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DIGITAL TRANSFORMATION IN THE BRAZILIAN FLOWER INDUSTRY: CULTURAL AND TECHNOLOGICAL ISSUES, ECONOMIC BENEFITS AND FIRMS' ACTUAL ADOPTION

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This work closes the chapter in my life of the period that I studied in Italy. It was two long years with intensity, emotion, and learning. Although the pandemic affected it somehow, I prefer to focus on the good side of things. That being said, let's focus where matters:

First of all, I need to say thank you to my family, my father Luiz Barbosa and my mother Ilma Fernandes. I know all the effort that you both put into my development and I do am grateful for this. Your support is really important for any achievement that I reach.

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Finally, I need to say thanks to my sister, Bruna Barbosa, and also to all my Brazilian and Italian colleagues that made my experience in Italy amazing. I know that it is the end of a chapter, but the memories I will keep with me for a long time.

"If you're not making someone else's life better, then you're wasting your time."

-- Will Smith

ABSTRACT

Being digital, which in the past was a distinctive position, today is becoming a requirement for incumbents and other companies to survive in the digital world. This research explores how the new technologies are impacting the Brazilian flower industry, which opportunities are in place, and how other sectors are facing these changes. The methodology applied in this work consisted of many qualitative interviews with different stakeholders of the sector, desk research, and participation in events. Starting with the flower industry overview, it is presented how the floriculture sector is organized, who are the main stakeholders, and what is the size of the market in Brazil and globally. The following section presents which technologies are in place and how could they be used in this scenario. Then, some cultural and technological issues are presented, looking from the perspective of each stakeholder, which is followed by an analysis of the economic benefits that some initiatives could offer. Finally, the last chapter presents the firms' actual adoption and the long-term objectives for the sector.

Keywords – Supply Chain, Flower Industry, Digital Transformation.

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1 INTRODUCTION

"Thriving as a mainstream company today means being data-driven, but cultural challenges — not technological ones — represent the biggest impediment around data initiatives" [1]. The amount of data generated by different businesses continues to grow, mainly pushed by the technology companies, but even the more traditional ones can collect the benefits from a more data-driven approach.

1.1 Overview

Today, the advance of technology has enabled different companies to manage their data assets without the need for a heavy cost structure, and this "increased accessibility of data has enabled a different way of making decisions that involve more empirical evidence rather than personal experience, intuition, or belief" [2]. In this sense, the decision-making process may change, but only if the digital transformation is carried out with a cultural change of the organization.

Many enterprise information technologies are being used to capture a huge amount of data in their regular activity. "Increasingly, these systems are imbued with analytical capabilities, and these capabilities are further extended by Business Intelligence (BI) systems that enable a broader array of data analytic tools to be applied to operational data" [3]. These digital assets are valuable and "many organizations are hungry to use data to grow and improve performance - and multiple players see market opportunities in this explosion of demand. There are typically many steps between raw data and actual usage, and there are openings to add value at various points along the way" [4].

This work proposes to look at how to leverage the power of data in the Brazilian flower industry, using the most advanced tools available and benchmarking with other industries and countries that recently passed through this digital transformation. "The true power of data is unlocked when organizations move their thinking beyond score-keeping and toward a forward-looking mindset" [5].

1.2 Motivation

Approximately 7.5% of the Brazilian territory (635 thousand km^2) is used for agriculture, equivalent to the entire territory of France (644 thousand km^2) [6]. From it, 15.600 hectares (equivalent to 156 km^2) are used by the flower industry [7]. In 2020, this sector generated R$ 9.5 billion (US$ 1.7 billion) in value of the gross domestic product (GDP) [7], approximately 0.7% of the agricultural GDP for that year.

Despite its size, many of the managerial decisions in this sector still rely on a leader's "gut instinct" and a few financial metrics to support its decision-making. Which variety to plant, which price to trade, when to sell the product are some questions that are answered routinely. "Just like yesterday's newspaper, there is little demand for last week's fresh flowers" [8].

In 2017, Royal FloraHolland, a Dutch organization leader in the commercialization of flowers, started a process to move all direct transactions to the digital, increase the efficiency of both supply and demand and comply with the financial laws in Europe. Their work is still in progress with the project called Floriday, which was a huge step to increase the inflow of data from its operations and create the building blocks for their data platforms to support the decision-making in the flower industry.

On the other hand, the biggest flower cooperative in Brazil, since its foundation, has been known as an implementer, not a developer, of Information Technology (IT). However, in the last couple of years, they began to gain international recognition as an important IT developer in this industry especially in proposing additional tools for the original model [9]. This thesis aims to analyze the state of the art tools in the sector and analogical markets and recommend the best practices to improve the visibility of Brazilian research in the global market.

About 97% of the production of flowers in Brazil are sold in the internal market [10]. Once the country's production is not integrated with the commercial flows for the international market, local growers and buyers have access only to national support. In this sense, internal research and development have space to create its solutions for this market, based on knowledge of other countries and industries.

1.3 Objective

"One of the main characteristics of buyers of flowers and ornamental plants in Brazil is to concentrate their demands strongly on a few specific dates throughout the year" [11], so advanced planning is critically important. Once the decision-making in the Brazilian flower industry is heavily based on the intuition of a few local experts, it can become a problem for the perpetuity and standardization of strategic decisions. This thesis proposes to look at the entire value chain focusing on the digital transformation currently in progress.

The primary objective is to look at the benefits and advantages with a focus on the different business units. "Organizations can benefit by focusing their data initiatives on clearly identified high-impact business problems or use cases" [1], so this work proposes to start looking for the organizations to get its initiatives and identify the most promising opportunities to pursue.

1.4 Methodology

The Brazilian flower industry is a complex environment, due to its fresh products and the size of the value chain, with many stakeholders involved and different parameters of quality available. The work for this thesis was mainly focusing on desk research, event participation, and interviewing with experts to define the sector and get the tendencies happening with the digital transformation.

To create the baseline and support the research for the next topics, the first phase of desk research had the following goals:

- Understand the Brazilian Flower Industry;
- Get the tendencies happening abroad;
- Deep dive with the stakeholders of the value chain;
- Define the strategic decisions to be made by growers.

The participation in events in the field was intended to gather data from people that were not reachable by interviews. Two online events were selected due to their importance in the global and regional context: Cooperative Day, held by Royal FloraHolland on 15th December 2020, and Veiling Market, held by Veiling Holambra from 14th to 16th April

2021. From the first event, the objective was to have an immersion in the global context of the flower industry and what are the goals for the next years, and, from the Veiling Market, the intention was to look at the same aspects, but this time focusing on the Brazilian market.

Initially, the interviews were held with business employees of the cooperative of growers, to understand how the process is structured and get information that is not described in the literature. A semi-structured interview, with a pre-elaborated question script, was applied as the data collection instrument using the in-depth interviews approach, where "interviews are often used to provide context to other data, offering a more complete picture of what happened in the program and why" [12].

To obtain valuable results from the interviews, a few goals were defined to structure the conversation with each stakeholder. Below is presented the main objectives for each group and the target interviewed.

The target growers for this research are the Brazilian ones, from different cooperatives. It is aimed to interview the operational managers and the employees responsible for the pricing and client relationship. From the interviews, the goals were to:

- Understand what are the strategic decisions in the flower industry;
- Find where there is and where there is no data provided to them;
- Understand their long-term objectives;
- Level of information technology adopted;
- Type of sale with higher return;
- Get the main pain points in the whole production process.

The cooperatives are the fundamental base for the movement of the products to the final consumer. Therefore, for this research both main cooperatives from Brazil, Veiling Holambra and Cooperflora, were contacted. Also, the main global flower cooperative, Royal FloraHolland from the Netherlands, was selected due to its pioneer in the field. The conversations were willing to:

- Understand in which level the growers and buyers today use data for their strategic decisions and what is the role of the cooperative;

- Get a view of the goals for the short term;
- See what is common to be outsourced and what they build internally.

There are not many software companies focused in the Brazilian flower market. Due to this lack of expertise outside the cooperatives, the project selected one Dutch company that is a spin off of the main cooperative from the field: Insights. The service is an additional feature that offers analytical tools for the growers. The conversation had the following objectives:

- What are the main challenges in developing tools for this sector;
- Good practices learned with the time;
- The main goals for the next few years.

The last segment before the customers are the buyers. They are divided into wholesalers and retailers. For the wholesalers, the decision was to select the logistics and procurement department of these companies to perform a qualitative interview. The goals for the qualitative interviews were:

- Get the importance of the flowers in their segment;
- Main problems occurred in the past and learnings;
- See if their suppliers are many or focused on just one farm/cooperative.

2 FLOWER INDUSTRY OVERVIEW

Although ornamental plants are included in the agriculture sector, these products cannot be considered commodities, due to its wide variety "involving cut flowers, foliage, bulbs, flower pots, green plant pots, lining and plants for landscaping, representing a world market with a turnover of around US$ 90 billion a year" [13], from which it is estimated that US$ 55 billion is related to floriculture and US$ 35 billion to the global nursery production [14].

"The commercial floriculture understood as the professional and business activity of production, commerce, and distribution of flowers and plants cultivated for ornamental purposes, represents one of the most promising segments of contemporary Brazilian agribusiness" [11], a sector that generated R$ 9.5 billion (US$ 1.7 billion) in value for the GDP of the country in 2020. Considering the analysis that an institution reported in 2015 [10], around 46% of its GDP is represented by the growers' sales (direct or by cooperatives), so an amount of R$ 4.4 billion (US$ 0.8 billion) can be estimated as the turnover for this part of the value chain in 2020.

The Netherlands is the leader in the exportation of these products around the world. "The wholesale business brings cut flowers and plants with the right specifications from growers to florist shops, garden centers, and supermarkets" [15], with a turnover that reached € 7 billion in the level of the trading companies in 2020.

In Europe, data provided by CBI in 2013 presented, as the biggest markets in terms of consumption value of cut flowers, the following countries: Germany (€4.3 billion), France (€3.1 billion), the UK (€2.9 billion), and Italy (€2.7 billion) [16].

The floriculture supply chain is large. To get to the final customer, there are three main players in the production chain: the growers, the wholesalers, and the retailers. Figure 1 illustrates the entire production flow of the flower industry.

Once the flower is ready to be sold, there are many ways for the grower to do it, depending on their structure and the relation with the market. Figure 2 displays the

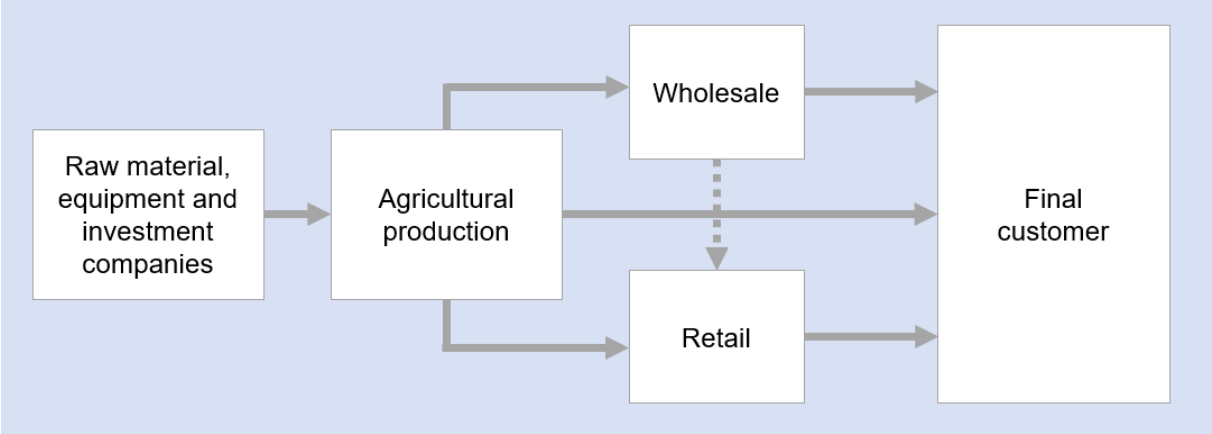

Figure 1: Production chain of flowers and ornamental plants in Brazil. Adapted from [10].

main formats of sale offered today by growers and for the second commercialization, by the different wholesalers and retailers.

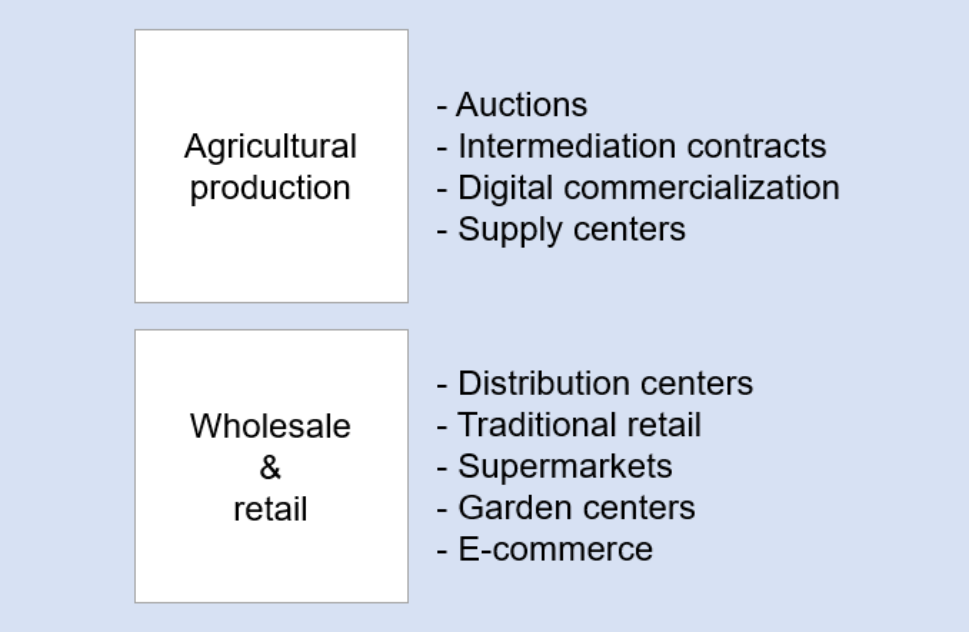

Figure 2: Commercialization flow in the internal market. Adapted from [17].

