NOVA IMS Information Management School

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CLIMATE INFLUENCE ON THE OLIVE OIL PRODUCTION AND PRICE

Implementation of a Dashboard

André Lopes Pereira da Silva

Dissertation

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

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
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Dissertation presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management & Business Intellgience.

Supervised by

Professor Pedro Cabral

November, 2023

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 acknowledged the Rules of Conduct and Code of Honor from the NOVA Information Management School.

André Lopes Pereira da Silva

Lisbon, 27/11/2023

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ABSTRACT

The climate is a main changing factor in the production, quality, and prices of agricultural products. Olive oil is not an exception to this reality. With the extreme climate events the Mediterranean Basin was affected by in the previous years, such as severe droughts, heat waves, and heavy rains, olive oil production was critically affected, influencing supply and demand, and causing price volatility. Studying how these climacteric events affect the pricing of olive oil in countries of higher production volume is lacking and is crucial to optimise the pricing strategy of this business. Alongside Pompeian, the biggest olive oil producer in the United States, the main objective of this master thesis is to develop and deliver a dashboard. This dashboard will allow its final user to make conclusions regarding the correlation between temperatures, rainfall, olive oil production, and olive oil prices based on previous years' historical data, to make the decision-making processes more straightforward for Pompeian professionals. This dashboard was developed according to the Prototype Methodology, respecting Pompeian requirements and Data Visualization (DV) six principles. Once the dashboard development was concluded, its validation was made through an interview with its future end-users, Pompeian selected professionals. The validation of the dashboard was successful, since 90% of the interviewees considered the dashboard delivered its original goal, and it was easy to use and of high usefulness, since it got average ratings of 1,88 regarding difficulty (being 5 the most difficult) and 4,52 regarding usefulness (being 5 the most useful).

KEYWORDS

Data Visualization; Climate Influence; Olive Oil; Production; Price; Dashboard

Sustainable Development Goals (SDG):

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DV	Data Visualization
IOC	International Olive Oil Council
SST	Sea Surface Temperature
SDLC	Software Development Lifecycle

1. INTRODUCTION

Climate is one of the main factors impacting agricultural production, quality, and prices (Kumar & Khurana, 2023). Olive Oil is not an exception to this reality. With the extreme climate events the globe was affected by in the previous years, such as severe droughts, heat waves and heavy rains, olive oil production was critically affected, influencing supply and demand and causing price volatility. Studying how these climacteric events affect the pricing of olive oil in the four bigger production countries, Spain, Italy, Greece, and Portugal, is lacking and is crucial to optimising the pricing strategy of this business (Orlandi et al., 2020).

The year 2022 was one of the most unstable years in memory regarding climate (*Global Climate Highlights 2022 | Copernicus*, n.d.), with human-induced warming reaching 1,26 celsius degrees (Forster et al., 2023), which directly influenced the prices and availability of olive oil. In December, a new maximum price for olive oil was reached. Even though other facts, such as the Ukrainian war, directly influenced this event, the most impactful fact was the Mediterranean basin's climate conditions, especially Spain, the most significant worldwide olive oil producer, which saw its production reduced by 50%. (*Global Olive Oil Buyers Stymied by Spain's Drought, Turkey's Export Ban*, 2023)

Even though data regarding the influence of climacteric effects on the prices of olive oil is present in many media headlines, the market needs a proper tool where professionals can compare and analyse the previous years more visually. With the increasing climate inconsistency as the years go by, it becomes harder and harder for the companies to prepare themselves for the upcoming olive oil crops (Davide Cammarano, 2023).

Alongside Pompeian, the number one olive oil brand in the United States of America and owned 50% by the biggest olive oil cooperative in the world, DCOOP, the main goal of this master's thesis is to provide a dashboard to the final user, based on historical data, that will allow a more profound understanding on how the climate is influencing the olive oil production and price. Furthermore, to understand how the climacteric events in the four major olive oil supplying countries influence the olive oil prices a PowerBI dashboard based on Pompeian requests will be developed to aid them in data-driven decision-making.

1.1. RELEVANCE AND OBJECTIVES

The main question this Master's Thesis addresses is how climate impacts olive oil production and pricing and how to understand that relation. As stated in the introduction of this Thesis, firstly, we need to comprehend how the climate has behaved in the past ten years in the region of the four more prominent olive oil producing countries, the Mediterranean basin. We also need to understand olive oil as a product, its origins, and how it is priced.

Answering the needs of Pompeian, the leading Olive Oil company in the United States, the final objective of this project work is to develop a tool that Pompeian considers is lacking in today's olive oil market, that will facilitate the decision-making process by providing the company with easy access and understanding of historical data regarding climacteric events, production, and pricing evolution.

2. LITERATURE REVIEW

2.1. CLIMATE IN THE MEDITERRANEAN BASIN

The Mediterranean Basin [Fig. 2.1] is a region between the southern European and northern African coasts. Being influenced by both continents, its climacteric profile is characterised by hot, dry summers and humid, cool winters (Britannica, T., 2023).

Figure 2.1 - Mediterranean Basin
(Ribeiro, 2019)

However, with the climate changes that affect our globe, the trend is for the droughts and heat waves to become more intense and for the rainfall to decrease. For instance, in the warm season, it is expected for the rainfall to drop between 25 and 30%, and the warming to increase between 4 and 5 ºC by the end of this century, as it is already warming 20% faster than the rest of the globe (Cannon, 2022). As these extreme events become more and more frequent, the crops in the Mediterranean Basin will be affected in terms of productivity and quality.

If we analyse the data regarding the last decade, we can see that the average Mediterranean SST – Sea Surface Temperature is getting warmer over the years (García-Monteiro et al., 2022).

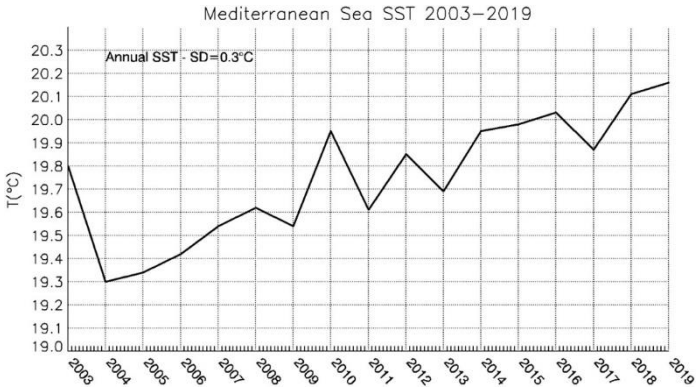

Figure 2.2 - Mediterranean SST Through The Years
(García-Monteiro et al., 2022)

This growth is a clear sign of how the climate is changing in the Mediterranean Basin, and as we will see further on the dashboard, there are already consequences in the crop production of this region [Fig. 2.2].

2.2. OLIVE OIL

Olive oil is a product that derives from the olive, the fruit of the olive tree. The origin of the olive tree (*Olea europaea*) goes back about 6000 years to ancient Persia and Mesopotamia. Throughout history, olive tree-derived products have had different but always beneficial meanings. Olive branches, for instance, were seen as a sign of victory and peace, being also used as a reward at the Olympic Games in ancient Greece, as the winner would receive it as the prize (Rhizopoulou, 2004). Nowadays, whether used in cosmetics, for cooking or as a dressing for food, olive oil is perceived by consumers worldwide as the healthiest fat/oil (Yubero-Serrano et al., 2019).

Olive oil is a commodity that has particular importance in the Mediterranean agricultural scene. Being one of the pillars of the diet of this region, and due to the climacteric conditions mentioned above, the Mediterranean Basin is where, as of today, approximately 95% of the olives in the world are cultivated (Fraga et al., 2021). In terms of olive oil production, it is also in the Mediterranean Basin where the more prominent producers are, with a clear emphasis on Spain, which in 2021 had a production of 1.46M tons, followed by Italy – 366k tons, Greece – 233k tons, and Portugal – 123k tons [Fig. 2.3] (Bungaro, 2021).

