

A Work Project, presented as part of the requirements for the Award of a Master's degree in
Management from the Nova School of Business and Economics.

Optimizing Grocery Spending: Smartcart's Vision for Transparent and Efficient Shopping

Comprehensive Development of a Progressive Web App: A Full-Stack
Approach

Miguel Frederico Oliveira Morais (42792)

Work project carried out under the supervision of:

Hugo M. Aguiar

30/01/2024

1.1.1 Acknowledgements

We want to express our gratitude to Professor Hugo Aguiar for his invaluable guidance in supervising this thesis, and to our friends and family for their support and encouragement.

1.1.2 Abstract

This group project develops a prototype application designed to enhance consumer transparency in supermarket pricing. The core purpose of SmartCart is to address the prevalent issue of opaque pricing mechanisms.

A comprehensive market analysis identifies key features desired by consumers. Subsequently, agile software development principles guide the prototype creation, incorporating real-time data scraping algorithms. A business model and organizational strategy were developed with integration of market analysis to ensure alignment with long-term vision and operational goals.

Key findings demonstrate that SmartCart successfully provides users with timely and accurate price comparisons across multiple supermarkets. Usability tests also indicate high user satisfaction.

Keywords:

Web App, Prototype, Smart Shopping, Full-Stack Development, Business Model Canvas

This work used infrastructure and resources funded by Fundação para a Ciência e a Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209).

Table of Contents

1.1.1 Acknowledgements	2
1.1.2 Abstract	2
1.1.3 List of Figures	4
1.1.4 List of Tables	4
1.1.5 List of Abbreviations	4
1.1.6 Access to SmartCart	4
Executive Summary.....	5
2. Introduction.....	6
2.1 Problem Definition	6
3. Analysis Diagnosis.....	7
3.1 Literature Review – PESTLE Analysis	7
3.1.1 Political	7
3.1.2 Economical	8
3.1.3 Social	9
3.1.4 Technological	10
3.1.5 Environmental	10
3.1.6 Legal	11
3.2 Empirical Research	12
3.2.1 Research Instrument	12
3.2.2 Users’ Perceived Grocery Information Transparency	13
3.2.3 Identified Desirable Features and Willingness to Pay for It	14
4. Solution Development.....	14
4.1 Defining an Architecture Model	15
4.2 Backend Development.....	16
4.2.1 Extracting Information Through Web Scraping	16
4.2.2 Storing Information in a MongoDB Database	19
4.2.3 Building an API using Node.js	22
4.3 Frontend.....	24
4.3.1 Creating a User Interface in React	24
5. Future Development and Competitiveness.....	27
6. Conclusion	28
7. References	30
8. Appendices	35
8.1 Customer Survey.....	35
8.2 Customer Survey Results	36
9.3 Lean Survey	41
9.4 Lean Survey 1.0 Results	42
9.5 Lean Survey 2.0 Results	44

1.1.3 List of Figures

Figure 1 - SmartCart's Architecture	16
Figure 2 - Most used web frameworks among developers worldwide (Sourced from Statista, 2023)	24
Figure 3 - Frontend's UI Initial Draft	26

1.1.4 List of Tables

Table 1 - Deming Cycle	7
Table 2 - Product Data Model v1	17
Table 3 - Product Data Model v2	18
Table 4 - Categorization Mapping	21
Table 5 - Product Data Model v3	22

1.1.5 List of Abbreviations

Abbreviation	Definition
API	Application Programming Interface
EAN	European Article Number
E.g.	Exempli gratia (“for example”)
Et al.	Et alia (“and others”)
MVP	Minimum Viable Product
REST	Representational State Transfer
SKU	Stock Keeping Unit
UI	User Interface

1.1.6 Access to SmartCart

SmartCart’s web prototype can be accessed via the following link: <https://smartcart.work>. This URL works for both desktop and mobile devices as the platform has been optimized for both use-cases. For more convenience, it is possible to access the platform with the following QR Code:



Furthermore, accessing the following link will allow you to view a screen recording that provides a quick demonstration of the use of the application, including searching for products, comparing prices, seeing the original entry on the supermarket’s website, and adding the products to the cart: <https://drive.google.com/file/d/11GvSTLzfNuuS5QXbIiVB2gYNfhhTLsX/>

Executive Summary

In a climate of rising grocery prices and economic instability, this thesis presents SmartCart, a mobile app designed to provide real-time price transparency in the grocery sector. A PESTLE analysis within the study examines macro-environmental factors affecting grocery costs, with a focus on political, economic, and environmental elements. SmartCart emerges as a solution to the urgent demand for straightforward, accessible pricing data, enabling consumers to make well-informed choices amid economic pressures. This tool represents a significant step toward equipping shoppers with the means to navigate grocery options efficiently.