When humans make decisions, the process is often muddy, biased, or limited by the inability to process information overload. Data and analytics can change all that by bringing in more data points from new sources, breaking down information asymmetries, and adding automated algorithms to make the process instantaneous [4]. This research presents a broad view which are the main strategic decisions that are done by the growers' side. The conclusions came through both an intellectual and qualitative approach.

2.1 Products

"The product range in flowers and plants is huge, and this diversity in assortment requires strong operational management in floriculture wholesale and trade business" [15]. This variation is not only related to biological characteristics but also can be modified by supply and demand periods. For example, on one hand, the production can vary from summer to winter, due to climatic conditions, and on the other hand, the product demand from Valentine's day is completely different from the one of the All Souls' day. Figure 3 presents research conduction in Brazil from 2014-2016 of how different products are consumed in different holidays, based on the ceremony.

Date	Roses	Orchids	Mixed bouquets	Poted flowers	Baskets and flower arrangements	Chrysanthe-mums	Others
European Valentine's Day Feb 14th	51	10	24	5	5	0	5
International Women's Day Mar 8th	61	7	9	11	9	0	3
Easter April	11	13	0	0	47	8	21
Monthers Day 2nd Sunday of May	38	22	5	18	6	0	11
Valentine's Day Jun 12th	64	13	6	3	6	0	8
Father's Day 2nd Sunday of Aug	0	19	0	0	28	15	38
Beginning of Spring Sep 23th	34	19	12	8	0	12	15
Secretary's Day Sep 30th	45	19	10	13	0	10	3
All Souls' Day Nov 2nd	21	1	0	14	3	53	8
Christmans and New Years's Eve Dec 25th and 31th	17	6	0	19	11	0	47

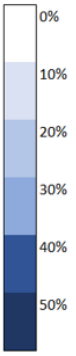

Figure 3: Flowers preferred to present in the main dates of consumption in Brazil, average 2014-2016 (%). Data extracted from [11].

The products can be divided into two groups: cut flowers and potted plants. "Cut flowers, the largest product group, can be split into mono-bouquets or mixed bunches. In potted plants, there are numerous types, colors, and sizes. The main distinction for plants is the difference between flowering plants and leafy plants" [15].

In Brazil, the main species cultivated of cut flowers are roses (30%), chrysanthemums (15%), lisianthus (12%), lily (7%), and gerbera (6%). The potted plants have a wide mix of varieties, where the six main species are: orchids (14%), lily (7.5%), chrysanthemum (7%), kalanchoe (6.4%), violet (6%) and bromeliad (6%) [11].

2.2 Market Size

The market size of the floriculture sector is increasing globally, even if at different growth rates. In this section, it is presented an overview of the size of the sector firstly with a global perspective, and then locally, with a focus on the Brazilian and Italian sectors, due to the objectives of this research. "The floriculture consumption is strongly related to income levels, thus clarifying why markets with high purchasing power also have high consumption levels" [18] and why economics in developing countries have a strong growth rate compared to developed countries. According to the research developed by Rabobank in 2017, it is expected a 2% growth per year in cut flower and potted plant expenditures in Europe and North America, with Asia growing 6-8% annually [19].

2.2.1 Global

Comparing the different regions around the globe, Asia presents the most optimistic growth expectation. In the period of 2017 to 2027, the consumption value is due to growing by 80%, with the assumptions of continuing economic growth and a strong relation between purchasing power and floriculture expenditures [19]. Figure 4 presents the market value for each region and the expectation of growth for the next few years. The European region and the United States are the biggest buyers, but the biggest growers and exporters are the Netherlands, Ecuador, Colombia, Kenya, and Ethiopia [20].

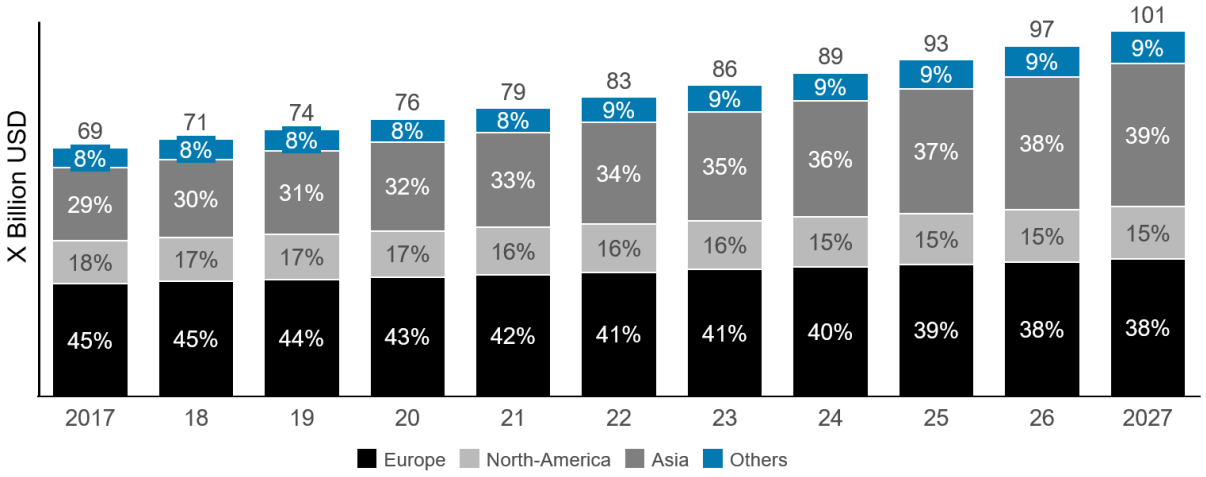

Figure 4: Expected development of consumption value of flowers and potted plants 2017-2027. Adapted from [19].

The cut rose is planted all around the world, as presented in Figure 5. Although the Netherlands is commonly known as the Auction of the world, their production has, from

the last few years, followed a downward trend. The countries on the equator gained, in the last years, more and more space as important growers as the technology allowed the transportation for a reasonable price. "Cut flowers have to be transported quickly using a "cold-chain" – a series of refrigerated facilities on farms, lorries, planes, and boats – which put the flowers into a dormant state, so they stay fresh" [20].

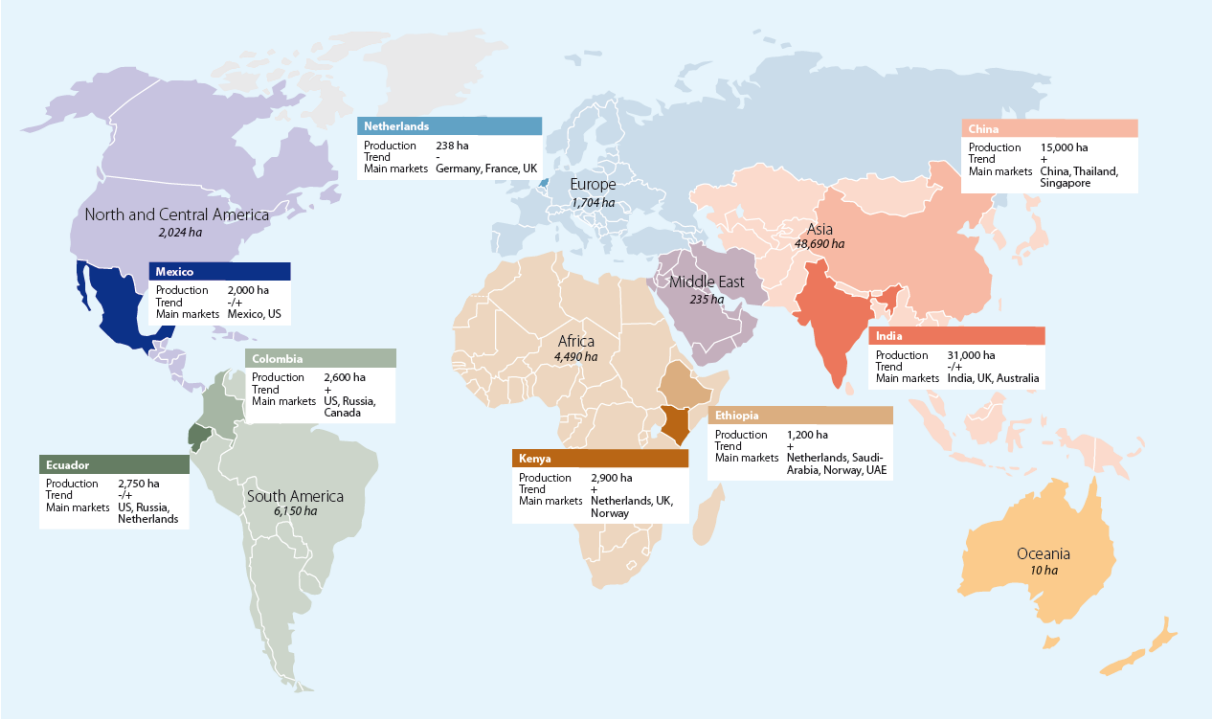

Figure 5: Comparison of cut rose-producing regions and nations. Extracted from [14].

Sylvie Mamias, secretary-general of Union Fleurs, the international flower trade association, says that "one of the reasons behind the increase in flower exports in Africa dates from the 1970s when an oil crisis increased the cost of heating greenhouses in northern countries". In this sense, the production moved to the south where flowers could be grown with little energy input all year round. For Europe, this meant seeing more flowers imported from Israel and Morocco, and later East Africa, while US buyers developed trade with Latin America [20].

There are some characteristics in common with the new producers, "areas of high altitude with cool nights, which many flowers benefit from, proximity to the equator for maximum hours of sunlight, and cheaper labor". Also, the change from the north to the south meant an "end to seasonal production and the beginning of a 365-day-a-year international competitive trade". [20].

2.2.2 Brazil

The Brazilian expenditures for the floriculture sector are increasing year after year. Considering the period of 2012 to 2020 the annual growth had a 9% rate. Figure 6 presented the date provided by IBRAFLOR (Instituto Brasileiro de Floricultura - Brazilian Floriculture Institute).

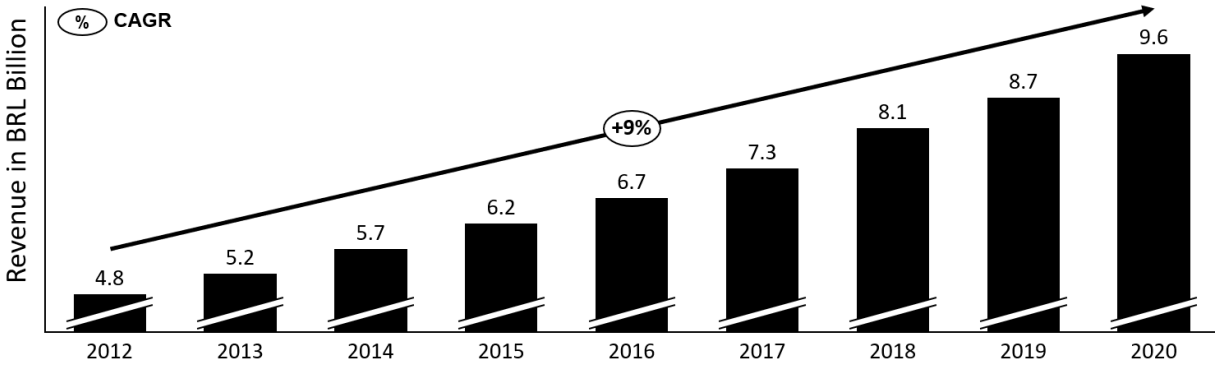

Figure 6: Revenue of the floriculture sector at consumer level in Brazil. Data extracted from [7].

Despite taking place direct trade between the grower and the final consumer, or even from the wholesale to the consumer, retail is still the main channel for the commercialization of flowers and ornamental plants to the end-user. Among the main retail channels are florists, supermarkets, decorators, and landscapers, the latter two of whom are linked to the service sector [10]. Figure 7 presents the participation of the different stakeholders at the value aggregated to the final user. The characterization of the different players in the value chain will be detailed in the next sections.

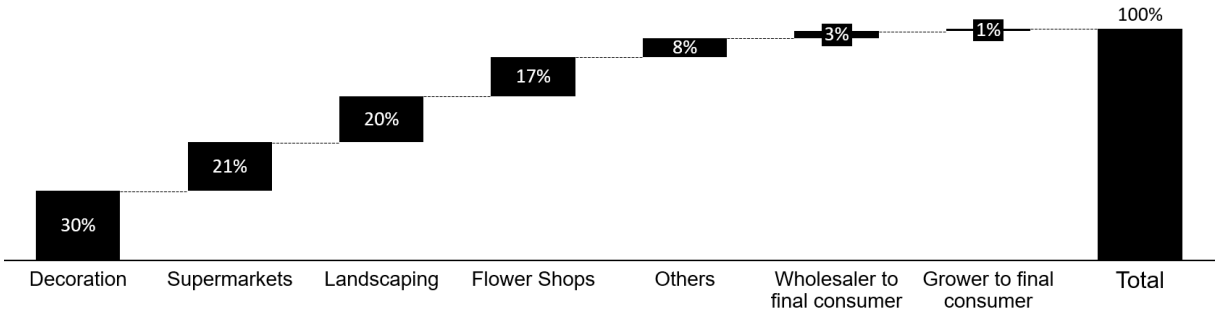

Figure 7: Revenue distribution of the floriculture sector per segment in 2020. Data extracted from [7].

Although in 2015, the GDP estimated of the floriculture sector represented only 0.6% from the total agricultural GDP, the employment of the sector represented around 7% of the total formal jobs of the field. “These figures show that the sector is labor-intensive

and contributes to the retention of the population in rural areas", as presented in the research developed in [10]. It is a technical work that is difficult to automatize, compared to other sectors, what is the main reason for this level of labor-intensive. Table 1 presents how the floriculture sector employs people in different activities with data from 2020.

Employment type	# of employees
Agricultural production	81,000
Wholesaler employees	9,000
Retail employees	112,000
External workers	7,000
Total	**209,000**

Table 1: Brazilian employment structure in the floriculture sector in 2020. Extracted from [7].