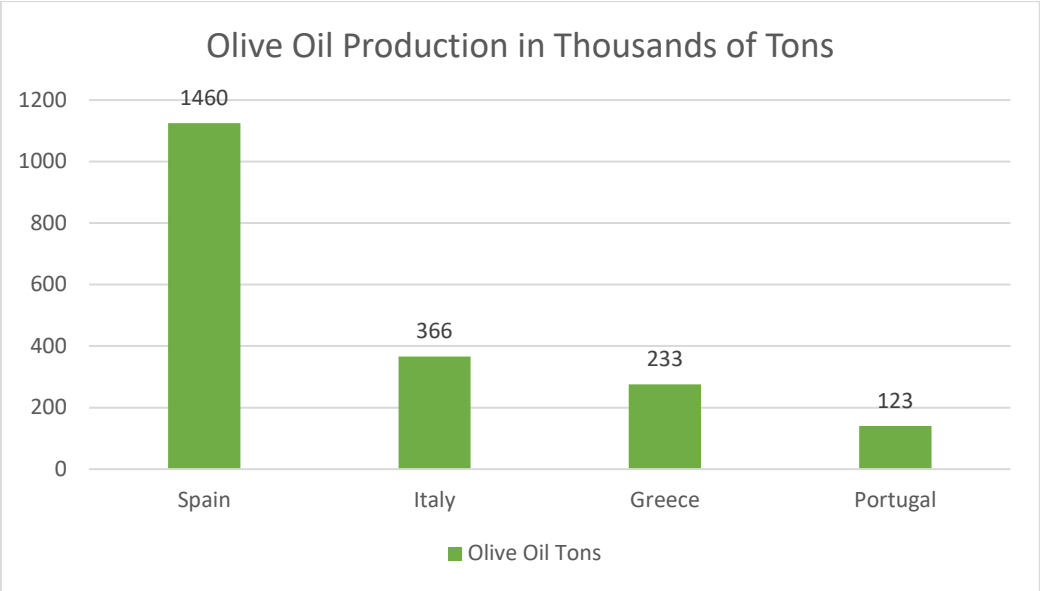

Figure 2.3 - Olive Oil Production in Thousands of Tons

As mentioned before, the increasing temperatures and lack of rainfall in the Mediterranean basin severely affect olive oil cultivation. Due to these two factors, researchers reported that Catalonia, Spain, an important area for olive oil production, may become inviable for this purpose in 20 years (Ozdemir, 2016).

2.2.1. Olive Oil Pricing Definition

The definition of the price of a product is essential to any market since it is what allows companies to profit, and the olive oil market is no exception to this.

However, the olive oil price is influenced by a vast range of factors, such as the market itself, the offer, the demand, the carryover, the stakeholders that take part in the negotiation, the quality, and production (Rodriguez, 2016), which is directly influenced by the climate.

The IOC – International Olive Council states that the average cost of production for a kilogram of olive oil, considering the different patterns of olive tree production, super-intensive, intensive and traditional, is 2,78€, being 2,33€ the field expenses and 0,45€ the transportation and the process of turning the olives into olive oil (Rodriguez, 2016).

Even though the production cost varies a lot from country to country due to the typology of farms, cost of labour, etc, there are indexes such as Poolred in Spain, which is an Information System for Origin Prices regarding Olive Oil, that provide its users with data related to quantities, prices, and characteristics of the buying and selling operations in the origin market (*POOLred-Sistema De Informacion De Precios En Origen Del Mercado De Contado Del Aceite De Oliva*, n.d.).

This system allows users to access live data regarding the metrics listed before, and as a consequence, it minimises market speculation (*¿Qué Es El POOLred? Aceite De Oliva Y Su Precio.*, n.d.).

2.2.2. Olive Harvesting

Olive harvesting is the process of collecting fruit from olive trees, which occurs from the middle of October until the end of February, the crop season. This process is a critical aspect of production because, if done by hand, the costs are high. The alternative is mechanisation. Trunk shakers have demonstrated that they are capable of harvesting olives efficiently and at a low cost. However, the orchards must be adapted to allow the use of such machines (Tombesi et al., 2007).

There are two factors that are fundamental to guarantee good production in the crop: an abundance of olive tree flowers in the months of April and May, and the rainfall should be superior to 400 mm in the months of September and October. However, only a value above 1000mm is considered an ideal value (Tombesi et al., 2007).

The flourishing period of olive trees directly depends on the yearly rise in spring temperatures (Pérez López et al., 2008). Since these higher temperatures can damage the intermolecular interactions crucial to providing growth to the plant and the fruit (Nissim et al., 2020), the amount of available olives and their quality will decrease, resulting in a drop in olive oil production.

Once olive oil is ready, it will be graded against the criteria set by the International Olive Council. Olive oil that passes the necessary chemical tests and has zero taste defects will be graded as extra virgin. The oil that has chemical or sensory defects will be refined and blended with virgin or extra virgin olive oil to add flavour and antioxidants before being sold (*Olive Oil Harvest*, 2020).

2.3. DATA VISUALIZATION

The term “data visualization” has a long history dating back to the 2nd century AD. In ancient societies, drawings and other visual representations were used to investigate the world and record historical events. (Crapo et al., 2020) Data visualization (DV) often results in graphical images of data or concepts, which assists in making decisions (Ware, 2012).

DV can be defined as the “presentation of data in a pictorial or graphical format, and a DV tool is the software that generates this presentation. DV provides its users with intuitive means to interactively explore and analyse data, enabling them to effectively identify interesting patterns, infer correlations and causalities, and support sense-making activities.” (Bikakis, 2018).

To succeed in DV, its developers should respect six principles (Hammond, 2023):

1. Know the audience.
2. Keep things simple.
3. Use the right chart type.
4. Use colors wisely.
5. Highlight the most essential information.
6. Avoid clutter.

Once these principles are respected and implemented, we will have a DV dashboard providing valuable information for decision-making processes.

2.4. Other Studies

Whereas this dashboard's objective is to understand the influence of climate on olive oil production and price, there is already one dashboard developed by the European Union that studies the impact of climate and crop diseases on the production of olive oil. This dashboard, called Med-Gold, intends to provide climate services focused on farmers' land, allowing them to view precise seasonal forecasts and long-term climate projections. (DeAndreis, 2022) Med-Gold dashboard covers olive, grape, and wheat cereal market information.

2.5. Final Remarks

Considering climate change, it is imperative to comprehend how the Mediterranean Basin's climate affects the production and price of olive oil.

The manufacturing and cultivation of olive oil are getting more difficult because of climatic shifting patterns, including rising temperatures and less rainfall. The effects of these events will extend to olive oil pricing, which is impacted by various variables.

With the help of DV tools, companies can improve their decision-making processes and adapt to changing market conditions by combining historical climatic and olive oil data, assuring the sustainability and profitability of the olive oil business in the face of climate change, which is precisely what this master thesis will deliver.

3. DATA & METHODS

3.1. METHODOLOGY

This thesis section will discuss the methodology and procedures used to build the PowerBI dashboard and its elements, the data sources utilized, and the data collection and analysis methods.

The chosen methodology for this master thesis was the Prototyping Methodology. Having prototype development as its primary focus, this methodology is an iterative trial-and-error process that relies on mutual feedback from the developer and its final users (Lewis, 2023).

The flowchart below [Fig. 3.1] takes us through the six Software Development Lifecyvle (SDLC) phases that allowed the creation process of this master's thesis.

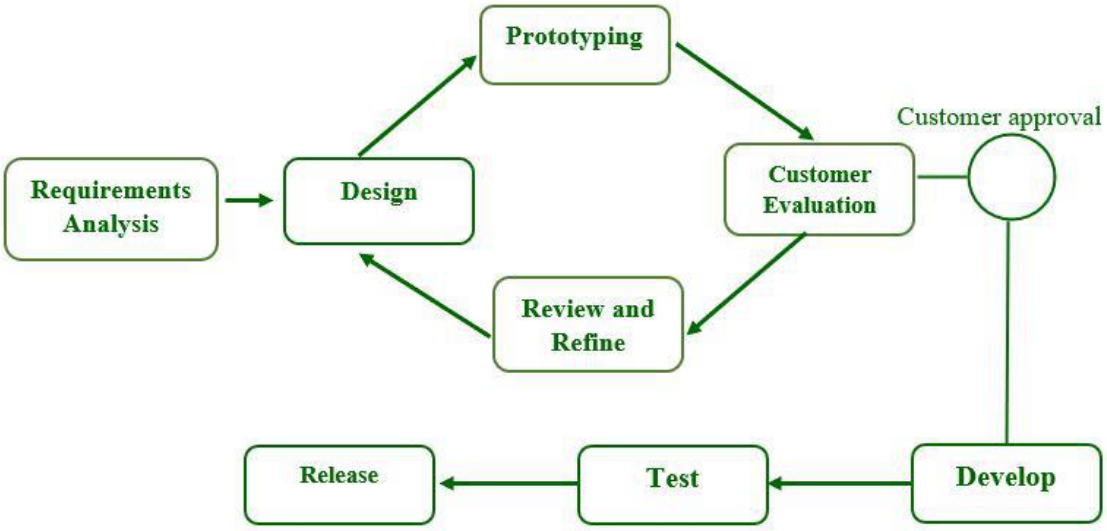

Figure 3.1 - Prototyping Model
(«Software Prototyping Model and Phases», 2021)

In the Requirement Analysis phase, we should set interviews with the final user to understand its requests for the final solution and understand which components should be present in the final model in order to answer it.