Empirical studies, including customer surveys within the Portuguese market, underscore the necessity for a platform that addresses the opaque nature of grocery pricing. Findings reveal that although price comparison is a common practice, it remains an arduous task for many. SmartCart addresses these issues by introducing functionalities such as a shopping list and a savings estimator, and it contemplates a freemium revenue model shaped by user insights. Despite the competitive landscape, SmartCart's business strategy distinguishes itself by promising notable time and cost savings, backed by solid technology and a user-oriented financial approach.

The MVP of Smartcart adopted a simplified method, utilizing web scraping to populate a MongoDB database, using a Node.js API alongside a simple yet effective React-based user interface. User feedback has been pivotal in the ongoing improvement of the platform, aimed at providing an effortless and intuitive price comparison experience for frugal shoppers.

The initial user feedback, gathered through a survey assessing functionality, usability, satisfaction, and willingness to pay, identified critical areas for improvement. This feedback, analyzed through Lean principles, directed the evolution of SmartCart, enhancing the UI and cart functionality, and led to the exploration of a freemium model. The outcomes of Lean Cycle 1.0 and subsequent user input from Lean Cycle 2.0 continue to refine the app in line with customer preferences and industry movements. Moving forward, further development is essential not only to build a competitive edge but also to validate the innovative approach and economic potential of SmartCart.

2. Introduction

In the evolving economic landscape, consumers grapple with the intricacies of grocery pricing amidst a backdrop of global market volatility. The intersection of economic shocks and unprecedented climate events has catalysed a European cost-of-living crisis, significantly impacting household finances. With grocery prices reaching new heights and wages failing to keep pace, the need for a digital tool to foster price transparency is evident (Sohag et al., 2023; Das, 2014; Barry, 2023). Price transparency, involving clear, accessible, and understandable pricing information (Soh et al, 2006) and information transparency, entailing openness and availability of comprehensive data, are crucial for informed consumer decision-making in grocery shopping (Lam et al., 2020).

This report proposes an innovative mobile application – Smartcart - designed to demystify grocery pricing, providing consumers with real-time price data to optimize spending. By analysing the macro-environmental factors through a PESTLE framework, the thesis underscores the political, economic, and environmental dimensions that influence grocery spending (Planet Tracker, 2022; Food and Agriculture Organization of the United Nations, 2023; Ulussever, 2023).

Drawing from recent studies, this work delves into the geopolitical effects on agriculture, legislative changes impacting consumer protection, and pivotal role of technology in promoting informed consumer choices (Nekmahmud, 2022; Liu et al., 2021; Barnard, 2023; Guzman, 2022). The synthesis of these insights lays the foundation for Smartcart, aimed at equipping consumers to navigate the complexities of grocery shopping in an economically strained era.

2.1 Problem Definition

This thesis scrutinizes the economic constraints impacting consumers and seeks to evaluate the deployment of a mobile application as a strategic tool to enhance price transparency and value assessment in grocery shopping, thereby enabling consumers to better adapt to the prevailing economic conditions. Therefore, the Deming Cycle (2000) (Plan, Do, Check. Act) is employed to

unravel the specific problem around the opaque grocery pricing within a complex economic environment with rising inflation:

PLAN	Identify Portugal's consumer difficulties with rising grocery costs and diminished real income; devise a digital platform for enhanced price transparency and budget management.
DO	Implement the digital solution, providing consumers with comparative pricing and economical shopping guidance.
CHECK	Assess platform effectiveness in aiding consumers' financial decisions and ability to preserve real income against inflation
ACT	Refine the tool based on consumer feedback and data insights to maximize utility and cost-saving potential, then restart the cycle for continuous improvement.

Table 1 - Deming Cycle

3. Analysis Diagnosis

3.1 Literature Review – PESTLE Analysis

To understand the dynamic and multi-faceted environment in which our SmartCart operates, a PESTLE analysis was conducted. PESTLE, an acronym for Political, Economic, Social, Technological, Legal, and Environmental factors, is a strategic framework used to systematically analyze the macro-environmental factors that may impact an organization (Wood, n.d.). This analysis helps in understanding the bigger picture of the environment a firm is operating in and assists in aligning the internal strategies with the external factors.