According to data provided by Ibraflor [7], the country has a total of 8.300 growers, with 15.600 hectares as the area with these products. Each farm has an average of 1.88 hectares (18.800 square meters) with an average number of 8 employees per hectare. Figure 8 presents how the space is divided in the different technologies adopted in Brazil and the area used by each product.

Figure 8: Segmentation of type of infrastructure and product for the different growers in the Brazilian floriculture sector (area in hectares). Data from [7].

Figure 9 presents the main area of production in Brazil, where the states in the figure represent 77% of the total flowers cultivated area in the country, the remaining is divided into the other states. It is possible to see that the most of the production is in the state of Sao Paulo, where the main cooperatives of the country are located.

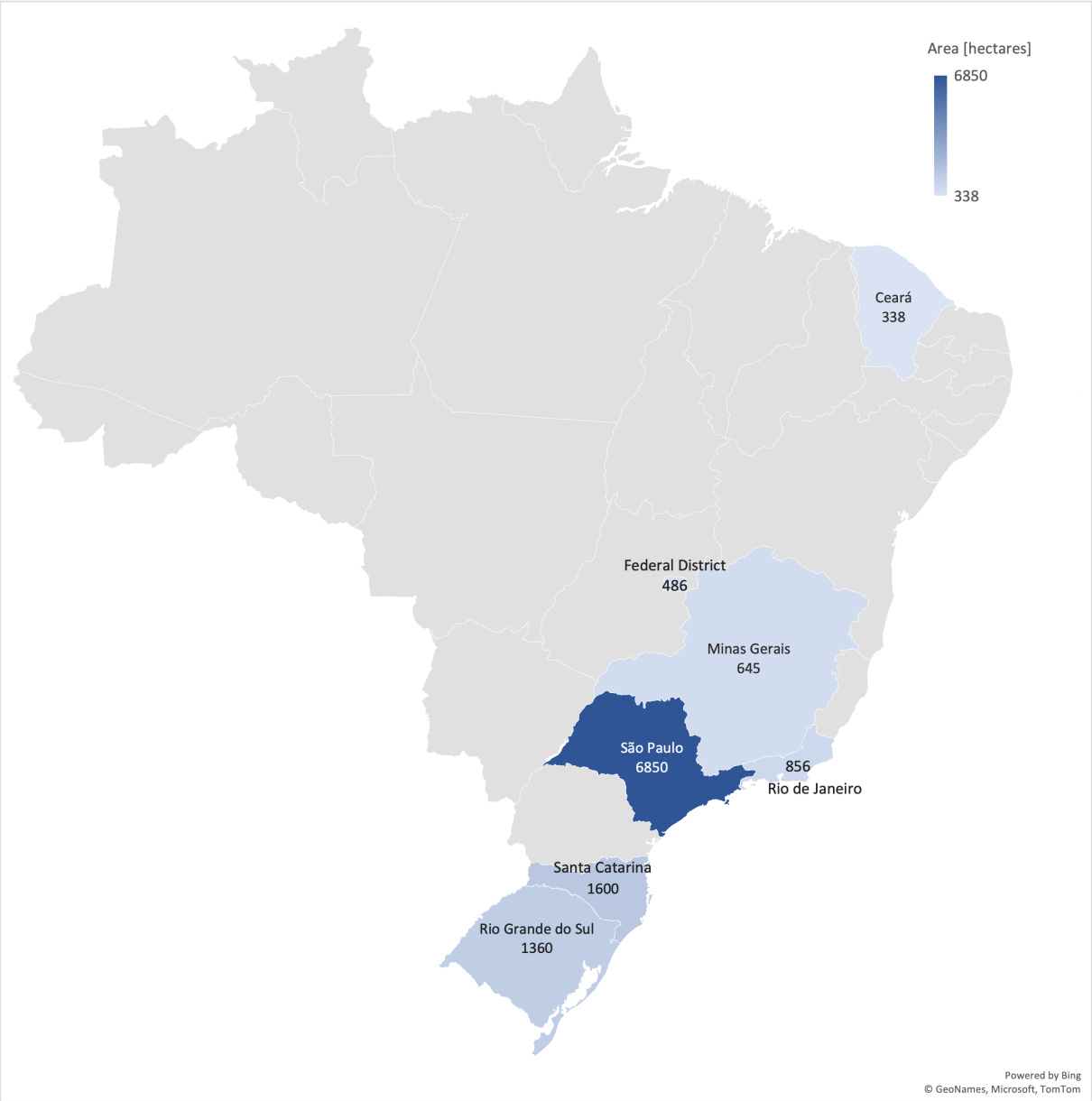

Figure 9: Cultivated area per region of the floriculture sector in the main regions of Brazil in 2015. Data from [10].

2.2.3 Italy

When talking about the European market for the floriculture sector, Italy represents 12% of the production value, right after the Netherlands (33%), Germany (13%) and with the same participation of France (12%), [18].

Istat, the Instituto Nazionale di Statistica, presented in the research estimation of surfaces and production of flower crops and whole potted plants (Stima delle superfici e produzioni delle coltivazioni floricole e delle piante intere da vaso [21]) the main numbers of the sector in Italy. Although the most recent data is from 2005, it is possible to

determine which regions of the country are the main hubs for the production of these products. Figure 12 and Figure 13 presents the production area for fronds, leaves and cut flowers by region in Italy. Liguria is the leader in the production of fronds and leaves, with 1.846 hectares of production, and Campania, on the other hand, is the leader of cut flowers, with 1454 hectares of these products. The total area of production in Italy was, in 2005, 9.609 hectares (equivalent to 96,09 square kilometers). The area is equivalent to 62% of the Brazilian size for the flower industry.

Based on the data provided by Figure 12 and Figure 13, it is possible to notice that the North of Italy presents the higher production of fronds and leaves (including the following species: Aralia, Cycas, Filodendro, Palma, Strelitzia, Formium, and others), and the South is characterized by the cut flowers.

The infrastructure of floriculture in Italy diverges by the type of product specified. Basically, the fronds and leaves are characterized by the cultivation in outdoor areas, and the cut flowers, by the greenhouses or glasshouses. Figure 10 presents the numbers of how the production area is divided and Figure 11 the products cultivated in 2005.

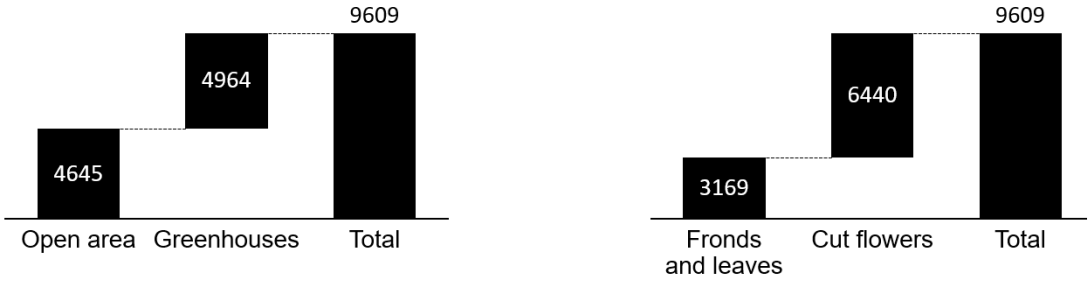

Figure 10: Segmentation of the infrastructure adopted in the Italian floriculture sector in hectares in 2005. Data extracted from [21].

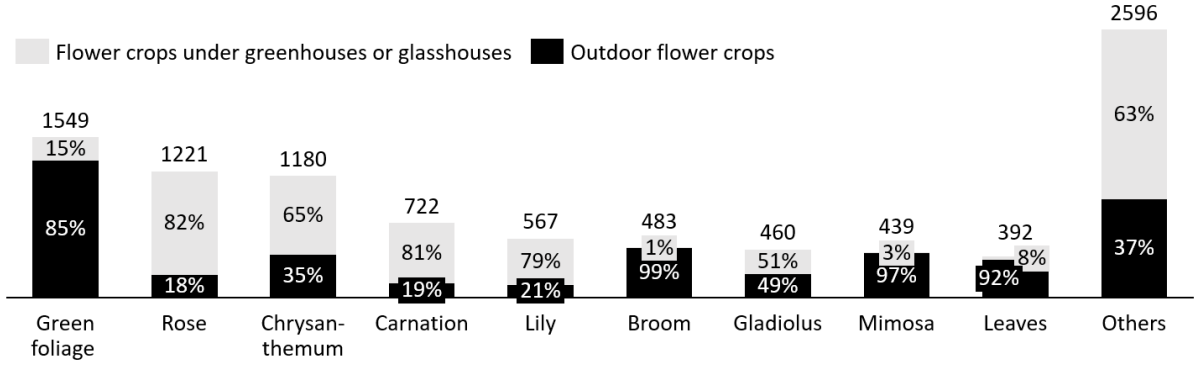

Figure 11: Italian area and production of flower, green foliage, and leaves crops by flower type in 2005 (area in hectares). Data extracted from [21].

Figure 12: Italian production area of fronds and leaves in 2005. Data from [21].

2.3 Product Chain

There are different paths in which the flower can go through the farm to the final consumer. Different players act in this process, according to the product, the format of the sale, and the technology involved. The reason for an immersion in the process is to evaluate in which situation a data-driven support mechanism can create more value for the grower and understand the whole scope of the process.

Figure 13: Italian production area of cut flowers in 2005. Data from [21].

2.3.1 Raw material, equipment and investment companies

In 2014, the raw material, equipment, and investment companies, also known as "before the farms" were responsible for 13% of the total financial movements of the flower industry, equivalent to R$1.3 billion (US$0.2 billion) [10]. It can be divided into two parts: companies that provide raw materials (and other operational expenditures - OPEX) and companies focused on equipment and investment (defined as capital expenditures - CAPEX). Table 2 presents information about each of the sub-sectors.

Type	Sector	Revenues
OPEX 66.3%	Seedlings, seeds and bulbs	19.3%
	Substrates	13.3%
	Vases	11.8%
	Packaging	7.7%
	Fertilizers	6.4%
	Energy supply	2.5%
	Pesticides	2.4%
	Heating fuel	1.9%
	Water supply	0.4%
	Individual protection equipment	0.3%
	Biological control	0.3%
	Pruning and harvesting tools	0.3%
CAPEX 33.7%	Greenhouse	11.4%
	Plastics and agro-textiles	9.1%
	Irrigation and fertigation structures	6.3%
	Tables, railings	4.0%
	Air conditioning structure	1.2%
	Filling machines	1.0%
	Lighting equipment	0.5%
	Trays and boxes	0.1%

Table 2: "Before the farms" revenue structure. Adapted from [10].

2.3.2 Agricultural Production

Agricultural production can be divided into three main types of groups, as defined in Table 3. Together, they made R$ 2.1 billion (US$ 0.4 billion) in revenue in 2014 [10].

Type	Revenues
Growers in cooperatives	35%
Growers in supply and distribution centers	25%
Independent growers	40%

Table 3: "At the farm" revenue structure. Extracted from [7].

Growers in cooperatives are those that use an organizational structure to commercialize their products. This organization does not have the product but serves as the interface between growers and wholesalers, retailers, and final consumers. According to the managers of the biggest flower cooperative in Brazil, the company's main role is to facilitate the interaction between the producers and buyers, integrating the production to the market [22].

Growers in supply and distribution centers sell their products in centers specialized, or not, in flowers to the final consumer. Finally, independent growers are those that sell their products directly to the final consumer, or to the other growers.

2.3.3 Wholesalers

The wholesalers - also known as cash and carry - represent the main intermediaries in the production flow of the flower industry. They are divided into three main categories, as presented in Table 4. They are in the middle of the growers and the final retailers, described in more detail in the next section. The wholesalers presented are not the only ones, but concentrate on the main financial movements of the sector. The difference between line and central wholesalers is the operation format: line wholesalers sell their products for different clients in a predefined path, while the central ones usually have a main hub where clients go to get their products. This segment movement R$ 2.1 billion (US$ 0.4 billion) in 2014 [10].

Type	Revenues
Central wholesalers	3.6%
Line wholesalers	70.0%
Garden centers	26.4%

Table 4: “After the farm: wholesale” revenue structure. Adapted from [10].

For some regions outside the Sao Paulo center of commercialization, the routes developed by the wholesalers had a dual function, while they have sold flowers with retailers, in return for their property, they bought flowers in the regional producers, thus, besides reducing the buying and selling costs, they enlarged the line of commercialization products [23].

2.3.4 Retailers

Finally, the retailers are the last point before the product passes to the final consumer. In 2014 the financial transactions in this part of the process were around R$ 4.4 billion (US$ 0.8 billion) [6]. The way it was distributed is shown in Table 5.

The supermarkets have been gaining market share since the beginning of the millennium, where the participation of this segment is increasing, from inexpressive participation in 2003 to almost 10% in 2014. This behavior of the consumer is explained by the increase

Type	Revenues
Floricultures	22.6%
Supermarkets	8.8%
Decorators	53.7%
Landscapers	14.9%

Table 5: "After the farm: retail" revenue structure. Adapted from [10].

in the average income of the population and, mainly, by the more accessible prices practiced by the supermarkets. Although the supermarkets are considered retailers, the price this sector charges to the final customer influences the price maker of the wholesalers, especially the line wholesalers, being considered as a competitor [24].

It is important to define the decorators and landscapers, once both segments represent over sixty percent of the total retail sales of the sector. Also, [10] used the assumption to build Table 5 that 40% of the revenue from the flower shops are for activities of decorators, so the 53.7% of participation of decorators, do not include part of the revenue of the flowers shops, due to the 'service as a product' part of its context. These companies do not only sell flowers, there is a differential and value-added by the service they provide to their clients.