The following phase is the Design phase, where the preliminary version of the dashboard will be designed.

After having the design ready, the Prototyping phase takes place. In this third phase, the model starts to be built according to the requests raised by the final user in the first phase.

In the fourth phase, the Customer Evaluation, the end-user examines the prototype created in the previous phase and notes its strengths and weaknesses to give feedback to the developer. If the customer approves the solution, the developer can move forward to the

Development phase. However, if the solution is denied, the project needs to move to the Review and Refine phase.

In the Review and Refine phase, the developer analyses the users' feedback and understands which changes can be made.

In the following step, the process returns to the Design phase, repeats itself until the final user accepts the prototype, and passes on to the next one.

Following the users' approval, the development phase starts, where the final model is built based on the prototype.

Once the final dashboard is built, we proceed to the testing phase to confirm that everything works according to the end-user requests.

Finally, the implementation of the dashboard takes place.

3.2. DASHBOARD DEVELOPMENT – SDLC PHASES

3.2.1. Requirement Analysis

The requirement definition was made in the first meeting with the Pompeian team. In order to deliver the final PowerBI Dashboard, firstly, we had to understand with clearance what problem we were answering: the lack of structured data that directly related the climate to the olive oil production and its price in the highest production olive oil European countries. It was also during this meeting that the first DV principle was guaranteed "Know your audience".

In the second phase of the meeting, we defined the time window of the data, which is the last ten years (2012-2022), and the data sample area, which will be the highest producing olive oil countries in European Union: Spain; Italy; Greece; and Portugal.

In the following part, we discussed which components should be part of the PowerBI solution. Regarding the meteorological part, these were the ones the Pompeian team felt were necessary:

- Temperature;
- Rainfall.

Regarding the olive oil production, these were the variables we used:

- Olive oil production;
- Olive oil prices;

After defining the variables to be analysed, we proceeded to define the metrics, correlations and type of graphics that will be shown on the dashboard:

- Average temperature in the highest production countries;
- Total rainfall in the highest production countries;

- Olive oil production by highest production country;
- Olive oil prices by highest production countries.

In terms of the report structure, Pompeian team made some specific requirements, namely:

- One Country Comparison Page where we can easily understand the production, price, temperature, and rainfall context for each country across the years;
- One Country Detail Page where the variables correlate to see the direct influence of each attribute on the other attributes.

Regarding the type of graphics, Pompeian asked for the following:

- Line chart to understand the price evolution of the different countries across the years;
- Bar charts to compare the temperature, production and rainfall for several countries across the years.
- Line and clustered column charts for chronological and cross-attribute analysis.

Lastly, the graphical part of the dashboard was decided, where the client asked for the PowerBI to be both minimalist and intuitive and for the colour scheme to be related to olive oil, being green, brown, grey, and white, the predominant colours.

3.2.2. Design Phase

In this phase, the DV principles “Keep things simple”, “Use the right chart type”, and “Use colors wisely” were taken into consideration. The initial sketches of the dashboard were made and it was clear which graphics fit better for each requested analysis. Additionaly the colour palette was chosen. Each of these elements were chosen respecting respecting Pompeian requirements and the DV principles.

3.2.3. Prototyping Phase

Once the design was completed, it was time to start the prototyping phase. Using the sketches from the Design Phase as guidance, the graphics were created and their sizes adjusted. It was also in the prototyping phase that every graphic was connected and functioned as a filter to the other visual elements [Fig. 3.2] and [Fig. 3.3]. In this phase, the DV principles of "Highlighting the most important information" and "Avoiding clutter" were respected by having individual visuals for each variable, and by having the possibility of reducing clutter using the timeline slicer.

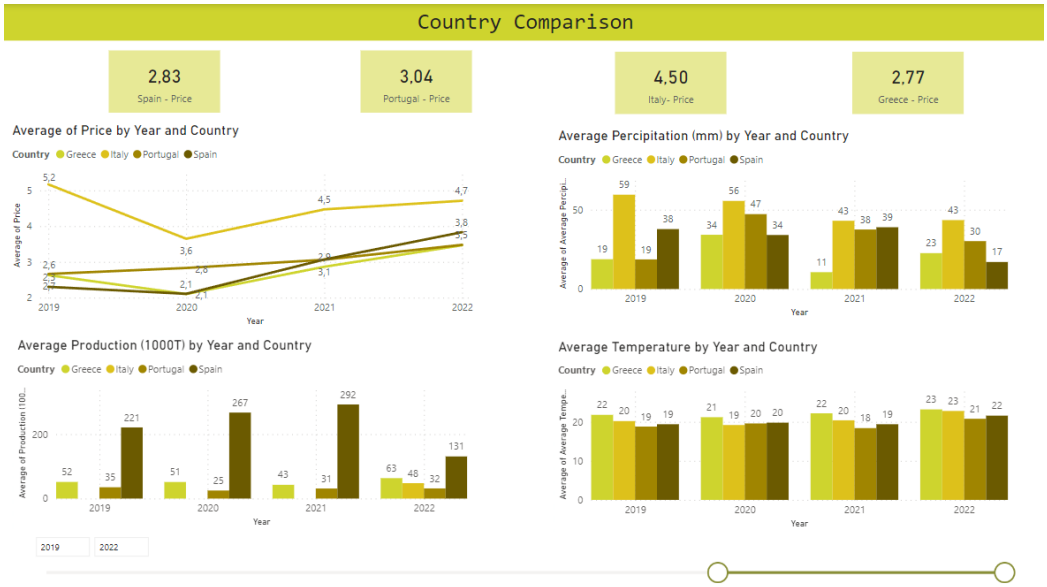

Figure 3.2 - Prototype Country Comparison Page

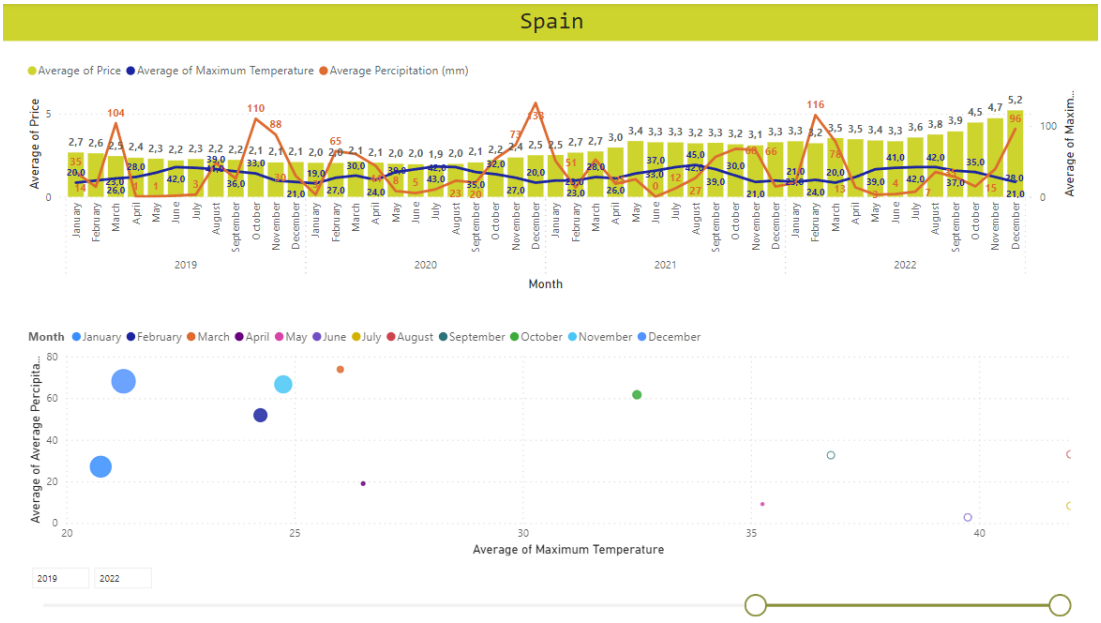

Figure 3.3 - Prototype Country Analysis Page

3.2.4. Customer Evaluation Phase

Once the prototype phase was finished, a meeting with the client took place. The objective was to present the prototype to the client and gather feedback.

