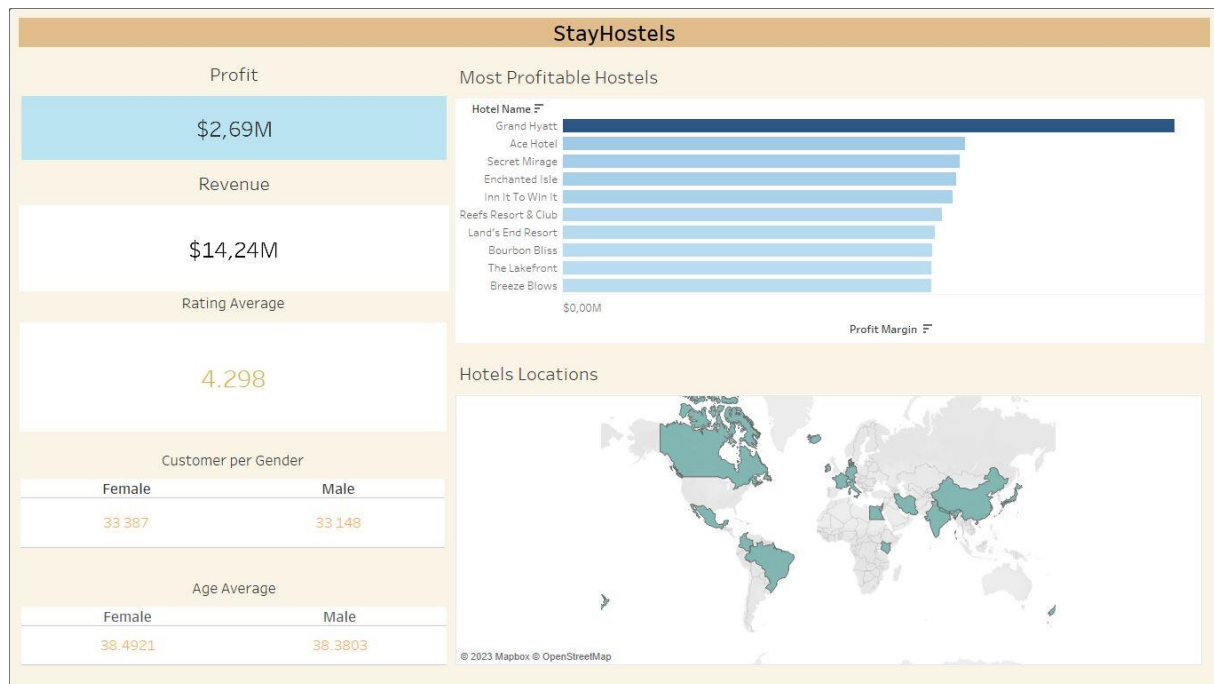
## APPENDIX C

### Use Case III: Your Online Store Dashboard in Power BI



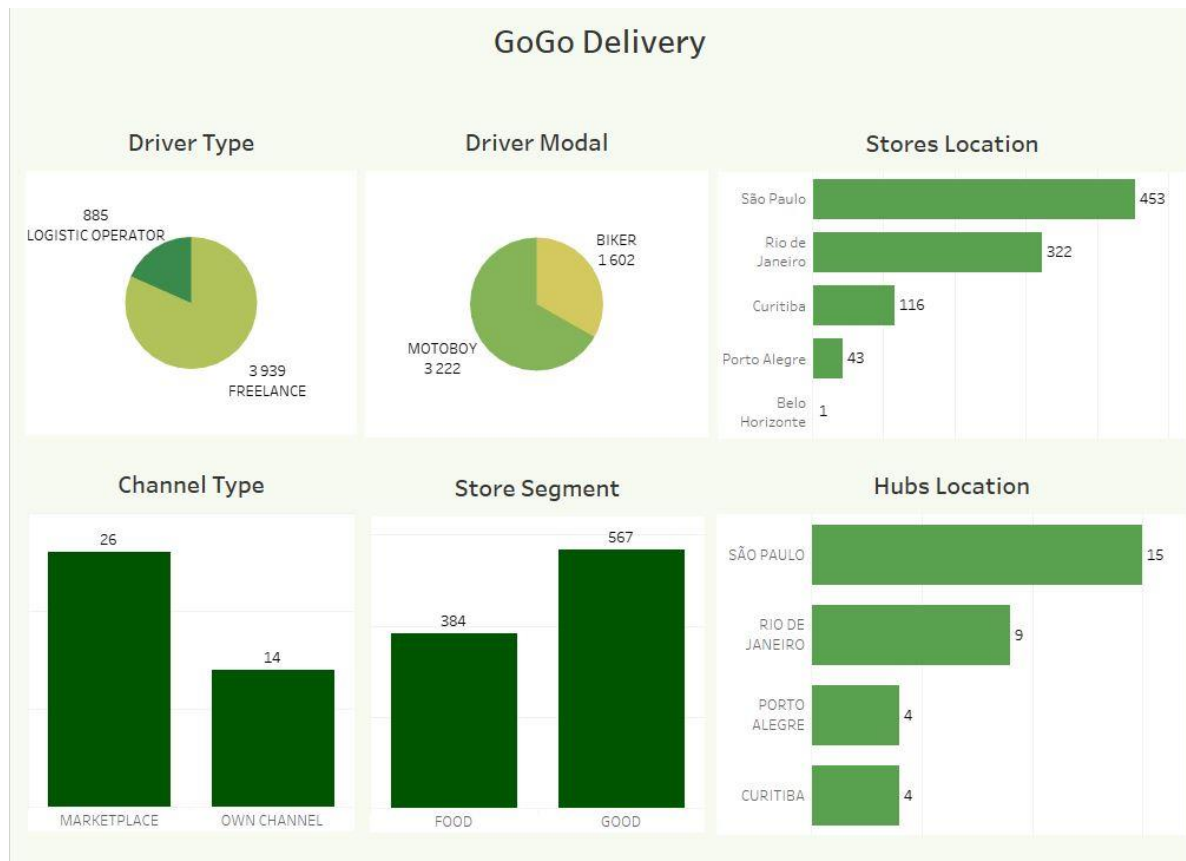
## APPENDIX D

### Use Case I: StayHostels Dashboard in Tableau



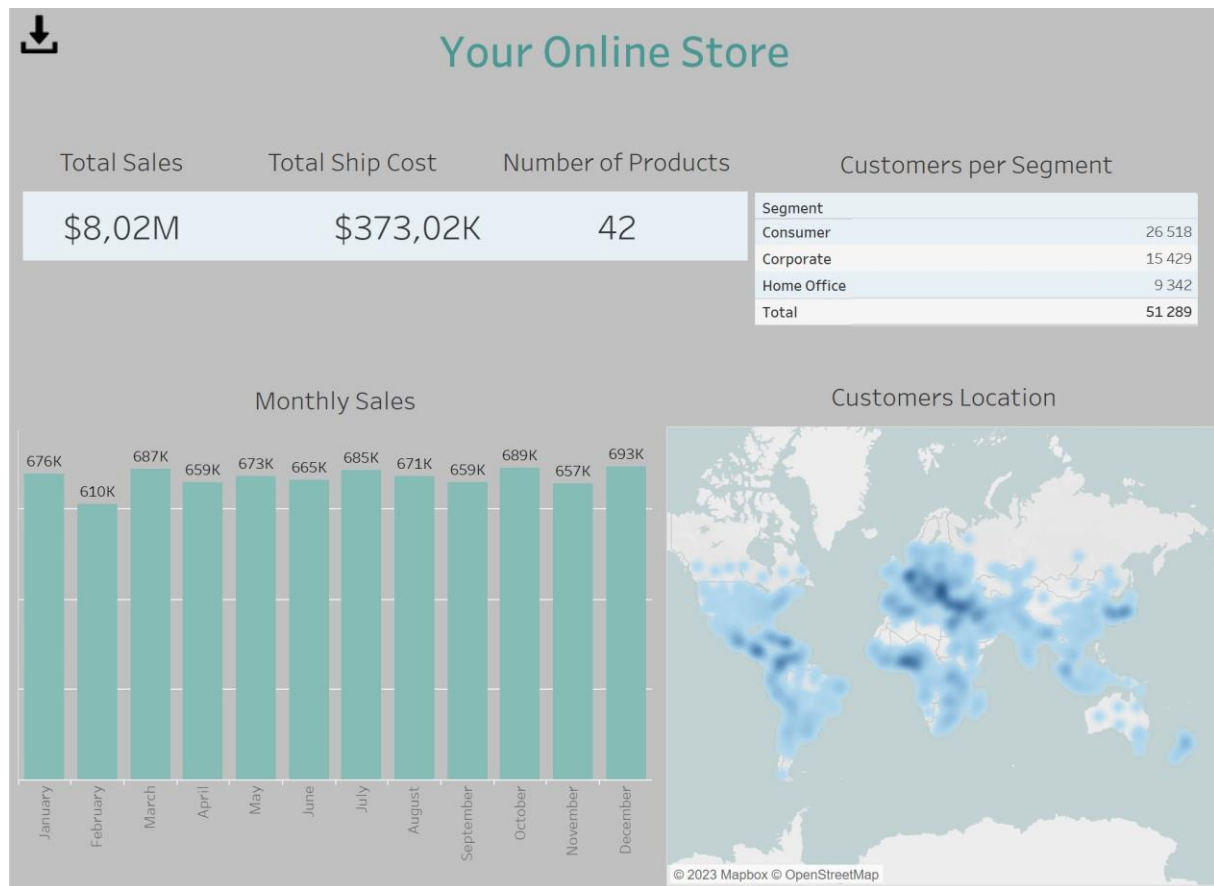