> "Landscape: is responsible for (i) the development of the landscape project, (ii) the purchase of flowers and ornamental plants, (iii) execution, and (iv) maintenance of the project within a scheduled period. Its service is widely used in commercial sectors and condominiums, as well as in homes and businesses. Given the fact that the project does not have a daily effect, there is constant maintenance of flowers and ornamental plants, with replacement whenever necessary." [10]
>
> "Decorator: characterized by the signature of unique, fast projects that do not require constant replacement. Generally, the decorator buys a large number of flowers and ornamental plants, so that he uses the marketing centers and marketing cooperatives as the main purchasing channel whenever they are close by. When distant, the decorator buys via order and the wholesale distributor makes the delivery. In more distant regions, such as the state of Amazonas, for example, orders use air transport, which increases the value of the final product." [10]

2.3.5 Final Consumer

The final consumer, the one that buys the product in a flower shop, supermarket, or even online, is the one that makes the final decision. The average annual Brazilian per capita consumption of flowers and ornamental plants is estimated at R$ 45 (US$8) in 2020, considering the R$ 9.5 billion (US$ 1.7 billion) that this sector movement at the level of the final consumer [7]. On average, women spend R$ 100 (US$18) to R$ 200 (US$36) over a period of one year on flower and ornamental plant products, and men, around half, R$ 50 (US$9) to R$ 100 (US$18) [25].

Figure 14: Situations that may encourage greater consumption of flower and ornamental plants according to consumers' view in Brazil (multiple responses). Extracted from [25].

According to research conducted during 2017 and 2018, what could drive more consumption of these products is if they had lower prices, as presented in Figure 14. This is a result of a cultural statement in which, unfortunately, flowers and ornamental plants are considered expensive products and not essential for daily life. On the other hand, lower prices may reflect limitations for the producers. Greater availability of products was also appointed as the second main issue that could stimulate responders to raise their purchases. This is an indication that flower shop owners need to diversify more and offer different options to retain a greater number of customers. But for the retails, a great diversity of products sometimes represents a problem since they may not be sold and represent lost money [25].

If Brazilian consumption of flowers and plants is compared with other countries, Brazil is considered a market under development. According to [11], the country still has a low consumption per capita, if compared with developed markets, although this can be considered a signal to a potential of expansion to reach more saturated markets. Table 6

presents the main differences in the consumption of emerging markets, growth markets, and saturated markets.

Groups of countries by development stages of their markets	Main consumption characteristics
Emerging markets	Low per capita consumption; Low percentage of buyers; Tradicional assortment; Special occasions of consumption (e.g. Mother Day, Valentine's Day, Women's Day, Weddings, Funerals)
Growth markets	Strong growth of per capita consumption; Growth percentage of buyers; Consumer wants to have more choice than the traditional; More gift occasions are developing (e.g. birthdays, Easter, Christmas, visits, Friday Bouquet).
Saturated markets	Minimal growth in consumption or even stagnation or decrease; Flowers for everybody, every day; Much interest in innovation of assortment; Trends in flowers and plants are important (interior decoration and personal style).

Table 6: Main consumption characteristics of flowers and ornamental plants, in different countries in the worldwide market. Extracted from [11].

2.4 Commercialization Flow

The commercialization flow depends heavily on the structure that the growers have and the professionalization of their market. Figure 2 presented an overview of the different types of sale that may exist, from the point of view of the growers which productions are sold to other companies, and for the point of view of these other companies, that mostly have as the buyer the final consumer. This section is intended to make a broader description of these transactions.

2.4.1 Agricultural Production

Part of the Brazilian cooperatives uses the Dutch Auction System. It is implemented using fast-paced auction clocks displayed on a digital board. Aside from the current asking price, each clock also contains information about the setup of the current auction. As the clock ticks down counterclockwise, each bidder can stop the clock by pressing a

button indicating that she is willing to accept the price corresponding to the current clock position. The first bidder who makes a bid wins [2].

For the buyers, there are also different ways to participate in the auction. One new feature used is an advanced bid, a bid done before the auction takes place. The growers insert the sales proposals for the next few days, allowing the customer to view the available products and manage their purchases, guaranteeing the amount paid at the time of purchase, regardless of the price they could reach at the auction [26]. Figure 15 represents the characterization of the buyers from a flower auction at the two main scenarios.

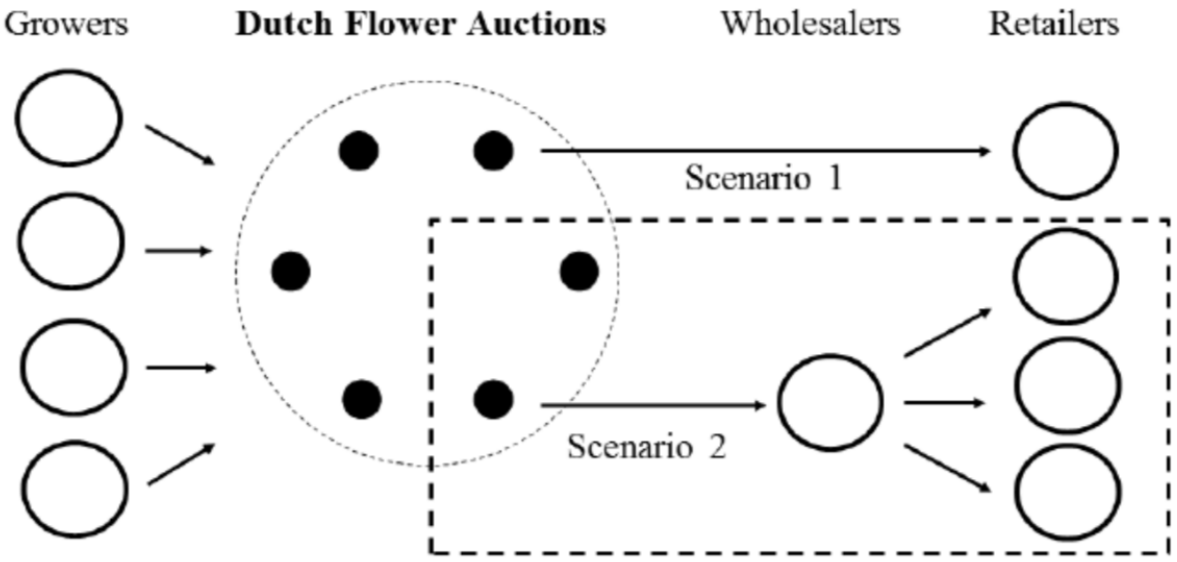

Figure 15: Overview of the two buying scenarios. In the first scenario, retailers buy for themselves. In the second scenario, wholesalers buy for their retail clients. Extracted from [27].

Intermediation contracts (also known as direct sales) are a system in which producers and distributors close short, medium, or long-term contracts, formal or informal. Prices, product features, and terms delivery times are agreed upon when closing contracts [17]. This type of sale creates an opportunity to make sales even before the products are harvested from the sites, thereby reducing the risk of loss of sales and speculation about excess stock available.

Via web services, it is possible for registered buyers to acquire directly from the growers' different types of products. The growers market their products in advance (even before harvesting the products), providing information about quantity, quality, and product. The buyers have access to this information and can negotiate with the specific grower [22]. The cooperatives work as the marketplace where growers can display their products and registered buyers are allowed to make deals.

The supply centers are the oldest and most traditional marketing system, in which producers stand side by side, offering their products to customers [17]. This system is mostly used for independent growers, once those that sell their products in cooperatives sign exclusivity contracts (so they are not allowed to perform sales out of the channels available in the cooperatives).

2.4.2 Wholesalers and Retailers

The distribution centers aim to meet the needs of wholesale sectoral marketing in states or municipalities where there are no supply centers or where they do not have this type of wholesale in their functional structures [17]. They differ from the supply centers because of the private structure.

Traditional retail is mainly represented by florists, street markets, and street commerce, which, in most cases, operate only seasonally on special dates, notably Mother's Day, Valentine's Day, and All Souls' Day [17]. On the other hand, holidays near the weekend, which inhibit the holding of wedding parties, and holiday months, when there are fewer parties, are periods with a decrease in demands for the decorators and other resellers [28].

The supermarkets and the garden centers are two different structures but focused on the commercialization of flowers together with other products. In the productive chain of flowers and ornamental plants, self-service has been gaining space and assuming more and more importance [10].

E-commerce is getting more attention in the commercialization flow. The technological aspects related to the operationalization and ease of navigation on the purchase sites also can be identified as decisive aspects for the growth in sectoral importance [17]. With the pandemic that affected Brazil from 2020, the use of e-commerce and social media as the most frequent action to restart the sales during the closed periods[29].

3 DIGITAL TRANSFORMATION

Digital transformation is one of the components of productivity growth, where it enables an organization to put its resources to the most efficient use, reduce losses and optimize resource management. In the past, being digital was a differentiator, but today it became a necessity for incumbents not to lose their market for the emerging new digital companies.

The four main domains in a digital transformation include technology, data, process, and organizational change. The technology brings the building blocks for the transformation, including the Internet of Things (IoT), blockchain, data lakes, artificial intelligence, and others. The data can be perceived as the flow of information throughout the company and is closely related to the tools presented before. Transformation requires an end-to-end mindset, so the process is important to the transformation not be reduced to a series of incremental improvements. Finally, the organization means embracing the human side of the change, so the new process and technologies can be incorporated into the daily routine inside the company [30].

This thesis will focus on the technology and data aspects of a transformation. This section is divided into a discussion of how the floriculture sector is in the aspect of the digital transformation in process, focusing on the Brazilian hub, with benchmarking across the leading companies in the world.

3.1 Internet of Things

"Supply chains are increasingly being virtualized in response to globalization and emerging market challenges" [31]. In this context, IoT technologies allow the chain to gather data from physical elements and, consequently, analyze, control, and interact with devices, equipment, and people [31]. The IoT systems are usually combined with robotics, automation, and analytics to create devices for capturing new data, decision support software, and big data analytics. Also, it can be combined with on-farm machinery,

automation, drone manufacturers, and growing equipment.

The IoT-based systems in supply chains "build on traceability systems that provide the information to track the location of certain objects (e.g. product, box, pallet, truck) and trace its history" [31]. But in the context of flowers, the IoT technology can go far beyond the trackability function. There are many IoT tools for monitoring ambient conditions (e.g. temperature and humidity) and other quality parameters, so Internet-connected actuators can equip objects to remote operations such as coolers, irrigation, and other functions [31].

Although IoT technologies are widely spread across industries, increasing the amount of data generated by the process can also lead to friction. One example is using IoT sensors to control the temperature in the transportation of flowers, a process that is highly related to flower durability. Temperature sensors combined with warning systems can create awareness of problems in the process and allow to a more transparent relationship between growers and carriers.

3.2 Blockchain

"Organizations that invest in emerging supply chain transparency technologies, such as blockchain or smart contracts, often realize more efficient visibility of partners' activities and minimize supply chain risks" [32]. Blockchain technology has the potential to transform the collaboration and share of knowledge between supply chain partners, and this is also applied to the floriculture sector. This technology can be used to improve supply chain transparency and traceability (e.g. certification authentication), increase supply chain efficiency (e.g. decrease storage times), manage inventory and crop data (e.g. track product quality), and be used in financing and payments solutions (e.g. smart contracts).

According to Wageningen University, in horticulture, various platforms enable companies to share data. Blockchain technology can link all participants in a network in which they could reliably share and retrieve information. The Public-Private Partnership Project "Blockchain: Automated Compliance" is investigating the conditions under which blockchain technology can add value for breeders, growers, and traders in floriculture to increase transparency about the use of improved crop protection products at batch level throughout the chain [33].

The data ecosystem in the sector still consists of many linear data flows, and that

each part within the production chain has its own structure. However, this is "a fragile digital ecosystem when a party decides not to pass on that data and information to the next player in the chain" [33]. There is also often a lack of feedback from data in the chain, as presented in Figure 16, so an individual consuming at the end of the chain has no, or limited, information about the origin of its acquisition.

Figure 16: Fragility of the data chain in the Supply Chain. Extracted from [33].

Although the technology exists (blockchain), its implementation must have a goal: increase the value-added for the final consumer or reduce the costs for the members of the supply chain. This case is applied in the floriculture of developed countries where "it costs to breeders, growers, traders, and other parties a lot of time and money to demonstrate that their products meet the legal or non-statutory requirements" [33], so the implementation of an integrative system could be one solution to reduce costs for certifications because of a less amount of inspection and audits. "Blockchain can reduce the burden of proof and costs for growers by sharing and maintaining data and information in a standardized and reliable way for buyers and certifiers" [33].

Some of the challenges for blockchain technology to move from early stages applications to large-scale production are divided between the technological and implementation challenges.

For the technological side, there is limited transaction speed, once it can only execute a limited number of transactions per second and industry and business often require high levels of processing power; latency, since the frequency with which blocks become available and can be added to a blockchain varies; lack of uniformity, once the Key Data Elements (KDEs) used to store data are not harmonized across industries and users; and the energy costs, since computers require a large amount of energy to mine blocks for the blockchain.

On the other hand, the implementation challenges includes transparency issues. given that competing development of private blockchains inhibits transparency; access, once there are potentially limited access to blockchain technology in developing and rural communities; costs, because of the high upfront cost for the technological infrastructure; and the behavior change, that is, the willingness of farms to adopt blockchain practices.

3.3 Artificial Intelligence

Artificial Intelligence (AI) algorithms are becoming popular within the industry and agriculture sector. The algorithms can manage complex data and create information and insights to help companies to make the right decisions. From the daily supply to the cooperative, to the type of sale (clock presales, auction clock, direct trade), the growers need to decide when to offer their products and how.

When deciding where to apply AI, the first step is to identify where technologies should be incorporated. The key decision points where there is a constant need for individual involvement are often the best place to install smart tools and to maximize the investment, but to work properly, a high amount of data is needed.

From price predictions to which plant to cultivate, different models that apply AI and machine learning can leverage the power of data for the sector, but a digital transformation must be held with a change of culture. To give an example, the recommendation from the algorithm should be used to identify leads and maximize the revenue for the grower. Choosing the right customers with the highest propensity to buy, with the right opportunities for each segment at the right time can support campaigns and the commercial department to increase conversion.

Usually, the AI-based approach is used when high availability of historical data can be used to train the machine learning model, like historical sell-out data, sales transactions, and data related to temperature, rainfall, wind speed, and humidity.