In this meeting, both positive feedback and some change requests were delivered.

The main topics that the customer appreciated were:

- The possibility of comparing the price evolution in each country;
- The possibility of comparing averages;
- The interaction between visuals;
- The possibility of relating rainfall, temperature, and price variables.

The change requests were:

- On the Country Detail Page, the Scatter Chart should be replaced by an identical visual as the one above, but for the variable production instead of price.
- On the Country Comparison Page, the average production should be replaced by the sum of production for the selected period.
- On the Country Comparison Page, the average temperature should be the average of the maximum temperatures instead of the average temperature.
- Allow the selection of specific years in the slicers.
- On the Country Detail Page, the first visual should have a colour code for the meaning of each month regarding the olive crops.
- A new page dedicated to the olive crops should be added, with the price and production for October, November, December, January, and February. Moreover, the average maximum temperature and total rainfall for the flourishing months (April and May) and for the months where rain is needed mostly (September and October) should also be present in this page.
- Slicers should be present on every page to select the countries we are visualizing.
- The cards with the average price for each country on the Country Comparison Page should be removed since they do not add valuable information.

3.2.5. Review and Refine Phase

After analysing the requests made by the customer, all of the changes were accepted since they were possible and made sense for the solution the customer was seeking.

With the new requests incorporated into the dashboard's design and with the new prototype built, a new meeting with the customer occurred.

In this meeting, the customer approved the new dashboard as the final version.

3.2.6. Implementation Phase

Once the dashboard was approved and tested, the Pompeian team created a dedicated Microsoft Teams folder to facilitate access to the dashboard. This folder contains both the Power BI file and the dataset that feeds the visuals.

3.3. THE DASHBOARD

The final version of the Dashboard consists of three different pages [Fig. 3.4], [Fig. 3.5], and [Fig. 3.6]. The first one aims to give a broader market overview and comparisons between countries. Providing another market perspective, the second intends to understand the influence of the climate of previous months on the crops. And the last one presents a detailed view of the correlation between the attributes of rainfall, temperature, production, and price.

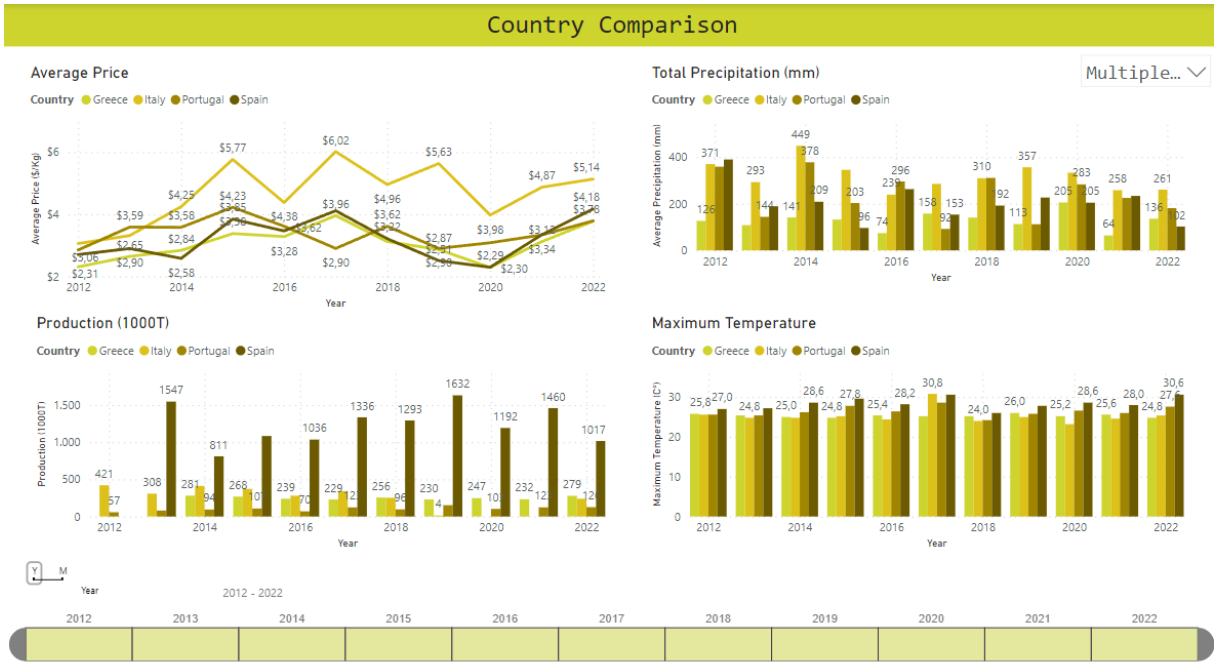

Figure 3.4 - Country Comparison Page

On the first page of the Dashboard, the Country Comparison Page [Fig. 3.2], there are four main visuals plus the filtering slicers. On this page, the line chart allows us to analyse each country's yearly price evolution. The bar charts compare three variables for each country: production, rainfall, and temperature. The bottom slicer is used to select the years that will influence the visuals, and on the top-right corner of the page, we have another slicer that allow us to select the countries we want to analyse.

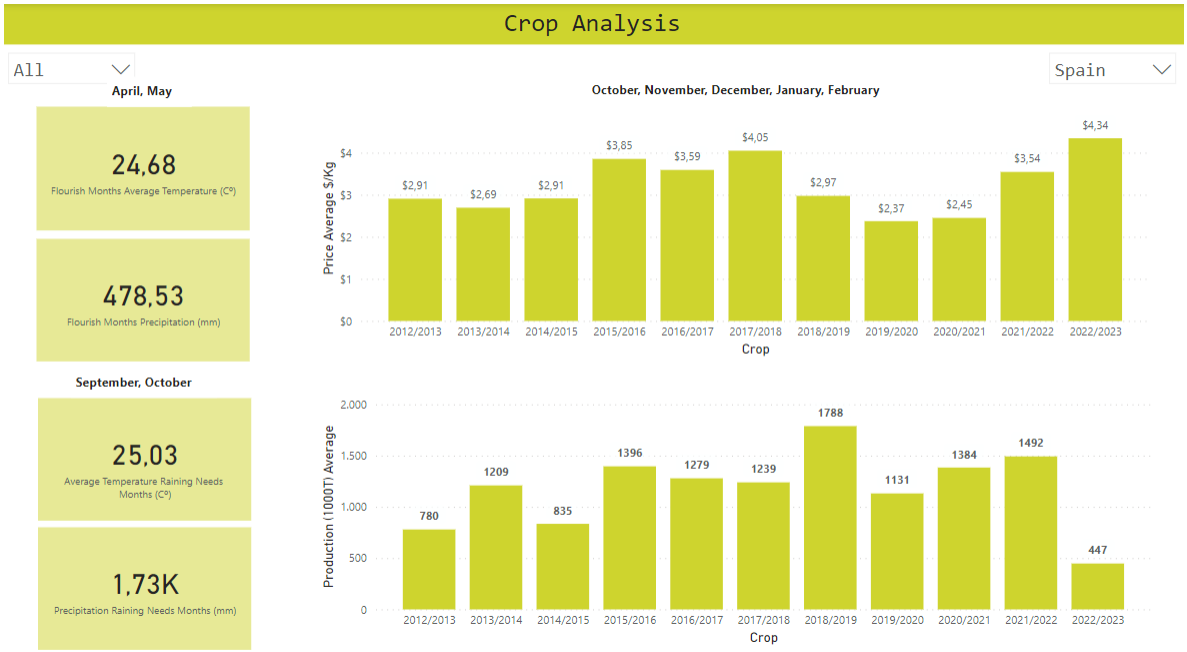

Figure 3.5 - Crop Analysis Page

The next page is dedicated to the olives crop [Fig. 3.3]. On this page, the visuals are divided into three groups: the flourishing months, the months where the rain is mostly needed, and the months of the crops. By dividing the data this way, the users can understand the direct impact of the temperature and rainfall on crop production and prices.

The dashboard comprises four cards with the average temperature and rainfall and two column charts, one for prices and another for production, the cards always present the average of the variable regarding the crop and country selected, the intention is that the end user only selects one crop at a time. Two slicers make the filtering: on the top-right slicer, we can select the harvesting campaigns we want to analyse, and on the top-left corner slicer, we can select the country we want to see via a single-selection method.