3.1.1 Political

According to Sohag et al. (2023), the connection between the surge in food prices and political instability is robust. The Ukrainian conflict had enduring consequences on agriculture, with the recovery of cultivable land taking up to a decade. Furthermore, numerous countries in Europe, Africa, and the Middle East heavily rely on Russian and Ukrainian food imports, leading to supply disruptions and price hikes. This situation emphasizes the need for transparent and efficient grocery spending in the face of global food market volatility. In fact, geopolitical factors and nature dependency shape global food supply and prices, directly impacting consumer grocery spending (Planet Tracker, 2022). For example, Ukraine, also known as "the breadbasket of Europe," played a

crucial role in global food markets, with its wheat and corn exports accounting for 9% and 12%, respectively (Das, 2014). This is further supported by the ongoing protests in Italy, where food prices have risen more sharply than in the US and Japan. These increases are partially attributed to the higher energy and labor costs resulting from the war (Barry, 2023). The dynamics of food protectionism and trade barriers further complicate the grocery market, making transparency in pricing and supply chains more crucial for consumers (Planet Tracker, 2022). On the other hand, the disruption in the food market was not solely linked to the Ukrainian conflict, as the COVID-19 pandemic had already caused turmoil. Historically, surges in food prices have been catalysts for protests and political unrest. Currently, the situation mirrors past crises, with food prices surpassing previous levels and affecting regions like Asia, Africa, Latin America, and Europe (Buchholz, 2022). The price spike seen with COVID-19, however, was associated with a temporary recession leading to logistical disruptions rather than severe food supply issues or permanent trade restrictions (Nekmahmud, 2022). In fact, despite food prices slowly returning to pre-war levels, they remain higher than pre-pandemic levels due to ongoing supply chain disruptions and inflation (Barry, 2023).

3.1.2 Economical

In 2023, there has been a noticeable slowdown in inflation, particularly when it comes to grocery prices. According to the Food and Agriculture Organization of the United Nations (2023), food prices saw a 4.3% increase between August 2022 and 2023, marking a significant decline compared to the 10.9% surge witnessed during the same period in 2022. However, despite this moderation in food inflation, consumers in 2023 are still contending with elevated food prices, which remain substantially higher than in 2022. It's essential to clarify that food prices are not actually decreasing; it's the rate of inflation that has decelerated (Repko & Lucas, 2023). This price increase in food significantly influences the overall Consumer Price Index, impacting not only price stability but also consumers' purchasing power. Examining the trajectory of global food prices over the years, there was a relatively stable period between 1991 and 2007. However, the situation changed in 2008, marked by the "World food crises," and the peak in food prices in 2019 was further exacerbated by

the COVID-19 pandemic (Ulussever, 2023). According to the EU Science Hub (2023), low-income countries burdened with high levels of public debt face limited capabilities to mitigate the impact of soaring food prices, resulting in food insecurities in numerous regions. Consequently, the challenge of meeting the world's food needs goes beyond safe and sustainable food production, as ensuring global food security hinges on both availability and affordability.

3.1.3 Social

In Europe, from January 2023, 60% of the household's expenditure was concentrated in three types of expenses which saw a steep increase: specifically, household, transport, and food bills (Eurostat, 2023). The ongoing cost-of-living crisis in Europe has notably influenced food prices across the continent, directly impacting grocery spending. Inflation, which was already on the rise due to the economic reopening following the pandemic, saw a jump from 2.5% in 2021 to 10% in 2022. This increase has significantly escalated the cost of essential items like food, with an average increase in food costs across Europe of 11.1%, making it increasingly difficult for households to afford necessities (Barnard, 2023). These economic pressures have disproportionately affected those with lower incomes, who allocate a more substantial portion of their earnings toward food and essential items. The lack of price transparency in the market further exacerbates this challenge, leaving consumers unable to fully understand or anticipate the fluctuations in food prices. This opacity in pricing across the EU, as unveiled by TRANSFOP European project, makes budgeting and financial planning more difficult, especially for those already facing financial difficulties (Cordis, 2014). Consequently, many households, particularly those already facing financial hardships, have been compelled to make cuts in essential expenditures, leading to severe hardships rather than merely reducing discretionary spending. Ultimately, the surge in food prices is not a transient issue; it is expected to have enduring consequences on the overall well-being and health of the individuals and families affected (Barnard, 2023).