4 CULTURAL AND TECHNOLOGICAL ISSUES

This chapter's focus is to get an overview of what is the current technological level of adoption for the Brazilian floriculture sector, and how it is incorporating the new technologies available in the market. The first section is about the growers, followed by a section about the cooperatives, and finally, the perspective for the wholesalers and retailers. "While technology is maturing fast, innovation seems to be delayed by organizational barriers" [31], and many are the complaints and context for these barriers as presented next. Most of the insights presented here are output from the qualitative interviews.

4.1 Growers barriers

The floriculture sector involves many small players, as present in the previous section of the industry overview. The average size of a company for this sector, in Brazil, is 1.88 hectares, really low if compared to other sectors - e.g. in the soy segment, one of the main food commodities exported by the country, the average property has 145.72 hectares of production [34].

This mix of small companies can difficult the effective for a processes change, but a "combination of 'the sermon' (communication, persuasion, and information), 'the carrot' (bonus or other benefits for the first growers who switched), and 'the whip' (fine or higher costs for growers who did not enter digitally)" [33] can help to boost the implementation. An example of this happened in the early 1990s when a first step was taken in floriculture for the automation of the auctions (where the growers had to purchase computers and change the way they transmit information for the cooperatives).

In this phase of the project, different growers from the main Brazilian cooperatives were selected, to have different perspectives for this research. From the qualitative interviews, it was possible to define the main strategic decisions to be made in the operational process and what are the barriers and issues for them related to the digital transformation.

The decision to expand the production is heavily influenced by the growers' expertise in the field, aligned with client feedback about current and new products. The current product's performance (e.g. demand in peak dates) is known by the growers, according to the conversations. The cooperative website has a page to display the sales transaction data, although currently, only the past three months of sales are presented. If the grower does not save this data recurrently, he has to pay a fee and request the data from the IT department.

When the focus is on testing new products, the first step is a productivity test inside the farm, to see if the product adapts itself to the climate conditions and the number of flowers collected per year is the expected and performed by other growers. In parallel, the market acceptance of the product is also evaluated in events of exposition (usually provided by the cooperatives). As it is an important decision to be made, there is a high effort to perform these tests before the final decision of which product to expand the production, however, it is still highly influenced by the human knowledge of the field, and less by data or other technology tools.

For some growers, the cooperative offers two ways to sell the products, as presented before. According to the interviews, direct sales (intermediation) have a higher return per flower compared to those that are sold in auctions. But the sales data show that this is not always the case, so for the peak dates, an important decision is if the product should be sold in advance for the clients, and if so, which price to perform. To answer this question historically data is used, as well as the knowledge of the production for the period, but there is no technological tool that helps in this process.

Also, it was possible to see that there is a client relationship to offer special discounts and encourage recurrency, but not in a structured way (e.g. all the contracts of recurrent acquisitions are verbal for the growers interviewed). Based on the sales data, a data mining approach could be developed to cluster the clients and prioritize the sales channels. The goals of this technique could be to give more attention to buyers with a good history of purchase, as well as transform auctions sales into direct sales in the long term.

There is also one cooperative that set the prices of the products (the commercial team), and the growers are not allowed to offer discounts to their clients. The reason behind this approach is to avoid "price wars" and guarantee a sustainable price for the grower. However, even in this case, the growers can add a mark-up to the price if they perceive that the one settled by the cooperative is too low.

4.2 Cooperatives issues

The main goal of the interviews with cooperatives was to define their level of technology implemented in the process and their objectives for the short term. To do so, one executive director from Cooperflora, the biggest Brazilian cut flower cooperative, was invited to a conversation. Information about Veiling Holambra was obtained through desk research and participation in events. Royal FloraHolland was reached by one interview with a product owner of the data department.

4.2.1 Brazil

The aim of the cooperative is commercialization, and to do so, Cooperflora has different departments to be the marketplace between growers and buyers. But different from an online marketplace, the cooperative, as like the others, works as the main center to get the products and take care of the process of sales.

Logistics is an important part of the operation. For regions near the cooperative (e.g. the city of Sao Paulo), they deliver the product store by store and not in a distribution center of the client (e.g. some chains of grocery stores adopt this service). The reason behind this action is the perishability of the product. Even though the buyer can get the product in the growers' farm, this is not common, once that buyers usually have a diversified portfolio of acquired products and it would not be feasible to get the products farm by farm, although they could find better prices.

In the first quarter of 2021, around 65% of the sales of Cooperflora were performed using a digital marketplace. The tendency is that this number continues to grow, but due to cultural conditions the expectation is to reach 90% as the maximum penetration rate for this channel - some customers still prefer to have the person contact inside the company to perform their acquisitions.

There are up to 13 pricing modifications during the week for the same product (in 2020 modifying the price more than twice per week was not common). This is culturally disruptive from the buyer's point of view, but the tendency is that the price becomes more and more volatile. There is the use of algorithms to define the price for each product, for each grower, each day. The commercial department defines the index, but this algorithms, based on the historical data, performs the fine adjustment.

By the number of uncompleted orders, the cooperative has data about which products there is a pent-up demand. They share this information with all the growers, but the

decision to cultivate, or not, and the size of the plantation is up to the decision of the individual grower. The sharing of data between the growers is transparent by cooperation. One grower can see his average price, as well as the ones from his peers. The volume sold is also available, however the buyer does not have access to this information.

About Veiling Holambra, currently the cooperative is developing a new platform to integrate the entire chain of flowers, they are willing to bring new tools to facilitate the process for their clients using a digital platform. Their vision is to create a digital ecosystem, connecting the production to the market: grower, cooperative, client and sales point. The plan is to have a marketplace, until the end of 2021, where the growers can present their products and, the wholesalers, can use the integrated system to offer the products to their customers - flower shops, decorators, among others. Their projects also include the development of algorithms to, for example, purchase suggestions for their clients, based on historical data.

4.2.2 Netherlands

Royal FloraHolland was reached by one interview and more information was obtained by the participation in their events. The cooperative is changing from an auction-focused platform to a digital marketplace, with three main building blocks: ordering; payment, and delivery. Ordering is related to Floriday, their digital B2B platform that provides growers and buyers the opportunity to choose the way of doing business that best suits them. Payments are related to the international market, connected by the cooperative with different currencies. The delivery services are logistics solutions and transform for all orders from the greenhouse to the buyer to deliver more often, faster and fresher. The company started a joint venture with four carriers to improve the delivery service inside the Netherlands.

There are only a few software companies focused on the Brazilian flower market, due to its smaller size compared to other sectors. In this sense, the Dutch market was selected and an interview was conducted with the Product Owner of Insights, an additional service offered by Royal FloraHolland to their growers. The conversation started with the long-term strategy for the company and how they are passing through the digital transformation in the Netherlands.

Traditionally, FloraHolland did auction kloks, but from the last few years, they are creating a new digital platform, Floriday, because they understand that the original way of selling can't be held forever. The main goal of the cooperative is the creation of an

ecosystem to connect growers from all around the world and get more efficient logistics.

The Insights solution is part of this transformation with a digital tool that allows growers to perform different analyses of their sales, trends, and historical information of the companies. It is a service available for growers from FloraHolland and also it is already being integrated with other companies from Germany and Belgium. Although there is this need for the digitalization of the sector, the cooperative is facing different issues with its clients, where the adaptation is a slow process due to different stakeholders with different capabilities that in the end have the same power of decision in assemblage, the most common way of making decisions in a cooperative.

One goal for moving to digital is to perform an improvement in the carbon print of the sector. With a 24/7 marketplace, the goal is to work together with the transportation companies to work more efficiently. They started the cooperation with the three largest transport companies to do it together and make it more efficient, because they think that they lose a lot of money by not being very efficient in a logistical way, between the different locations of growers and buyers. If it is done in a large body, it could be much more efficient.

FloraHolland does have price predictors, but most of them they don't use, because they aren't allowed to use them in the market, that's for competitors. Recall that regulations, there are all kinds of fair markets. And if FloraHolland predicts the price, it will be because they have too much data, too many growers next to them. So they can predict it pretty well, But if they do that, it will be a self-fulfilling prophecy. So that's why they aren't allowed to predict prices in general, for their growers.

To solve the issue of a fair market, some services have different options. So they have a price prediction with five different options and settings, that uses more actual data using the grower's data, uses the wide data, and then the user has to choose what to use. And then it's allowed because depending on the choice the grower creates, he gets a different prediction.

FloraHolland also wants to make smarter connections, although it may be very risky to do that fairly. For example, if a certain flower company is always buying red roses from two different products, and FloraHolland suggests that they can also buy another product, that's not allowed because other growers may also have good products and FloraHolland is an independent marketplace. FloraHolland has a lot of services but they always have to be very careful in what they do and automate.

4.3 Wholesalers and retailers perspective

To achieve the overall players of this segment qualitative interviews were developed with the procurement sector of supermarkets, with the main goal of understanding their position in respect to the flowers segment. From these interviews, it was possible to infer a willingness to buy directly from the cooperative to not pay fees to the intermediaries, once weekly acquisitions are usual. The procurement department is interested in the weekly price, so the daily changes are not important for their acquisitions.

Usually, for the clients of supermarkets, the products (flowers and plants) are used as a gift, so there is the need for the company to display the product in a way that it can make the client want the product. Usually, there is no markdown approach for old products, once in a premium network of supermarkets it would not fit its brand. In the supermarket context, there is no need for a huge variety of products, one of the interviewees mentioned an occasion where they reduced the number of products in the floriculture department and the sales increased. For them, variety does not mean better sales.

5 ECONOMICS BENEFITS

Many are the solutions available for growers, cooperatives, wholesalers, and retailers. But what are, actually, the expected economic benefits from such initiatives? This section aims to perform some analysis of what could be the gains of the implementation of advanced analytics and the development of an ecosystem for the Brazilian flower industry, both in terms of increasing revenues or diminishing costs for growers and cooperatives.

5.1 Growers

Together with the data from one grower, a few studies were done to define which digital technology could bring benefits and increase revenue for the company. Sales transaction data from 2016 to 2021 were used thanks to an agreement with the company. The question to be answered was: could a price predictor increase the revenue for the company, helping the sales department to define its prices? A tool that could predict the price could help the sales department when defining the price for the direct trade if an estimate of the price of the auction tomorrow were known (once the direct trade is done before the product arrives at the auction).

5.1.1 Estimation of profits

The decision to not include 2020 and 2021 was to avoid a scenario of crisis that could invalidate the analysis. Also, among all the products from the grower, the one selected was the rose Freedom, because it represents 59.1% of the volume sold for this specific company, so there would be available data every week.

The product is available in 3 different sizes: 40, 50, or 60 centimeters in length. The average price for the 4 years period varies from R$0.42 (US$0.08) for the smaller to R$0.87 (US$0.16) for the one with 60 centimeters. Figure 17 presents the data grouped by month for the years 2018 and 2019. It is possible to notice that the price can vary a lot along

the year, with the highest value in June, the month in which there is Valentines' day in Brazil.

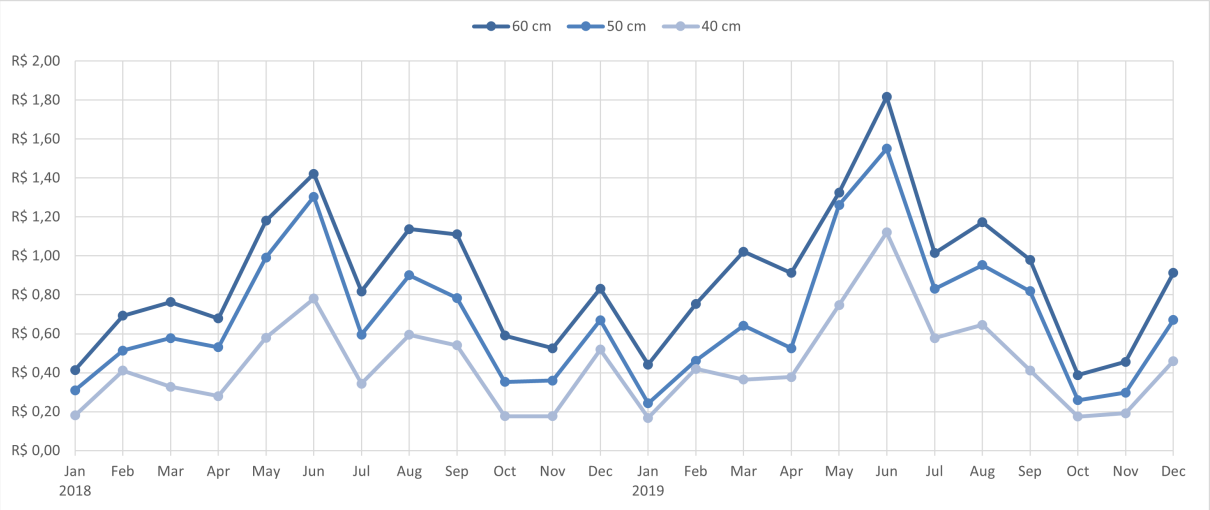

Figure 17: Average monthly price per unit of the rose Freedom for one Brazilian grower.

Even though the average price seems to have the same trend (comparing year after year), it can be highly volatile in the peak dates, as presented in Figure 18. Valentine's Day in Brazil is on the 12th of June, so it is possible to see the trend of growth before that date and then, the price starts to fall due to less demand for the product.