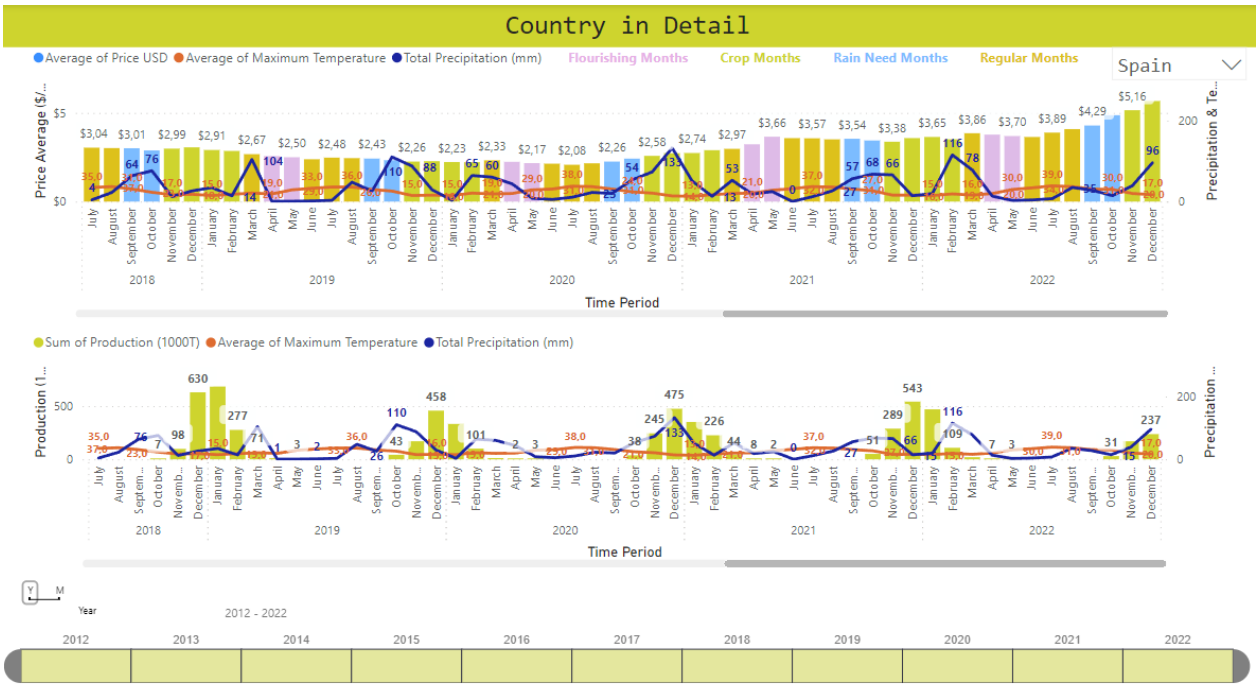

Figure 3.6 - Country Detail Page

The third page of the dashboard, Country Detail [Fig. 3.4], is where the deeper analysis can be done. Here, we can access the country's complete data in the dataset. Instead of only having the crop period, we can understand how the temperatures, rainfall, olive oil production, and olive oil prices behaved during the entire years of this study.
On this page, with the help of two Clustered Line and Column Charts, it is possible to understand the impact of the temperature and rainfall on production and price. Since the temperature is the orange line, the rainfall is the blue line, and the price and production are represented by the columns on their respective charts, it is possible to retrieve valuable analysis from these visuals.

In the first visual, the existing colour code makes it possible to understand which months influence the crop directly. The pink colour stands for the flourishing months, the blue represents the months when rain is mostly needed, the green colour stands for the months when the crops take place, and the brown colour for the months with no special influence on crops.

The filtering on this page works the same way as it does on the first one. The bottom slicer is used to select the years, and the top-right corner slicer selects the country of the analysis, which for this page is a single-selection slicer.

3.4. THE DATASET

The Dataset that feeds this dashboard is composed of two different tables, one filled with Climaterical Data, which source is TimeandDate.com (*World Temperatures — Weather Around The World*, n.d.), and one the other one with the Olive Oil Data, from the Europa.com website (*European Commission | Agri-Food Data Portal*, n.d.).

With these two tables, we have all the information we need to create the visuals on the dashboard, such as the country, temperature, rainfall, production and prices.

Since the olive oil prices on the Europa.com website are in euros, and Pompeian is an American company that works with the dollar as a currency, an auxiliary column was added where the price in euros was multiplied by 1,09, which was the exchange rate from euro to dollar at the time of development of this dashboard.

3.5. THE INTERVIEWS

In order to validate if the dashboard fulfils its purpose, ten interviews were conducted with Pompeian professionals. The interviews were divided into four parts: Introduction, Personal Questions, Dashboard Questions, and Five Exercises. Below you can find its full script:

Introduction

Welcome to this interview, where, in the scope of my Master Thesis, its primary objective is to validate a PowerBI Dashboard which main goal is to understand the correlation of the weather with olive oil production and prices. Participation in this interview is voluntary and you may leave at any time. This dashboard considers temperature, rainfall, olive oil production, and olive oil prices, within the four main European producing countries: Spain, Italy, Greece and Portugal. Your valuable insights from trying the dashboard and personal experience from your expertise in the olive oil industry will be essential to validate if this dashboard can deliver what it was built for. Let us start with the interview and understand how helpful this dashboard can be for your data-driven decision-making.

Personal Questions

This first part is about personal questions to understand the interviewed profile.

1. How old are you?
2. What is your gender?
3. What is your role in Pompeian?
4. Can you describe your role in the company?
5. How long have you worked in the olive oil industry?

Dashboard Questions

1. What are your expectations for this dashboard?
2. In your opinion, what are the advantages of having a page dedicated to the direct comparison between countries?
3. Do you think the “Country Comparison” page gives the necessary information about the context of the ten previous years regarding the variables we are analysing?
4. On the page dedicated to each country, do you find it easy to identify the correlation between the three variables in each graphic?
5. Still on the same page, can you adjust the graphics to identify patterns along broader periods or focus on a shorter period to analyse it specifically.

Five Exercises

1) Looking at the line chart with the average price per country, which country appears to have the highest average olive oil prices from 2012 to 2020?

- On a scale from 1 to 5, 5 being the most difficult option, rate how difficult it was to complete this exercise.
- On a scale from 1 to 5, 5 being the most useful option, rate how useful this exercise was to achieving the goal of the dashboard.

2) In the clustered bar charts that show each country's temperature, rainfall, and production by year, are there any noticeable years when a particular country experienced extreme weather conditions that impacted olive oil production? Did this subsequently affect olive oil prices?

- On a scale from 1 to 5, 5 being the most difficult option, rate how difficult it was to complete this exercise.
- On a scale from 1 to 5, 5 being the most useful option, rate how useful this exercise was to achieving the goal of the dashboard.

3) In the Crop Analysis Page, for Spain, what was the crop that was affected the most, in terms of production, by high temperatures and by low rainfall?

- On a scale from 1 to 5, 5 being the most difficult option, rate how difficult it was to complete this exercise.
- On a scale from 1 to 5, 5 being the most useful option, rate how useful this exercise was to achieving the goal of the dashboard.

4) For the Country Detail Page, have you observed any consistent patterns in the relationship between temperature and rainfall, and how these patterns correspond to olive oil production and prices?

- On a scale from 1 to 5, 5 being the most difficult option, rate how difficult it was to complete this exercise.
- On a scale from 1 to 5, 5 being the most useful option, rate how useful this exercise was to achieving the goal of the dashboard.

5) On the first visual of the Country Detail Page, which colour corresponds to the flourishing months, rain need months, and crop months? And by interpreting the data, how clear is the relation between each group of months and the crop?

- On a scale from 1 to 5, 5 being the most difficult option, rate how difficult it was to complete this exercise.
- On a scale from 1 to 5, 5 being the most useful option, rate how useful this exercise was to achieving the goal of the dashboard.

Conclusion

Do you consider the goal of the dashboard was achieved?

4. RESULTS AND DISCUSSION

From these interviews, we retrieved valuable data to understand whether the dashboard achieved its objective or if it did not.

Due to the high-level profile of end users Pompeian wants this dashboard to be used by, these interviews had only ten participants. These ten Pompeian professionals are directly connected to decision-making processes and are involved in different areas, such as Finance, Sales, Quality, Sustainability, Procurement, and Operations. The sample is composed of Pompeian professionals from 6 different countries, 50% females and 50% males, with an average age of 48 years old, being the younger 34 and the older 62. The average number of years of experience in the olive oil industry is 15, being the lowest 3 years and the highest 30 years.