3.1.4 Technological

In the quest to optimize grocery spending, technological advancements are proving to be a powerful tool, particularly to countermeasure the challenges of food inflation and enhancing transparency in the food supply chain. Specifically, cutting-edge tools like precision agriculture and blockchain are being harnessed to play a crucial role in this endeavor. Precision agriculture, which involves the use of information technology for better management of crop and livestock production, is a key player in reducing production costs (Boehlje, 2021). This cost reduction can potentially be passed on to consumers, contributing to more affordable grocery spending. Companies like Phytech and Syngenta are pioneering in this area, implementing advanced systems to monitor plant growth and soil conditions, thereby enabling farmers to make timely, informed decisions that improve efficiency and productivity (Marr, 2022). Blockchain emerges as a transformative force, particularly in terms of supply chain transparency (Henry et al, n.d.). It offers consumers detailed information about the origin and journey of their food products, enabling them to make informed decisions. This transparency is essential in building consumer trust and ensuring fair pricing in the market (Gaur et al, 2020). In addition to these advancements, the incorporation of technologies that directly interact with consumers in grocery settings is essential. Smart shopping carts, price comparison tools, QR codes for product information, and apps that offer real-time pricing or discounts based on supply chain efficiencies are redefining the shopping experience (Brian, 2020). These tools not only enhance consumer convenience but also play a vital role in ensuring transparent pricing.

3.1.5 Environmental

Recent climate change events have been highly influential on global food productions. Studies dating from 2007 (Lobell and Field, 2007) have shown that 30% of fluctuations on year-to-year growth per hectare were influenced by climate change. These induced unpredictable weather patterns compromise crop yields and food security. Important factors to be consider include soil erosion, water scarcity and pollinators. In 2016, there were 933 million (32.5%) urban residents living in water-

scarce regions, with China and India being the most affected countries. In 2050, it is predicted that this number grows to 2.065 billion people, which represents a 121.3% increase from 2016 (Liu et al., 2021), with suggestions that these numbers might be underestimated. Soil erosion rates have also been concerning. Recent analysis has shown that in the Midwestern United States farming has been contributing to the degradation of soil quality. The results indicate that soil thickness on hilltops has declined at an average rate of nearly 2 mm year over the past 150 years. Furthermore, natural disasters like hurricanes and floods contribute to disruptions in the food distribution process, with countries moving towards more regional production to offset potential damages, thus “driving nationalistic behavior” (Guzman, 2022). In this context, according to Edsall et al. (2013) there is a growing consumer demand for sustainable and transparently sourced food. Most consumers now perceive fresh food as more sustainable than processed food, and many are willing to pay a premium for sustainably sourced products. This trend is reshaping grocery spending, as consumers increasingly seek transparency in pricing and sourcing. Retailers are responding by focusing on fresh, locally sourced foods, which necessitates clearer communication regarding the pricing of these options (Edsall et al., 2013).

3.1.6 Legal

The European TRANSFOP project’s findings highlight the critical need for price transparency in the EU food sector, enabling consumers to make more informed decisions regarding their grocery spending (Cordis, 2014). Particularly, there have been some criticisms and concerns on the field of price transparency and competition laws in Portugal. One notable problem is the potential for price fixing. Amendments to consumer legislation and competition regimes have raised concerns from DECO (Portuguese Association for Consumer Protection) that these changes could inadvertently open up possibilities for price fixing (Martins, 2022).

In Portugal, a major case of price fixing involved four supermarkets and a manufacturer, who were collectively fined 132 million euros by the Authority of Competition for a decade-long price

collusion, affecting retail prices of various products including food items (Costa, 2022). A variety of governmental programs has been implemented on the growing concerns of price inflation. The program “IVA zero” (Zero VAT) has been implemented in April 2023 to a basket that includes 46 food items considered to be essential.

3.2 Empirical Research

A successful mobile application fulfills users' needs while offering significant benefits and advantages. Therefore, a user-centric approach is pivotal right from the outset of the app development process (Lopes et al, 2018). Customer surveys serve as vital tools to comprehend user preferences and behaviors, essential for enhancing the perceived value of the application. In the case of SmartCart, customer surveys were conducted to gain deeper insights into the grocery purchase experience within Portuguese markets.

The survey had dual objectives: firstly, to gauge whether an app designed to optimize spending on food could be perceived as a feasible solution to mitigate food inflation affecting household income. Secondly, it aimed to understand users' willingness to adopt such a tool in their daily lives. This included exploring the desired features that would effectively address the issue and assessing the willingness to pay for such a service. The valuable insights gathered from the survey formed the basis for shaping the app's target audience, mission, vision, and the primary features to implement.