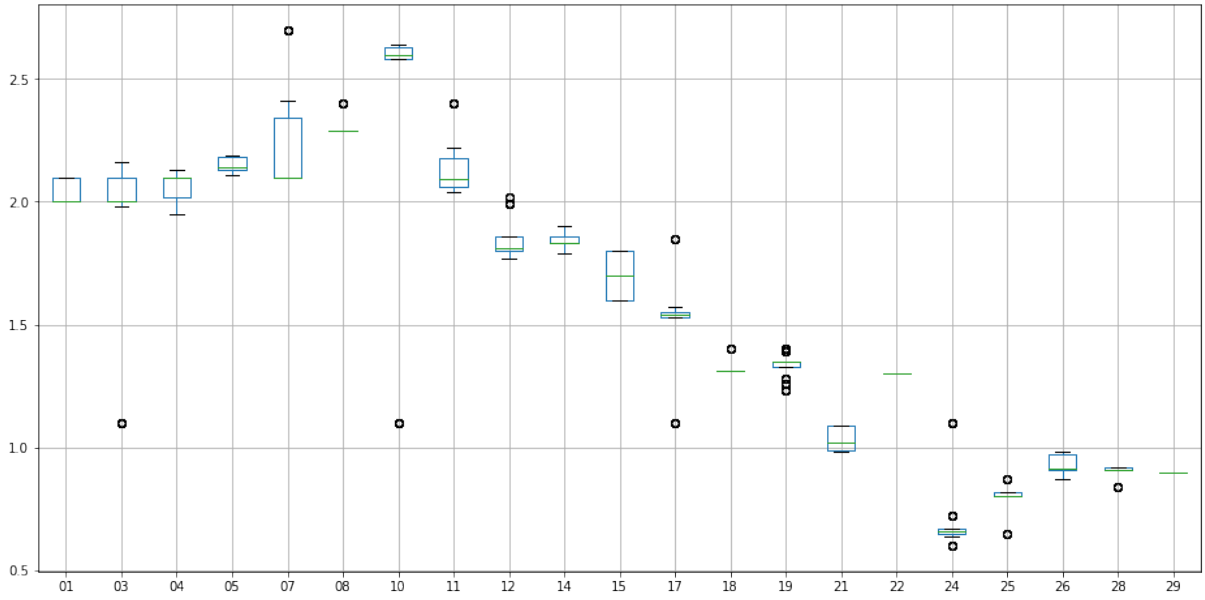

Figure 18: Boxplots of daily price variation from 1 June to 29 June 2019 for the rose Freedom 60 centimeters.

For the dataset available, the grower has two types of sales, direct trade or auction sales. To estimate the amount of money that a price predictor could generate for the

company, only days that the product was sold by direct trade and auction were comparable. This represents 348 days for the 4 years. Figure 19 presents the filters applied to the dataset.

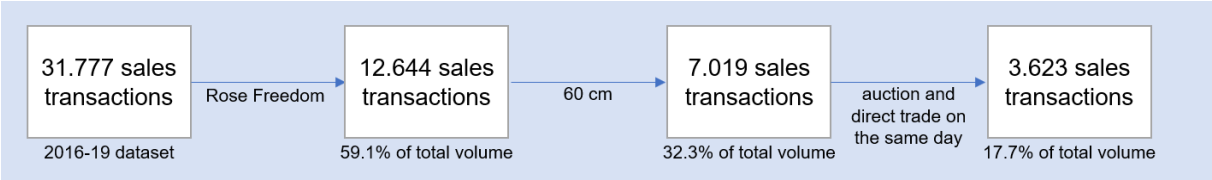

Figure 19: Filters applied to the dataset.

From the 348 days, in 107 (31%) the price asked from the grower was below the average price paid in the auction, so the amount of value that could be generated selling the product for a higher price was calculated comparing the difference between the average price of the auction and the average price asked for the direct trade, multiplied by the volume sold by direct trade.

$$Gain = \sum_{n=1}^{107} V_n(P_{AUCTION} - P_{DIRECTSALE}) \tag{5.1}$$

The equation above resulted in R$38,110.10 as a possible gain for the company, an increase of 16.9% compared to the revenue performed by direct trade for these 107 days. These results show that, although currently in 69% of the days (241 in the period analyzed) the company is asking a higher price for advance acquisitions compared to the auction sales, there is still space for improvements in revenue with a support tool to predict the future price.

To verify if this was an exception for this specific product, the same analysis was performed for the product with 50 centimeters. It had 3,819 sales transactions for the period, with 1,258 (5.3% of the total volume sold for the company) that passed the filters of the auction and direct sales trade on the same day. The amount of 158 days was the result and, from these days, 56 days (35%) had a direct sales price below the auction price for the same day. Applying the same equation, a possible gain of R$9,369.60 could be performed for the company, 18.2% compared to the revenue performed.

A third last analysis was done with a different product, the second in volume for the company. Rose Revival was selected, with a size of 60 centimeters. This product had 1,868 sales transactions for the period, with 598 (1.1% of the total volume sold for the company) that passed the filters of the auction and direct sales trade on the same day. The amount of 125 days was the result and, from these days, 47 days (38%) had a

Product	% days direct trade had price below auction	% increase in revenue for those days
Rose Freedom 60cm	31% (107 days)	16.9% (R$ 38k)
Rose Freedom 50cm	35% (56 days)	18.2% (R$ 9k)
Rose Revival 60cm	38% (47 days)	21.6% (R$ 1k)

Table 7: Summary of analysis of the potential increase in revenue

direct sales price below the auction price for the same day. Applying the same equation, a possible gain of R$1,371.00 could be performed for the company, a total of 21.6% if compared to the revenue performed.

These quantitative results, summarized by Table 7, show that there is potential to improve the decision-making of choosing the right price for the right moment, although it is important to remember the business aspects of the trade. The clients that acquire products from the auction do not need to have any relation with the company, it is only a transaction between businesses without the need for further negotiation. The direct trade, on the other hand, implies a deal between the client and the company that can, or not, be intermediate by human contact. Recurrent clients may request better prices than from those in the auction and, in return, they may become more loyal to a specific company.

5.1.2 Price Predictor

The price predictor was a use case requested by some growers interviewed in the first part of the research. There are in the commercial routine many deals agreed upon daily, but there is not much to help in the decision-making. Today's price is the best guess for tomorrow's price, but could other factors, like the day of the week or period of the month contribute to making better deals and increasing the revenue from sales?

Any new model developed must be comparable to a baseline. This is necessary because a meaningful reference point, usually a simple logic that is behind the "gut-instinct" of the experts, needs to be outperformed. If with the available data it is not possible to predict better than this, other data points that should be used in this use case should be discontinued, or the problem may need to be reframed. As pointed in the section of the project requirements, the metrics to evaluate the models are going to be the RMSE, MAE, and MAPE.

5.1.2.1 Selection of the data

To create the model, it was used the transactional data from the sales of one grower. The dataset was composed of the transactions from 2017 to 2021. Each transaction is characterized by a date, a buyer, product, the number of products sold, and the value per unit. To use the dataset, it was applied preprocessing to transform the data string into variables that could be used in the model, like weekdays, months, and days of the year.

For the price predictor algorithm, data from table "fact_sales" and "fact_stock_and_discard" were used. The fact sales table presents transactional data for each sale, as presented in Table 8. The fack stock and discard, on the other hand, presents the daily stock and discard of the products of the cooperative, including all growers. The structure of the data is available at Table 9.

Variables	Description
Date	Day of the transaction
Buyer Id	Reference of the consumer
Supplier Id	Reference of the grower
Product Id	Reference of the product
Quality	Product quality classification
Invoice Id	reference to the transaction id
Quantity of packages	Total of packages sold in the transaction
Quantity per package	Quantity of products stored in a package
Unit price	Sale price
Type of sale	Auction sale or direct sale

Table 8: Structure of the table fact sales.

Variables	Description
Date	Day of the reference
Product Id	Reference of the product
Quality	Product quality classification
Quantity	Total of units available
Type	Classification of stock or discard

Table 9: Structure of the table fact stock and discard.

To select which products from the grower would be used in the model, it was analyzed the volume sold in auctions for each product compared to the total volume sold by the company, so there would be enough data points for the analysis. It was selected one product for the analysis: Rose Freedom, which corresponded to 64% percentage of the

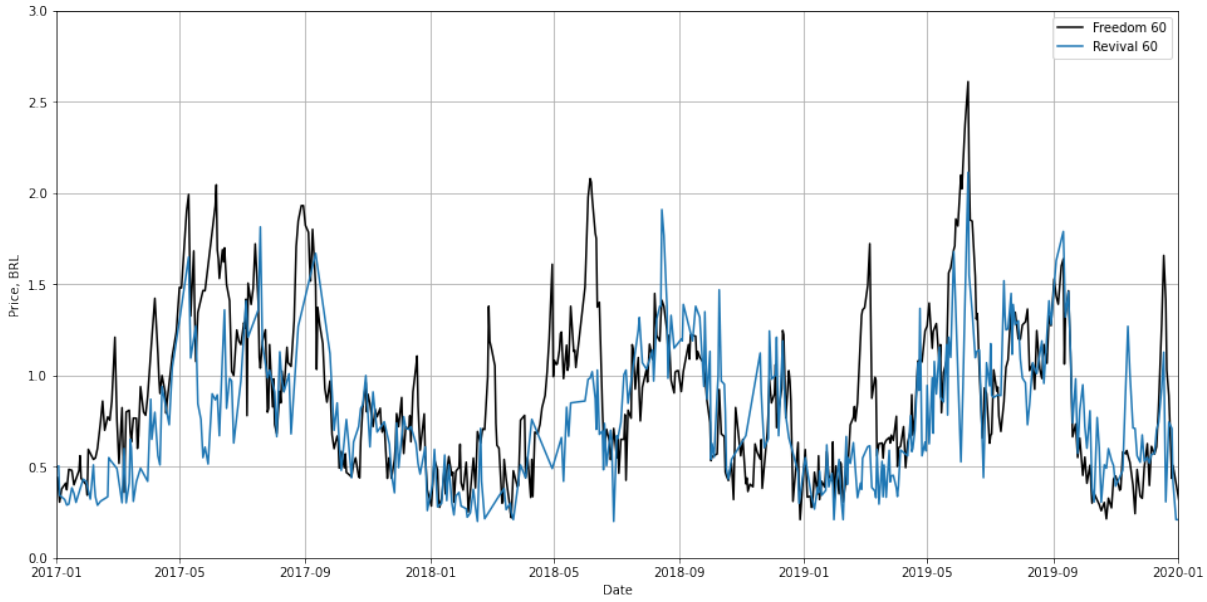

Figure 20: Auction daily average price for the Rose Freedom and the Rose Revival for the period of Jan/17 to Dec/19.

volume sold by the grower. Figure 20 presents the daily price for Rose Freedom. Notice that there is a correlation between the price with another product, Rose Revival, which is expected given their similarities.

With an exploratory data analysis, it is possible to notice, with Figure 21, the yearly season of the variation of prices. Connecting to the events presented in Figure 3, event A represents the peak of sales for International Women's day, event B represents Mothers Day, and event C represents Valentine's Day. It is possible to notice that from 2017 to 2019, the price of the rose followed the same trend, but after the pandemic of 2020, the peaks and valleys are very different now, which can be a difficulty for the performance of a price predictor algorithm.

5.1.2.2 Baseline Definition

For this specific prediction problem, after the interviews with growers, it was clear that the best baseline for tomorrow's price is the one performed today. When defining the price for advanced transactions, the commercial department of the company uses the price performed today as a baseline. All models developed will be compared and try to improve the evaluation metrics with this approach. If the model does not overperform the baseline, it should be discarded. If it performs better than the baseline, it could be used, although the commercial department would need to see the value of this algorithm. This baseline definition is also cited in the literature as the Persistence Model Forecast

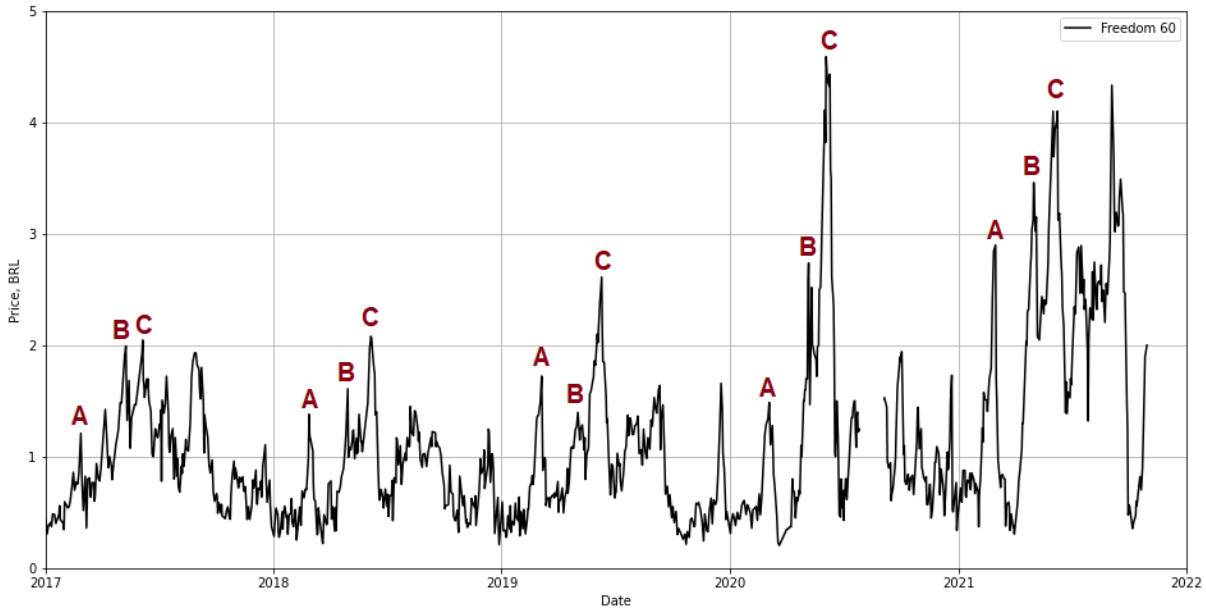

Figure 21: Auction daily average price for the Rose Freedom period of Jan/17 to Oct/21. Events A, B, and C mean, respectively, International Women's Day, Mothers' Day, and Valentine's Day.

or the Naive Forecasting.

$$\hat{Y}_{t+1} = Y_t$$

5.1.2.3 Model ARIMA

The Autoregressive Integrated Moving Average (ARIMA) model is a generalization of an autoregressive moving average (ARMA) model, commonly used in statistics for time series data. According to [35], "An ARIMA model is labeled as an ARIMA model (p, d, q), wherein:

- p is the number of autoregressive terms;
- d is the number of differences;
- and q is the number of moving averages.