The participants answered five questions regarding the dashboard where some qualitative comments were made, and expressed their expectations for the dashboard. From the answers, the main appreciation topics were the easiness on relating the four variables for each country, and the simplicity of using the filters and the slicers on the different pages. However, some end users stated that it would also have been useful a global view of the data instead of only having a view for each country.

For the last part of the interview, the participants were asked to answer to five exercises using the dashboard. These exercises covered different use cases that the end-users might face in the daily use of the tool. In order to elaborate some quantitative analysis, each exercise was measured on a scale from 1 to 5, by its difficulty (being 5 the most difficult) and usefulness (being 5 the most useful).

In the first exercise, the interviewees were asked to identify which country had the highest average olive oil prices in the period 2012 – 2012 and how rainfall and temperature correlated to the prices.

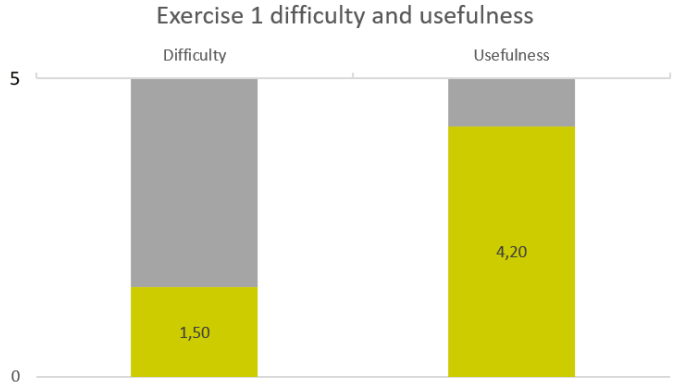

Figure 4.1 - Exercise 1 difficulty and usefulness

For this question, 100% of the participants used the Country Comparison Page to identify Italy as the country with the highest average prices. Regarding the difficulty of the exercise, the average rating was 1,5, and the average for the usefulness of the exercise was 4,2.

The second exercise asked the Pompeian professionals to identify any years where the production was affected by extreme temperature and rainfall and if it had any impact on the prices. Even though the answers to this exercise were more diversified, the highest percentage of the interviewees said that Spain was the country that was most impacted by extreme weather conditions, more precisely with low levels of rainfall in September (28 mm) and October (15 mm) of 2022, which affected the production in the first three months of the crop season of 2022 (438 000 tons), resulting in a sudden rise of the olive oil price per kilogram which was $5,67 in December 2022.

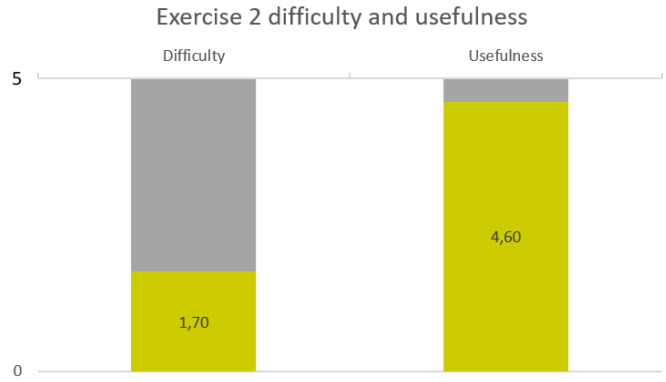

Figure 4.2 - Exercise 2 difficulty and usefulness

The end users considered this exercise to be a 1,7 regarding the difficulty and a 4,6 regarding its usefulness.

The participants were asked to go to the Crop Analysis Page in the following exercise. On this page, they should identify the crop in Spain whose production was most affected by rainfall and temperature.

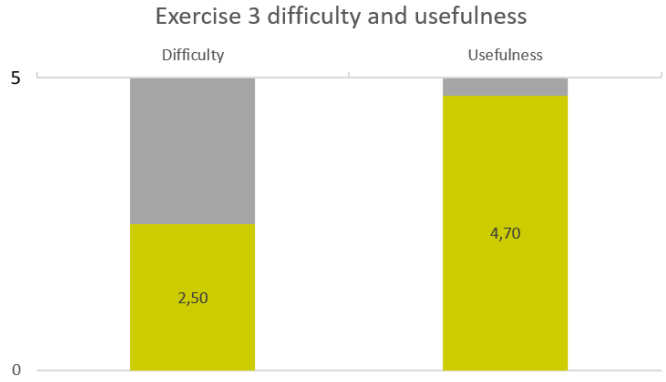

Figure 4.3 - Exercise 3 difficulty and usefulness

The interviewees were unanimous in identifying the crop of 2022/2023 as the most affected. The rating for this exercise was 2,5 regarding difficulty and 4,7 regarding usefulness.

In exercise 4, the participants were requested to analyse the Country Detail Page. They were questioned if they found any consistent pattern regarding the influence of rainfall and temperature on olive oil production and prices. The most common observation was that when the rainfall was higher, the prices would drop and that higher temperatures led to a reduction in the production of the crops, consequentially increasing the prices.

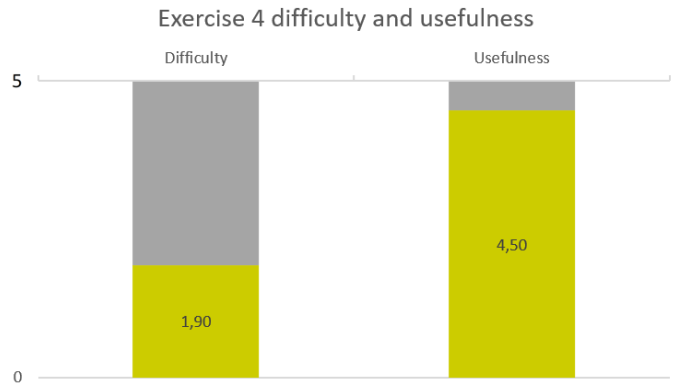

Figure 4.4 - Exercise 4 difficulty and usefulness

This exercise was rated with 1,9 for difficulty and 4,5 for usefulness.

In the last exercise, the users were asked to identify the colour of each set of months on the first visual of the Country Detail Page and to interpret the data. Finally they should evaluate how straightforward the relation between each group of months and the crop production was. When it comes to the identification of the colours, 100% of the users got it correct. Regarding the relation between each group of months and the crop, the users said that whenever the temperatures in the flourishing months were higher, and the rainfall in the rain needing months was lower, the production of the crop would decrease.

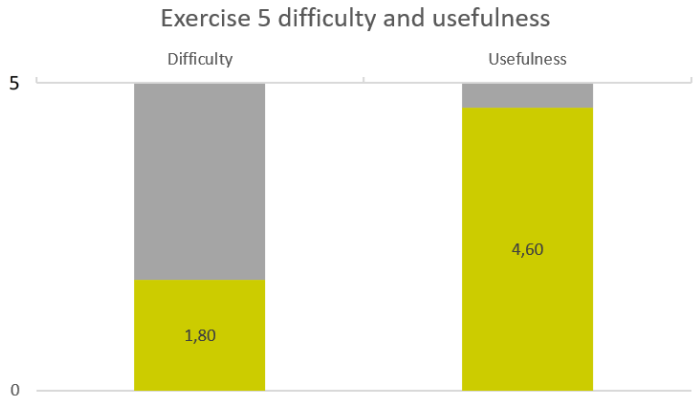

Figure 4.5 - Esercise 5 difficulty and usefulness

This exercise was rated with 1,8 regarding its difficulty, and with 4,5 regarding its usefulness.

The page that was considered more difficult to work with was the Crop Analysis Page, and I believe this was due to the different layout of the visuals when relating the variables. Regarding usefulness, the page that was considered more useful was also the Crop Analysis Page, due to the unique analysis it allows end users to do, completely focused on the months that directly influence the crop, and on the crop months itself, without any clutter around it.