3.2.1 Research Instrument

To ensure comprehensive insights, two distinct surveys were conducted—one targeting an international resident in Portugal and the other specifically for Portuguese, as cultural differences and habits could impact the outcome of the research. These surveys were distributed using Google Forms, yielding a combined total of 219 responses. Although the sample size might not offer statistically conclusive outcomes, these primary findings will be complemented by additional insights obtained throughout the app development process, contributing to a more thorough understanding of the target audience needs and preferences. In terms of demographics, most respondents in both surveys

targeting the international audience were women. Moreover, the samples together showcase a mix of students and full-time workers with a considerable level of education, predominantly residing in urban areas.

3.2.2 Users' Perceived Grocery Information Transparency

50% of the participants prefer to buy regular branded products when grocery shopping and an overwhelming 88% of surveyed users noted encountering price disparities among identical products across different supermarkets. This observation underscores the lack of transparency in grocery pricing. While consumers do recognize the variations in pricing, they experience challenges in identifying the most cost-effective products. However, about 50% of respondents in both surveys expressed neutrality regarding the ease of finding the most cost-effective groceries. This neutrality may suggest a lack of clarity or uncertainty among participants when navigating prices or seeking the best deals. It hints at a mixed or uncertain experience among the surveyed individuals, neither distinctly finding it easy nor particularly challenging to determine the most cost-effective products during their shopping experiences.

Results show that 60% of the respondents compare prices before their grocery shopping trips. They utilize various methods, including internet searches and advertising brochures, but also visiting different supermarkets, and memorizing prices. However, these price comparison tools are deemed arduous, time-consuming, and unsustainable for many users, highlighting ongoing challenges in navigating grocery prices despite their efforts to find the best deals. This underscores the necessity for a technology-based comparison solution, especially considering that 60% of the respondents viewed this tool as extremely useful. Notably, only one vote was registered in the "not useful" category, emphasizing the widespread recognition of the need for a more efficient means of comparison.

3.2.3 Identified Desirable Features and Willingness to Pay for It

Both Portuguese and International respondents showed a keen interest in specific app features. Specifically, they highly valued having a shopping list (60%) and a savings calculator (50%) integrated into the app. Additionally, the history of product pricing appealed to both groups. However, while the promotion aggregator was significantly preferred by the Portuguese users (53%), it didn't garner as much enthusiasm among international respondents (41%).

Interestingly, when it came to the payment of these features, a considerable percentage of respondents across both groups indicated an unwillingness to pay (70%). This suggests that relying on user payments for these features might not be feasible. The reason behind this could be that the app primarily targets individuals seeking to save money, and any additional costs might conflict with their primary goal. However, a small portion of respondents in both surveys (25%) were open to paying a one-time installation fee for these features, indicating the possibility of implementing a freemium model. This model could cater to users willing to pay for additional features, potentially generating supplementary revenue for the app.

4. Solution Development

Because of the complex challenges that developing extensive web applications presents, the primary objective was the development of a Minimum Viable Product (MVP). This MVP represented a basic version of the application, intentionally simplistic yet effectively encapsulating the SmartCart's core functionality. The initial phase of the development process involved the selective gathering of information from a limited range of products in order to confirm the feasibility of our solution. This approach was adopted to circumvent the complexities associated with handling the extensive product catalogues of supermarkets.

Furthermore, to simplify the process at this stage, the focus was narrowed down to products from a singular category within the "Food" section, thereby avoiding the intricacies of product

categorization that each supermarket performs differently. A crucial step in the project was establishing an appropriate architecture model. Following this, the development of each foundational component was undertaken in a sequential manner, beginning with data extraction (web scraping), then progressing to the backend, and finally to the frontend.

Upon completing the initial version of the solution, the emphasis shifted towards gathering extensive user feedback. This feedback was instrumental in facilitating multiple iterations of the product, each iteration aiming to enhance user satisfaction and improve the overall user experience.

4.1 Defining an Architecture Model

The architecture of the project plays a crucial role in structuring and organizing the various components effectively. At the heart of this project lie the main objectives: to scrape data from supermarkets, store this data in a database, enable structured extraction of the data, and present it through an elegantly designed frontend for user interaction.