Given the seasonal component of the data, it was used the Seasonal Autoregressive Integrated Moving Average (SARIMA) to create the forest, where an automatic method from the Python library auto-ARIMA was used to find the best parameters for the model, that is, the one with the lower error rate.

5.1.2.4 Model Random Forest

A random forest is an estimator that uses a defined number of classifying trees, which in turn are sets of splits or decisions on how to separate the data. After going through the splits and getting to the sheet, the data label is determined and then uses averaging to improve the predictive accuracy. "A random forest is random in two ways: (i) each tree is based on a random subset of observations, and (ii) each split within each tree is created based on a random subset of candidate variables. Trees are quite unstable, so that this randomness creates differences in individual trees' predictions", as defined by [36].

In this work, the model was tested using different features available in the dataset, and for the final model it was selected the mix of features that performed the smaller RMSE error was. The following features were used: month, week, year, year-day, last-day price, day of the week, holiday (true or false for Women's Day, Mother's Day, and Valentine's Day), and volume sold.

5.1.2.5 Model LSTM

The Long Short-Term Memory (LSTM) is a specialization of a Recurrent Neural Network (RNN) that explicitly adds the manipulation of the order between observations when learning the function of mapping the input of the observations to the output.

For the construction and testing of the LSTM-based model, the Keras API of the TensorFlow Python package was used, which already has the implementation of the model natively.

5.1.2.6 Model Prophet

According to its library, Prophet is a procedure for forecasting time series data based on an additive model where nonlinear trends are fit to yearly, weekly, and daily seasonality, plus holiday effects.

Prophet uses "a decomposable time series model with three main model components: trend, seasonality, and holidays. They are combined in the following equation" [37]:

$$y(t) = g(t) + s(t) + h(t) + e_t$$

$g(t)$ is "the trend function which models non-periodic changes in the value of the time series, $s(t)$ represents periodic changes (e.g., weekly and yearly seasonality), and

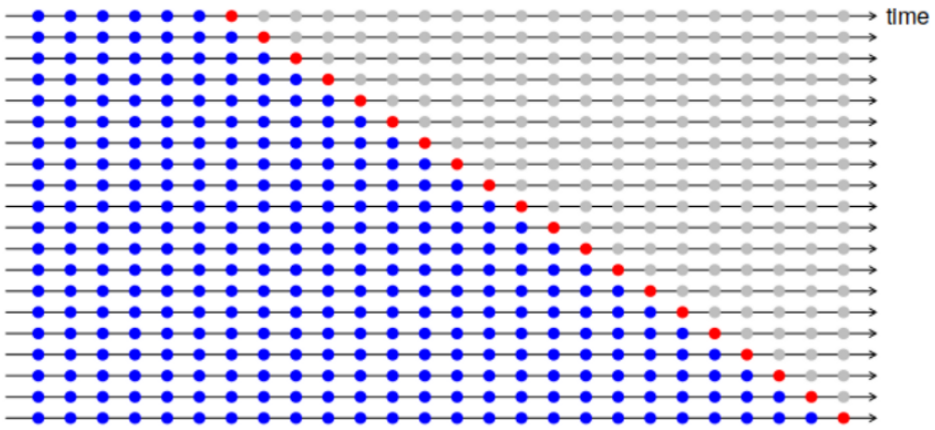

Figure 22: Illustration of the Walk Forward methodology. Extracted from [38]

$h(t)$ represents the effects of holidays which occur on potentially irregular schedules over one or more days." [37].

5.1.2.7 Walk Forward Validation

The validation follows the Walk Forward Validation method, commonly used for time series forecasts. In essence, it divides the dataset between train and test data, and "each time it feeds the historical data to the new data to enrich it to improve the new model and forecasting" [35]. Figure 22 illustrates this concept. With multiple splits across different periods with the training data expanding each time.

5.1.2.8 Results

The accuracy of the developed model was evaluated by comparing the models and the real prices for the same period, using the Walk Forward validation, as discussed in the development chapter.

For this project, the first model was developed on data from 2017 and was then tested on data from March of 2018. As such, the outputs of the first model for 2018 are out-of-time for previous years (i.e. 2017), and out-of-sample for transactions that happened after 2017 (i.e. in 2018). Then, the model was reestimated using data from 2017 to 2018, and tested in October 2018, and so on.

It was selected two periods per year of 10 days for the analysis. The first period consists of 10 auction sales before International Women's Day (8th March), by default, characterized by an increase in the average price some days before the holiday, followed by a decrease in the prices. The second period defined was a month without holidays,

Test Period	Naive	Random Forest	Prophet	SARIMA	LSTM
19/Feb/18 to 07/Mar/18	0.2009	0.2163	0.5907	0.1964	0.2044
18/May/18 to 11/Jun/18	0.2607	0.2669	0.6709	0.2505	0.2728
08/Oct/18 to 26/Oct/18	0.2276	0.1926	0.3914	0.2707	0.2167
15/Feb/19 to 06/Mar/19	0.1898	0.1734	0.4788	0.2054	0.2202
27/May/19 to 11/Jun/19	0.2196	0.2843	0.3232	0.2368	0.2210
09/Oct/19 to 30/Oct/19	0.1013	0.1258	0.2619	0.1148	0.0903
12/Feb/20 to 06/Mar/20	0.2483	0.2783	0.2891	0.2634	0.2562
26/May/20 to 11/Jun/20	0.5356	0.8222	1.0432	0.4967	0.5421
13/Oct/20 to 30/Oct/20	0.2161	0.2202	0.2492	0.2545	0.2214
17/Feb/21 to 05/Mar/21	0.4699	0.5606	0.5845	0.5421	0.4885
25/May/21 to 11/Jun/21	0.4342	0.4102	0.4008	0.5238	0.4371
12/Oct/21 to 29/Oct/21	0.2650	0.3219	0.2762	0.3353	0.2777

Table 10: RMSE between the prediction of the models and the test real value. Data for rose Freedom of 60 centimeters.

affecting the average price, defined by October. Table 10, 11 and 12 presents the different error rates for the models developed.

A deep dive in some of the cases were conducted plotting the forecast for the auction price for each model, as presented by Figure 23. The figure illustrates the real average price of the auction and the price forecast by each model, given the day of the auction. For this specific period (month of October), the LSTM model presented the lowest RMSE value (equal to 0.0903).

Figure 24 illustrates the price for the days before Women's day in 2020. For this period, the model of the Naive presented the lower RMSE (0.2483). Figure 25 shows the price for the days before Valentine's Day in the 2021 holiday in which the model of the Prophet presented the lowest RMSE (0.4008).

5.1.2.9 Discussion

Although in the short-term, as presented by Table 10, 11 and 12, the models had different results of performance, in the long-term the results are close to the same, as presented by Table 13. For 2021, a year with high variation of the price, the Naive Forecast achieved the best RMSE metric, but for the year of 2019, the Random Forest achieved the best result. All models, not including the Prophet model, achieve similar MAE results, which demonstrate a type of randomness of the results.

Given these results, the intention to create a price forecast is possible, but the complex

Test Period	Naive	Random Forest	Prophet	SARIMA	LSTM
19/Feb/18 to 07/Mar/18	0.16	0.17	0.53	0.14	0.15
18/May/18 to 11/Jun/18	0.20	0.23	0.57	0.19	0.21
08/Oct/18 to 26/Oct/18	0.17	0.16	0.35	0.20	0.16
15/Feb/19 to 06/Mar/19	0.14	0.11	0.38	0.16	0.18
27/May/19 to 11/Jun/19	0.17	0.21	0.27	0.18	0.18
09/Oct/19 to 30/Oct/19	0.08	0.12	0.24	0.10	0.07
12/Feb/20 to 06/Mar/20	0.19	0.20	0.25	0.22	0.21
26/May/20 to 11/Jun/20	0.40	0.67	0.93	0.37	0.39
13/Oct/20 to 30/Oct/20	0.16	0.16	0.19	0.18	0.17
17/Feb/21 to 05/Mar/21	0.34	0.48	0.48	0.40	0.37
25/May/21 to 11/Jun/21	0.32	0.33	0.32	0.40	0.32
12/Oct/21 to 29/Oct/21	0.18	0.22	0.23	0.27	0.19

Table 11: MAE (R$) between the prediction of the models and the test real value. Data for rose Freedom of 60 centimeters.

Test Period	Naive	Random Forest	Prophet	SARIMA	LSTM
19/Feb/18 to 07/Mar/18	16.99	18.60	53.84	15.14	16.31
18/May/18 to 11/Jun/18	13.25	14.24	32.11	12.06	13.41
08/Oct/18 to 26/Oct/18	27.28	28.64	74.67	33.16	27.19
15/Feb/19 to 06/Mar/19	12.27	9.38	29.42	13.48	15.77
27/May/19 to 11/Jun/19	8.23	9.72	12.5	8.14	8.47
09/Oct/19 to 30/Oct/19	26.75	40.27	84.94	31.96	22.63
12/Feb/20 to 06/Mar/20	22.87	21.2	29.53	26.37	23.62
26/May/20 to 11/Jun/20	10.27	17.62	23.66	9.95	10.21
13/Oct/20 to 30/Oct/20	15.81	15.02	17.67	17.44	16.28
17/Feb/21 to 05/Mar/21	20.82	26.97	26.69	23.43	22.44
25/May/21 to 11/Jun/21	9.26	9.62	9.4	11.6	9.15
12/Oct/21 to 29/Oct/21	16.73	15.38	17.65	25.57	16.95

Table 12: MAPE (%) between the prediction of the models and the test real value. Data for rose Freedom of 60 centimeters.

Test Period	Metric	Naive	Random Forest	Prophet	SARIMA	LSTM
Nov/20 to Oct/21	RMSE	0.3225	0.3532	0.5303	0.3522	0.3300
	MAE	0.23	0.24	0.42	0.26	0.24
	MAPE	17.93	17.87	34.61	20.93	18.29
Jan/19 to Dec/19	RMSE	0.1983	0.1893	0.2616	0.2178	0.199
	MAE	0.15	0.14	0.20	0.17	0.15
	MAPE	21.62	21.12	29.76	23.93	21.33

Table 13: Metrics for a 12-months time period for the rose Freedom.

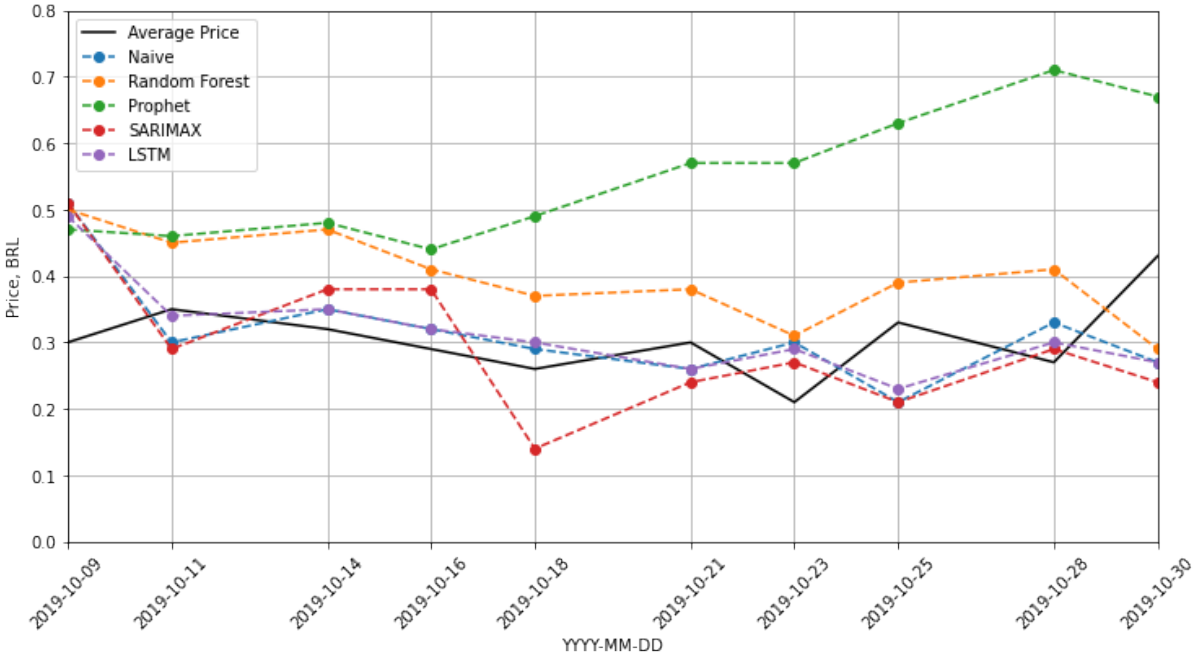

Figure 23: Price variation for the Rose Freedom 60 centimeters for the period of 09 to 30 of October 2019 including different model forests.

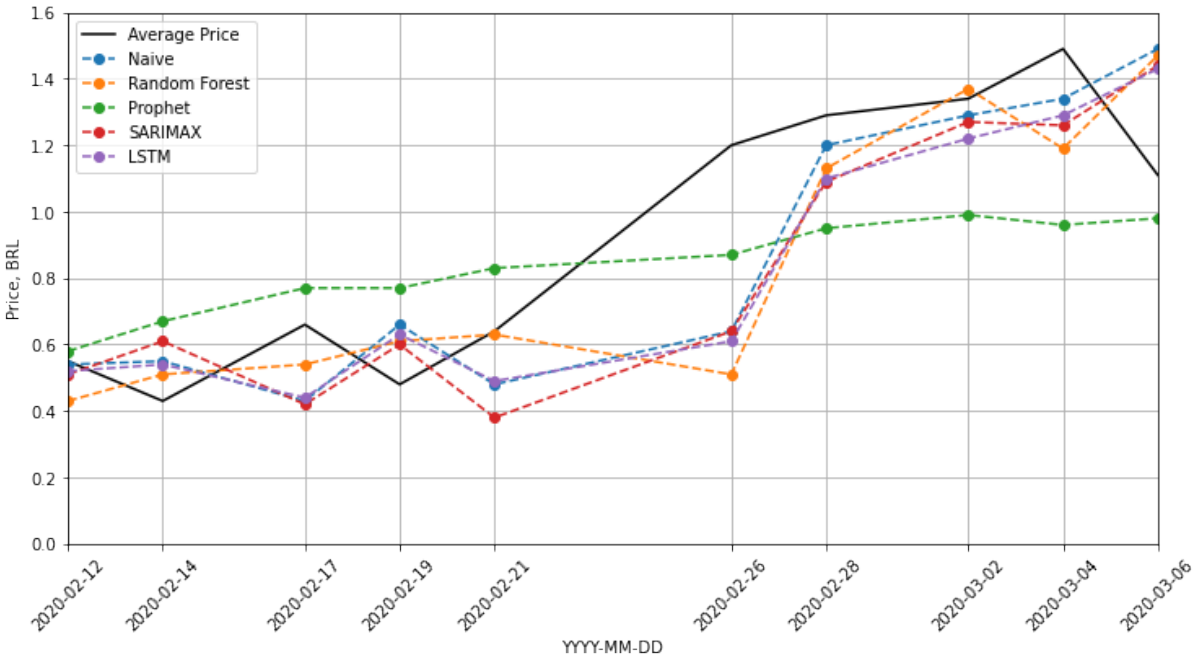

Figure 24: Price variation for the Rose Freedom 60 centimeters for the period of 02 February to 06 March 2019 including different model forests.