## APPENDIX E

### Use Case II: GoGo Delivery Dashboard in Tableau



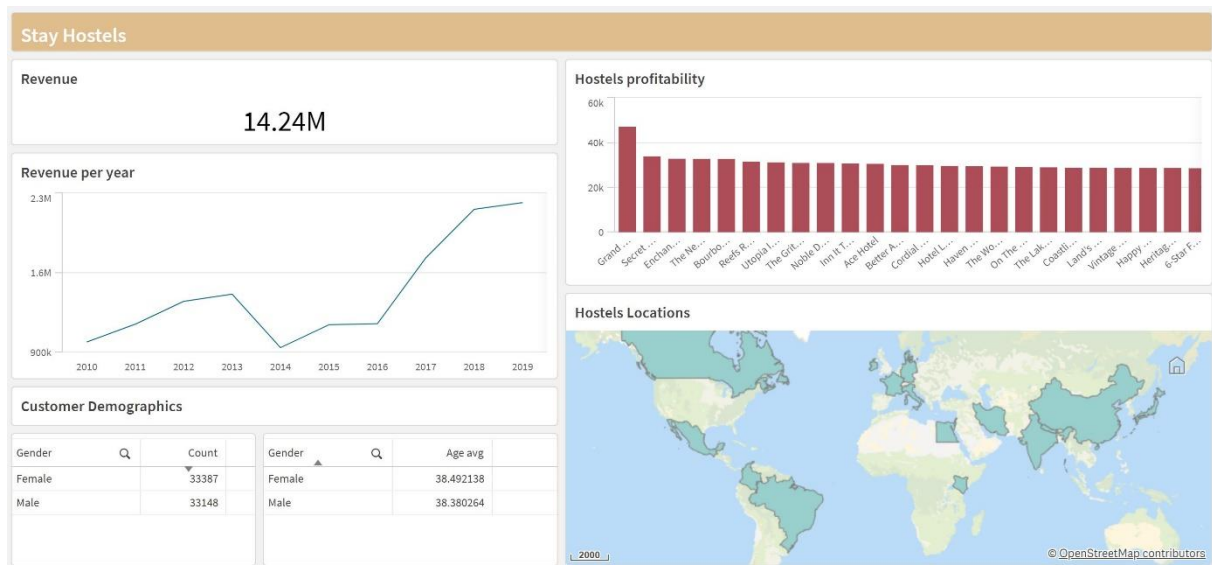
## APPENDIX F

### Use Case III: Your Online Store Dashboard in Tableau



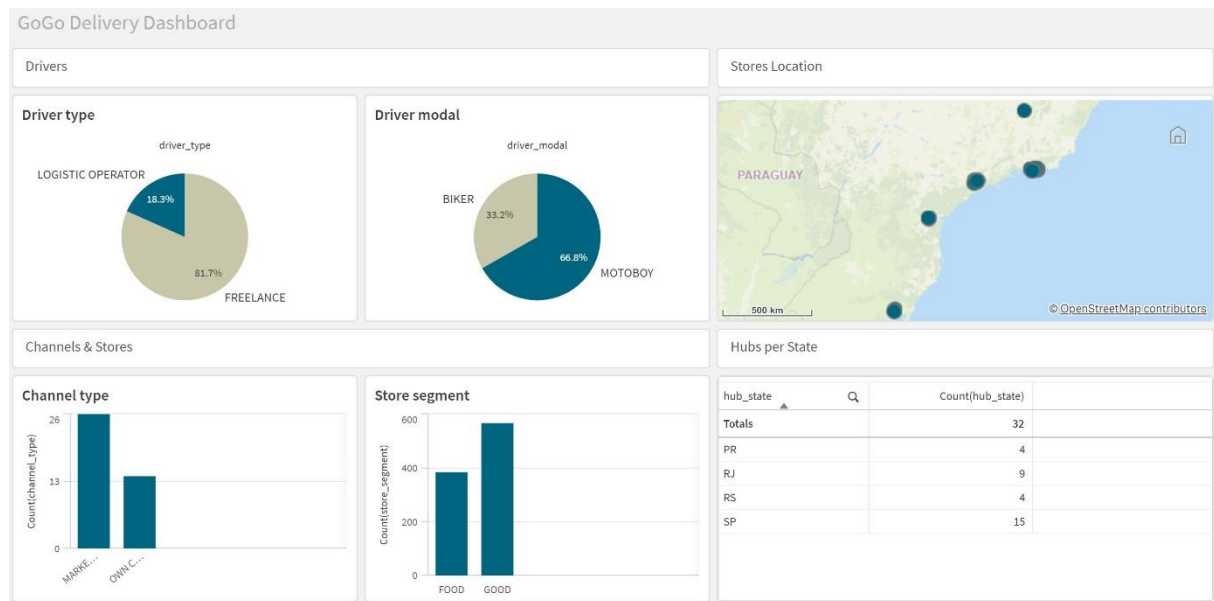
## APPENDIX G

### Use Case III: StayHostels Dashboard in Qlik Cloud



## APPENDIX H

### Use Case III: GoGo Delivery Dashboard in Qlik Cloud





## APPENDIX I

### Use Case III: Your Online Store Dashboard in Qlik Cloud