The backend serves as the application's backbone, handling data processing, storage, and retrieval. It's where the logic of the application resides and where interactions with the database occur. On the other hand, the frontend is the interface through which users interact. It's crucial for providing a user-friendly experience, translating backend functionalities into a visually appealing and intuitive format.

Additionally, understanding the role of an API (Application Programming Interface) is essential. An API acts as a mediator between the frontend and backend, allowing them to communicate effectively. It enables the frontend to request specific data from the backend, which in turn retrieves this data from the database, ensuring a seamless flow of information throughout the application.

Figure 1 illustrates the architectural model of our platform, detailing the sequence of interactions across various components—frontend, backend, and database—in response to a user request. It also

highlights the continuous updating of pricing data, a critical process essential for maintaining the platform's full functionality.

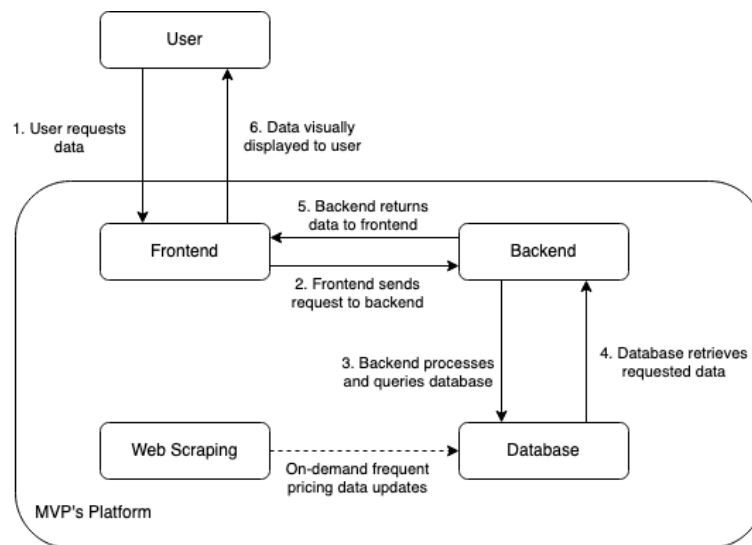


Figure 1 - SmartCart's Architecture

4.2 Backend Development

4.2.1 Extracting Information Through Web Scraping

The focus was on developing a solution that fundamentally relied on constructing a comprehensive database encompassing the pricing details of products across various supermarkets. The initial step involved a thorough exploration of the websites of these supermarkets. Given the extensive range of products, with supermarkets having tens of thousands of individual items, the development strategically commenced by building a preliminary database focusing solely on products inside a single category.

This endeavor employed a technique known as web scraping. In essence, web scraping is the automated process of extracting data from websites. This methodology was applied uniformly across all supermarkets included in the survey, with a particular emphasis on those most frequented by consumers.

One of the primary considerations was determining the specific information to extract for each product. The fundamental attribute, naturally, was the price. However, it was equally critical to obtain extra information from each product, like the product's title and image. The extracted information was meticulously organized following the structure outlined in our data model, represented in Table 2.

Field Name	Description	Type
title	Name of the product as described in the product's page	string
price.date	Time in which the price of the product was scraped	timestamp
price.discount	<i>True</i> if the product is on sale	boolean
price.old_price	The price at which the product could be bought before promotion. Null if the product is not on sale	float
price.current_price	The price at which the product can be currently bought	float
link	URL of the product's page	string
image	URL of the product's image	string

Table 2 - Product Data Model v1

The first considerable challenge arose during the initial phase of data collection. It was discovered that the solution lacked a crucial functionality: the ability to link the different prices across multiple supermarkets. This issue stemmed from the fact that each product in the model was identified by an Internal Id, unique to each supermarket. Consequently, there was no universal identifier to facilitate cross-supermarket comparisons.

In response to this challenge, efforts were put into further research, and results uncovered that supermarkets assign unique identifiers to products, known as Stock Keeping Units (SKUs). Each supermarket utilizes a distinct numbering scheme for its SKUs. However, it was also identified the existence of the European Article Number (EAN), a standardized barcode used universally in retail chains. The EAN presented itself as the ideal solution to the comparability dilemma.

With this new insight in mind, data collection through web scraping was resumed, now with the added objective of extracting the EANs of products. However, another obstacle quickly emerged: not all supermarkets displayed the EAN on their websites. This limitation narrowed the focus to three supermarkets: Continente, Pingo Doce, and El Corte Ingles. These retailers were not only amongst those most preferred by the survey respondents but also provided the necessary EAN data. Consequently, the product data model was revised to incorporate this newfound element, as depicted in Table 3.