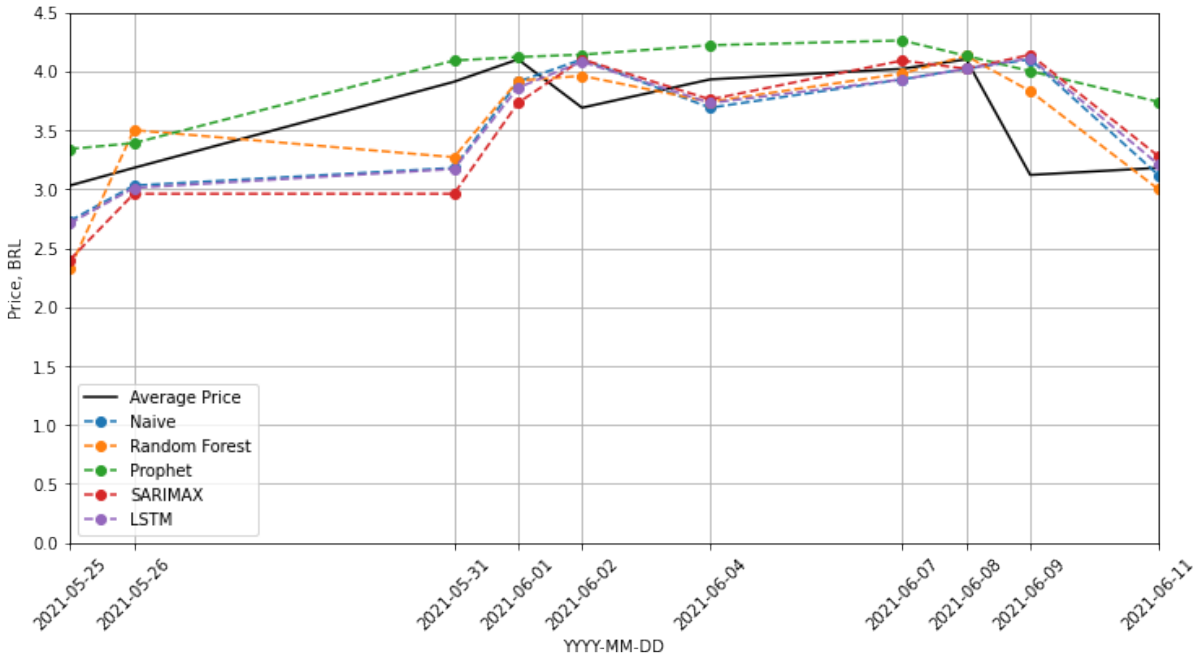

Figure 25: Price variation for the Rose Freedom 60 centimeters for the period of 25 May to 11 June 2021 including different model forests

models did not perform much better than a simple model as like the Naive Forecast. The data follows some tendencies in the long term, as presented by Figure 21, but this is true only in the monthly scenario and for some specific holidays.

Comparing the results from the different predictors, Figure 23 shows that the Random Forest is the only model that does not act only following the last day price but anticipates some price increases, like the data point from 23/Oct to 25/Oct. This can be associated with some variables that are used in this model, like the total volume sold by the grower and the expectation of volume available in the market. However, still, this better result, if compared with the other models, is not enough to fulfill the computation cost to implement this system.

5.2 Cooperatives

The goal of the cooperative is to be a reliable place for growers and buyers. In this sense, the figure of a marketplace to connect demand and supply does not have a "for-profit" vision. So, what kind of technology could a cooperative implement, to increase the benefits for itself and the growers and buyers?

This chapter will focus on presenting tendencies that are happening abroad and could be imported to Brazil, as well as analyze what happened in other supply chains. Com-

panies that are investing in sustainability are gaining space and returns over their investments in practices more aligned with the long-term. From lower interest rates of capital loans to an increasing market segment willing to pay a bit more for "green" products.

5.2.1 Sustainability

Sustainable products are becoming the norm and the digital environment for registration and certification, in the Netherlands, is trying to create transparency and accountability about sustainability efforts for many companies. Different responsibilities are shared between breeding companies, growers, distribution, and retail outlets, but to improve sustainability every player in the floriculture supply chain should collaborate. Once the cooperative is the connection between growers and buyers, it can create policies and processes to facilitate and engage a more ecological ecosystem.

If growers can demonstrate their sustainable production, they could reach the growing part of the market that only seeks to purchase certified sustainable products. To benefit from this market niche, different certification programs exist and digitalization can make it more transparent than ever. As presented before, one technology that could allow this is blockchain technology that can provide transparency and efficiency for the supply chain.

In the food chain, "adopting traceability based on private standards can lead to benefits for both the producer and the consumer" [39], so cooperatives can enjoy the benefits of the strategic choice of differentiating the production in terms of sustainable workplace and safety standards. "For the consumer the advantages concern an increase in controls, more information" [39] and better safety and quality of the products purchased.

Although implementing traceability can lead to a growth in transaction asset specificity, it also results in a decrease in the uncertainty level throughout supply chains and an increase of monitoring costs due to the specific investment necessary to implement traceability [39]. "These changes lead to new forms of governance revealing an increase in liability among the agents of the supply chain, and an enforcement of production rules, leading in general to an increase in vertical coordination" [39].

"Fairness is correlated with a higher willingness to pay", so it still represents an important value from an economic perspective [40]. "In a later study, results confirmed that consumers have altruistic preferences toward small farmers and that consumers are willing to pay a price premium if other actors in the supply chain are treated fairly" [40]. Due to the representativeness of cooperatives in the floriculture sector, those that invest in

traceability systems, using blockchain or company-owned technology, can be the pioneers and benefit from the preferences of the customers in more transparent and sustainable brands.

5.2.2 Digital Ecosystem

One of the reasons for the implementation of the new digital ecosystem in the Dutch floriculture sector is, among other things, to not be a laggard company. Digital marketplaces are disrupting the way retail works in the B2C scenario, and this is also something that could affect the flower industry. In the interview with the Product Owner from Royal FloraHolland about the short-term goals, one comment about the digital platform was that "if we don't do it for ourselves, if we don't create the platform with the growers as our grower platform, there will be a large company". This was also confirmed by the CEO of FloraHolland, Steven van Schilfgaarde, in his external communications about Floriday: "it is unique that we are determining our future together as a sector and are not waiting for others outside the sector to take the initiative" [41].

So, what is the real value of a digital ecosystem that these companies are willing to achieve? Greater value creation depends not only on the firms' ability to innovate successfully but also on accompanying changes in the firm's environment [42]. The cooperatives are in the middle of the floriculture ecosystem and their main suppliers are the growers, whose entire production needs to pass through the physical space of the cooperative. The transportation companies are enablers of this process with the cold chain logistics (in most cases) to reach the wholesalers and retail as the previous step before the acquisition of the final consumer. In this sense, innovation delivery requests external changes, "which require innovation on the part of other actors, embed the focal firm within an ecosystem of interdependent innovations" [42].

"Digital technologies present a potential to reduce trade and transaction costs, including those related to identifying and negotiating a deal, proving compliance with standards and to delivering products across borders quickly and efficiently" [43]. In this sense, there are new ways of engaging and actors participating in the trade and increasing the transparency and communication of information, automation of processes and documents, and integrating the trade logistics chain. And, once that the investment for the digital technologies is huge, doing this in a cooperative scenario means sharing the costs among the growers, which can leverage their technological level without the need of creating a tailored structure for each one of them.

6 FIRMS ACTUAL ADOPTION

Many are the technologies, plans, and possibilities to expand and invest time and effort to change the way things are done. But what is in progress along the floriculture supply chain? This section aims to share an overview of the current state of digital technology in the Brazilian floriculture supply chain, focusing on the two main cooperatives in Brazil, based on the experience of the interview with growers and understanding the services available for them.

For the growers that are part of the cooperative with both auction and direct trading, there are two alternatives to save the sales data: one is to download a text file from the online system and save this data in another worksheet (once that the data is available for the grower only up to 90 days after the transaction). The second way is to request directly to the support department by email, this way without this 90 days constraint, but upon payment of a fee. This process creates a need that each user must have his structure (e.g. using Excel worksheets, Power BI dashboards) to process the sales data, a barrier for small and medium enterprises without many employees in their sales department.

One important process in the supply chain is the flow of information about which products are leaving one company and entering to the other. Usually, this is done by outgoing and ingoing invoices, but for Veiling Holambra, since 2009, an agreement was established with the Department of Finance and Planning of Sao Paulo (Sefaz-SP) to create a special regulation with less paperwork. With these rules, a process similar to an invoice is done, with all the product specifications available in an electronic statement. In the interview with one grower, it was mentioned that this is a time-consuming process, due to the need to integrate the physical (the products in a trolley of roses can reach up to 1.800 units) to the digital (what is exactly the mix in each trolley).

About the marketplace, Veiling Holambra currently has a platform where only licensed clients are allowed to acquire the products. The technology was imported from the Netherlands, as it is possible to see in the background of the website with the Dutch API responses. In section 4.2.1 it was presented the intention of the company was to in-

tegrate their database with the wholesalers, so each one of them could offer the products directly to the final consumer in a centered way. This is already in place with Holambelo, the biggest wholesaler in the country, but the integration with other competitors could leverage their capabilities to reach their consumers. The strategy is clear, although the implementation may face some challenges due to competency gaps and the lack of digital culture for the sector. In a study developed in 2014, over 50% of the companies interviewed believe that the information deficiency and lack of professionalism are the greatest weaknesses facing the wholesale sector [44].

About the flower retail shops, after the beginning of the covid 19 pandemic, the Whatsapp application became the main marketing channel for the companies (100% utilization), followed by the social media such as Instagram (95%) and Facebook (81%) to sell better-elaborated products with greater purchasing value such as floral arrangements and cache-pots [29]. Different from the food and beverage delivery, there is not, yet, a marketplace focused on this segment in Brazil, where clients can see real photos of the products and evaluations from previous users.

7 CONCLUSIONS

Data is everywhere, although the way companies are using it deeply depends on the level of digitalization of the sector. The purpose of this work was to analyze what is happening and how could data change the way the Brazilian flower sector works. To do so, a combination of the participation in events, the performance of interviews and desk research aimed to study the case in Brazil and benchmark with other countries and industries.

From the flower industry overview, it was possible to see the relevance of the sector, once that in Brazil generated around R$ 9.5 billion (US$ 1.7 billion) in the 2020 GDP, has over 200 thousand employees and is increasing at a 9% annual growth rate.

In the digital transformation section, it was possible to understand how some technologies are being used. IoT is related to process control, addressing trackability and monitoring functions [31]. Blockchain technology is arriving now in the sector and there is not, yet, a functional use, although some researchers are looking to how they could use it to bring transparency to the sector, replace certifiers and reduce costs [33]. Finally, artificial intelligence and other algorithms are disrupting many industries, but their use is closely related to the amount of data collected and the maturity of the company, where technological companies usually have advantages because of the specialization of the jobs and functions.

The chapter on the cultural and technological issues presented the qualitative results from the interviews, separated by stakeholder. The grower's segment of this value chain is composed of many small companies and it was possible to notice that most of the decisions are taken with the expertise of a few managers. Which product to plan or how to define the price are some of the decisions that have to be addressed and where solutions involving data could add value and help the growers in the decision-making. The cooperatives are trying to keep their leadership in the commercialization by moving from the offline channels to digital marketplaces where they can have more control in the variables (e.g. price, volume), but still, due to its governance, they need to be very careful about which

new features to implement (once its is an organization of many growers, transparent is a key for the management, but it can also be understood as a barrier for innovation).

For the economic benefits, it was evaluated how a price predictor algorithm could increase the sales revenue for a grower. It was found that from 30 to 40% of the days the price asked for the direct trade was below the average price in the auction. Then, applying an algorithm that could forecast the price of the auction (to be the minimum price asked in the direct trade) would increase from 16 to 22% in the revenue for the product.

Then it was tested how to build this price predictor with different models, including ARIMA, Random Forest, LSTM, and Prophet. Although for some situations the models were performing better than the baseline defined, still there was no big improvement to sustain the argument of deploying this system. Further research could be performed including other data science algorithms and more data points, including data from the weather or tendencies happening in other products.

Still, in the economic metrics, sustainability is a perspective that is in the long-term goals for the cooperatives, looking at a niche that values more and more products that do not harm the environment. In other sectors, like the food chain, it is possible to see that some consumers would pay more for green products, so there is space for further research in what is the size of this segment and how companies should invest to reach the final consumer.

Finally, there is a sense of urgency in the sector. More and more marketplaces are disrupting different value chains, so in the cooperatives, it is possible to see the movement to not be a laggard company. Going digital and being more close to the final client that benefits cooperatives and growers. The movement of disintermediation is, yet, not in place in this sector, but also further research could model what would look like in this sector without the cooperatives and wholesalers, with the growers and final consumer more connected.

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