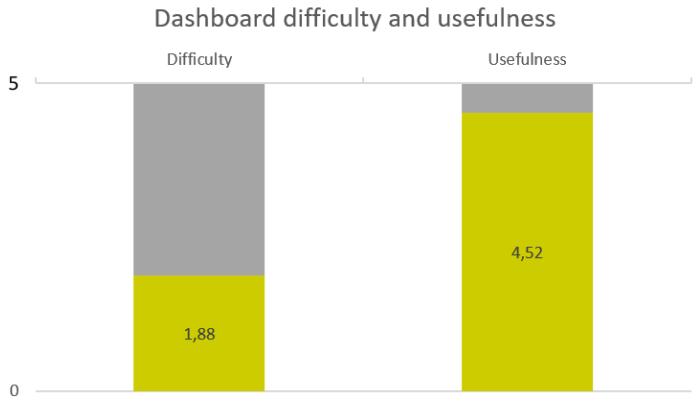

Figure 4.6 - Dashboard difficulty and usefulness

Overall, the dashboard got a rating of 1,88 regarding difficulty and of 4,52 regarding usefulness, and 90% of the interview participants considered the dashboard delivered what it was built for. These values show that Pompeian professionals consider this dashboard to be user-friendly and a valuable source of information.

5. CONCLUSIONS AND FUTURE WORKS

The main objective of this master's thesis was to develop a historical data dashboard to aid Pompeian in data-driven decision-making processes and a deep understanding of the direct influence of temperature and rainfall on olive oil production and price.

The dashboard was developed according to the Prototyping Methodology. For this methodology to be implemented successfully, much communication with the Pompeian professionals was needed. Due to their availability and expertise, after two rounds of requirement definition, design, prototyping, and customer evaluation, the final dashboard was presented to the Pompeian team and accepted as it was.

Compared to the Med-Gold dashboard, this dashboard has more differences than similarities. Even though both dashboard's objective is to relate the climate with the olive oil market, Med-Gold's approach is more focused on aiding the producers since it analyses climate, grove diseases, and production (DeAndreis, 2022). On the other hand, this Master's Thesis dashboard takes a more business-centric approach to the market by only including the climate, production, and price variables. Another significant difference between the dashboards is the functionalities both provide. While the Med-Gold dashboard provides the user with both historical data and long-term projections, the dashboard developed in this Master's Thesis only has historical data available. Finally, there is a significant difference between the visuals of the dashboards, which the different profiles of end users can justify. Since the Med-Gold dashboard is destined for the producers, they chose a geographical map as their primary visual overlaid with a heatmap regarding the chosen variable. On the other hand, this Master's Thesis dashboard is intended to satisfy the needs of Pompeian, a company that needs to have visuals based on values, like line and bar charts, in order to understand immediately the value behind the visual.

After analysing the data presented on the dashboard, related to the last 10 years in 4 different countries, using 4 different variables, one interview was made with each of the dashboard end-users. From the answers to those interviews, we could reach several conclusions. The first conclusion was that 90% of the interviewees said that the dashboard achieved its purpose. Regarding this percentage, the most common comment was that this dashboard would provide helpful information for correlation analysis regarding price, production, temperature, and rainfall. In addition, some interviewees also mentioned the importance of having this structured information to serve as a basis for a future predictive model regarding prices and production. Furthermore, another conclusion taken from the answers to the interview was that the average final score given to the dashboard by its final users was 1,88 regarding its difficulty of use (on a scale from 1-5 being 5 the most difficult), and 4,52 regarding its usefulness (on a scale from 1-5 being 5 the most useful). From these scores, we can conclude the Pompeian professionals consider the dashboard delivers what it was built for in an user-friendly approach. Finally, this work analyses the olive oil market from two different time

perspectives. The possibility of addressing the same data from a yearly and a crop perspective was a feature that was highly appreciated by the Pompeian professionals since exercise number 3, which intends to evaluate the Crop Analysis Page, got an average score regarding the difficulty of use of 2,5, and regarding the usefulness of 4,7.

However, while developing this study, some limitations were encountered. Despite the efforts to create a solid and reliable dataset, there are missing values in Italy's production data. Even though all the olive oil related data comes directly from the European Comission website, there was minimal available data regarding olive oil production in Italy from 2020 until 2022.

Another limitation was the number of Pompeian employees available to participate in the interviews. Since only high-level users are intended to use the dashboard, there were only ten people qualified to answer the interviews, the restricted sample size may influence the results of the interview analysis. On the other hand, since the interviewees are the dashboard end-users, based on their feedback, it is guaranteed that the dashboard fits their needs.

Nevertheless, there is some further research that can be done to improve the dashboard. One good addition would be the expansion of the study area and incorporation of other important countries when it comes to olive oil production, such as Tunisia, Morocco, and Turkey. Following the same line of thought, one more variable could be added to the dashboard: the consumption of olive oil in the United States of America. By combining historical data regarding climate and crop production in the main producing countries with the consumption in the market where Pompeian is present, Pompeian professionals could develop a predictive model that would aid in the pricing definition focused on the North American market.

Overall, we can conclude from this Master Thesis that the developed dashboard is considered by its end-users to be useful and user-friendly, delivering what it is built for.