Field Name	Description	Type
title	Name of the product as described in the product's page	string
price.date	Time in which the price of the product was scraped	timestamp
price.discount	<i>True</i> if the product is on sale	boolean
price.old_price	The price at which the product could be bought before promotion. Null if the product is not on sale	float
price.current_price	The price at which the product can be bought	float
link	URL of the product's page	string
image	URL of the product's image	string
internal_id	ID used by specific supermarket	string
ean	Universal identifier of the product	string

Table 3 - Product Data Model v2

Selecting the most suitable programming language for the web scraping task was another critical decision. Several popular languages typically employed for such purposes were evaluated, including Node.js (JavaScript), Ruby, Java, and Python. After careful consideration, Python was decided to be the optimal choice for this platform's development. The decision was influenced by Python's extensive array of libraries specifically designed for web scraping, its user-friendly nature, and the robust support available within its community.

Following the selection of Python, the initial database was successfully constructed, thus validating the feasibility of our project. The initial data, however, was stored in a simplistic format, with around a thousand products. Therefore, the subsequent phase of the project involved devising a strategy for efficiently managing and storing the data retrieved. This step was crucial for enhancing the utility of the database and ensuring its scalability for future expansion and application, considering that the next step was to consolidate the information for all the thousands of products in each supermarket.

4.2.2 Storing Information in a MongoDB Database

There was an aim to develop a comprehensive database solution that required significant flexibility due to the evolving nature of SmartCart's requirements. This necessitated a careful selection of technologies at each stage of the development process. Python was the best language for web scraping, given its efficacy and robustness in data extraction. Following the successful scraping of data, the next pivotal decision was choosing the appropriate database technology to store this information.

Initially, various low-code solutions were considered, including an implementation in OutSystems, due to the simplicity and rapid development capabilities of the platform. However, a certain degree of customization soon revealed itself fundamental for the development by requiring a level of control higher than what low-code platforms typically offer. This led to the exploration of other database technologies, evaluating each for its suitability to the platform's needs.

Considerations included several database systems, including MongoDB, MySQL, PostgreSQL, SQLite, and Cassandra. Each of these databases has its own set of features and advantages. For instance, MySQL is known for its reliability and widespread use, PostgreSQL offers advanced features and extensibility, SQLite provides a lightweight solution without the need for a separate server, and Cassandra excels in handling large volumes of data across distributed systems (Arsenault, 2023).

However, after thorough deliberation, MongoDB emerged as the most fitting. There were several compelling reasons for this decision:

1. **Schema Flexibility:** MongoDB's schema-less nature was a significant advantage. It allowed us to easily modify the data structure as our project evolved without the need for extensive database restructuring.
2. **Scalability:** MongoDB is designed for scalability, with support for replication. This was crucial for accommodating the potentially large and growing dataset resulting from our web scraping activities.
3. **Document-Oriented Storage:** The JSON-like document format used by MongoDB was particularly well-suited for storing the varied and nested data extracted from different websites.
4. **Agile Data Handling:** MongoDB's powerful querying capabilities and agile data handling made it an ideal choice for dealing with the diverse and complex data sets anticipated.

Having settled on MongoDB, efforts were turned to refining the data model, particularly in the context of product categories. Each supermarket had its unique way of organizing products, which posed a challenge for standardization in the database.

To address this, a strategy was put in place to create a new, unified list of categories. Each supermarket's specific categories were mapped to a new custom list, ensuring consistency and ease of comparison across different sources. Table 4 presents a detailed mapping, where the far-right column compiles an exhaustive list of all categories available in the app, complete with their respective IDs. Additionally, it indicates which specific categories from each supermarket are encompassed within these SmartCart categories.