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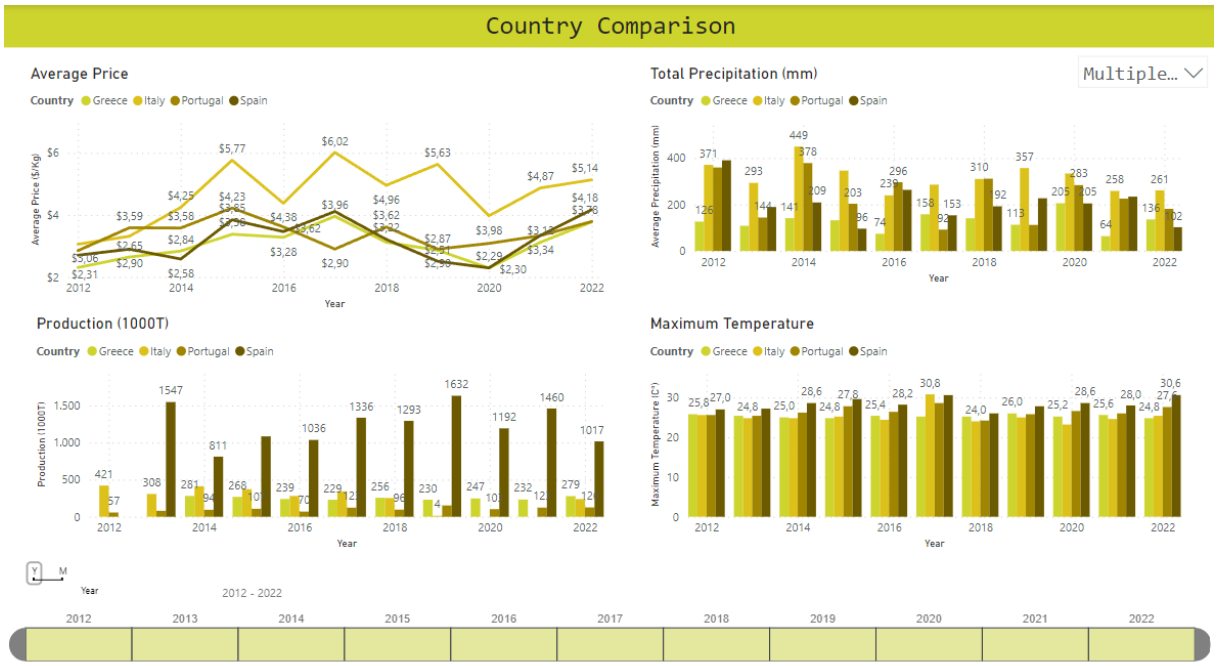
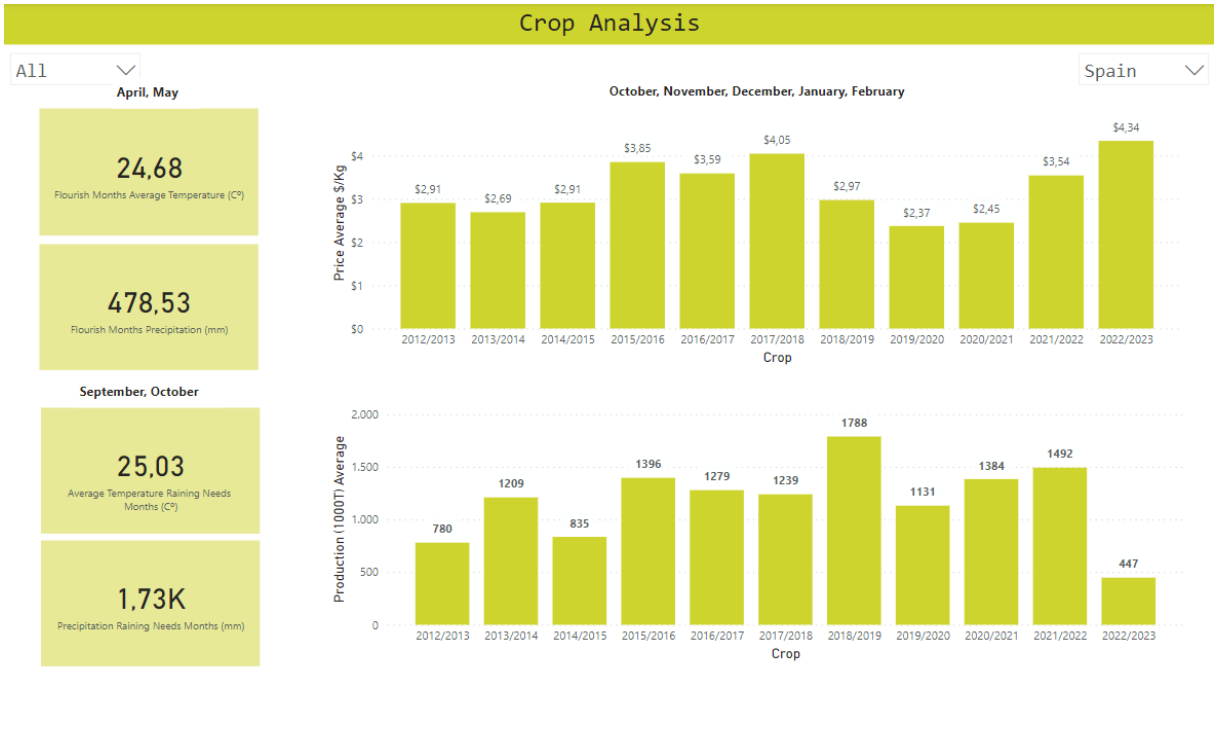
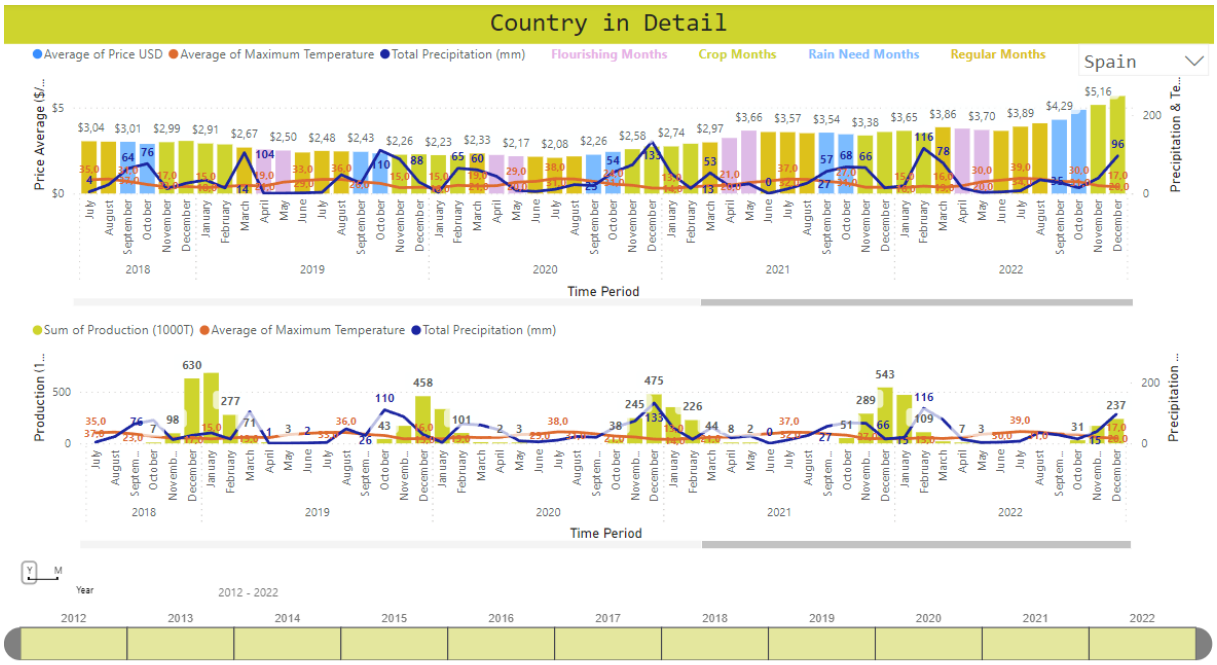
APPENDIX A

Dashboard developed for Pompeian






Country in Detail
Average of Price USD
Average of Maximum Temperature
Total Precipitation (mm)
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Crop Months
Rain Need Months
Regular Months
Spain
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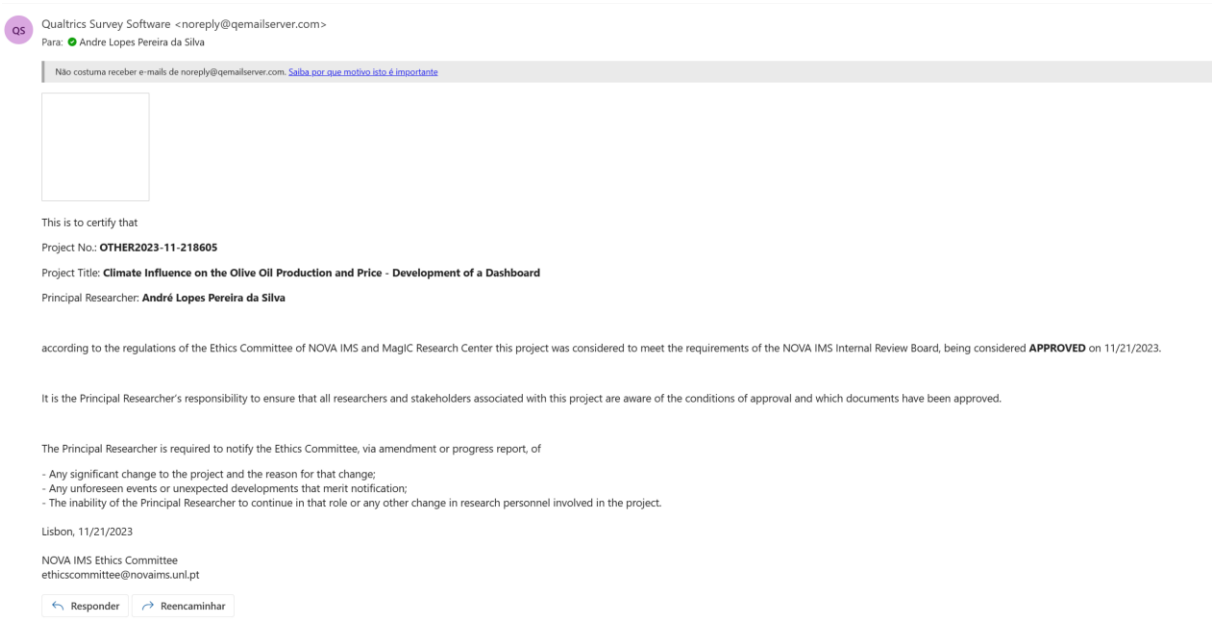
APPENDIX B

Ethics Committee of NOVA IMS and Magic Research Center approval



QS Qualtrics Survey Software <noreply@qemailserver.com>
Para: Andre Lopes Pereira da Silva

Não costuma receber e-mails de noreply@qemailserver.com. Saiba por que motivo isto é importante

This is to certify that

Project No.: **OTHER2023-11-218605**

Project Title: **Climate Influence on the Olive Oil Production and Price - Development of a Dashboard**

Principal Researcher: **André Lopes Pereira da Silva**

according to the regulations of the Ethics Committee of NOVA IMS and MagIC Research Center this project was considered to meet the requirements of the NOVA IMS Internal Review Board, being considered **APPROVED** on 11/21/2023.

It is the Principal Researcher's responsibility to ensure that all researchers and stakeholders associated with this project are aware of the conditions of approval and which documents have been approved.

The Principal Researcher is required to notify the Ethics Committee, via amendment or progress report, of

- Any significant change to the project and the reason for that change;
- Any unforeseen events or unexpected developments that merit notification;
- The inability of the Principal Researcher to continue in that role or any other change in research personnel involved in the project.

Lisbon, 11/21/2023

NOVA IMS Ethics Committee
ethicscommittee@novaims.unl.pt

Responder Reencaminhar

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação

Universidade Nova de Lisboa