Continente	Pingo Doce	El Corte Ingles	SmartCart	
Name	Name	Name	Name	Id

Bebe	Infantil	Bebes	Bebe	0
Casa, Mobiliario, Decoracao	Casa		Casa, Jardim e Auto	1
Jardim, Bricolage e Auto				
Beleza e Higiene	Higiene e Beleza	Cuidado Pessoal	Beleza e Higiene Pessoal	2
Animais	Animais		Animais	3
Bebidas e Garrafeira	Bebidas	Bebidas	Bebidas	4
Limpeza		Limpeza e Menage	Limpeza	5
Bio e Escolhas Alimentares	Alternativas Alimentares	Bio & Natural Nutricao e Bem Estar	Bio e Alimentacao Alternativa	6
Livraria e Papelaria Brinquedos e Jogos	Bazar		Brinquedos, Papelaria e Livraria	7
		Frescos	Alimentacao	8
Laticinios e Ovos	Leite, Ovos e Natas Frigorifico	Lacteos	Lacticianios e Ovos	8.1
Congelados	Congelados	Congelados	Congelados	8.2
Charcutaria e Queijos	Charcutaria	Frescos - Charcutaria e Queijos	Charcutaria e Queijos	8.3
Frutas e Legumes	Frutas e Legumes	Frescos - Frutas e Legumes	Frutas e Legumes	8.4
Padaria e Pastelaria	Padaria e Pastelaria	Frescos - Padaria e Pastelaria	Padaria e Pastelaria	8.5
Peixaria e Talho	Peixaria Talho	Frescos - Peixaria + Talho	Peixaria e Talho	8.6
Mercearia	Mercearia	Mercearia	Mercearia	8.7
Refeicoes Faceis	Take Away	Frescos - Pratos Preparados	Take Away e Outros	8.8
Desporto, Bagagens, Roupa			Outro	9

Table 4 - Categorization Mapping

Following this categorization strategy, the data model was updated to incorporate these new standardized categories, as illustrated in Table 5. This final iteration of the data model was more comprehensive and aligned with the goal of creating a versatile and user-friendly database. It allowed to systematically organize and store data in a way that facilitated easy access and analysis, regardless of the original categorization used by each supermarket.

Field Name	Description	Type
title	Name of the product as described in the product's page	string
price.date	Time in which the price of the product was scraped	timestamp

price.discount	<i>True</i> if the product is on sale	boolean
price.old_price	The price at which the product could be bought before promotion. Null if the product is not on sale	float
price.current_price	The price at which the product can be bought	float
link	URL of the product's page	string
image	URL of the product's image	string
internal_id	ID used by specific supermarket	string
ean	Universal identifier of the product	string
category.original	ID used by specific supermarket to reference category	string
category.new	ID used by our app to reference category	string

Table 5 - Product Data Model v3

In conclusion, the selection of MongoDB and the subsequent refinement of the data model were critical steps for the development. These decisions not only addressed the immediate technical requirements but also laid a strong foundation for the future scalability and flexibility of the database. This meticulous approach to technology selection and data modeling was instrumental in building a robust and effective solution tailored to the specific challenges of SmartCart.

4.2.3 Building an API using Node.js

Upon successfully gathering the necessary data, the next objective was to devise an effective method for delivering this data to clients across various platforms, including web and mobile. This crucial phase entailed selecting an appropriate technology for our backend infrastructure.

The delivery of information is done through a REST API. An API, or Application Programming Interface, is a set of rules and protocols for building and interacting with software applications. It acts as an intermediary, allowing different software systems to communicate with each other. A REST API, or Representational State Transfer API, is a specific type of API that adheres to the principles of REST, a software architectural style. REST APIs are stateless and use HTTP requests to GET,

PUT, POST, and DELETE data. They are widely used for their simplicity, scalability, and flexibility, making them ideal for web services that need to interact with a variety of clients, including browsers and mobile devices.

In the process of selecting a language for backend development, various options were considered. Each language and its associated frameworks offer different advantages, and considerations included, for example, Python with Django or Flask, Ruby with Ruby on Rails, PHP, and Java with Spring Boot. However, after careful evaluation, Node.js was chosen for the backend development. This decision was influenced by several factors:

1. **Integration with MongoDB:** Node.js integrates seamlessly with MongoDB, which was already chosen for the database. This integration facilitates efficient data handling and retrieval, crucial for SmartCart's performance (MongoDB, n.d.).
2. **Asynchronous and Event-Driven:** Node.js operates on an asynchronous, event-driven model, which is highly efficient for handling concurrent requests, making it well-suited for high traffic environments and data requests.
3. **Community and Ecosystem:** Node.js has a robust and active community, providing a wealth of libraries and tools. This ecosystem allows for rapid development and problem-solving support, which is invaluable in a development environment.
4. **Performance:** Node.js is known for its high performance, especially in handling I/O-intensive tasks, which is a critical requirement for our REST API (Kursova, 2017).
5. **High Adoption:** Node.js is the most popular, in terms of usage, web framework among developers worldwide (Statista, 2023), as depicted in Figure 2.

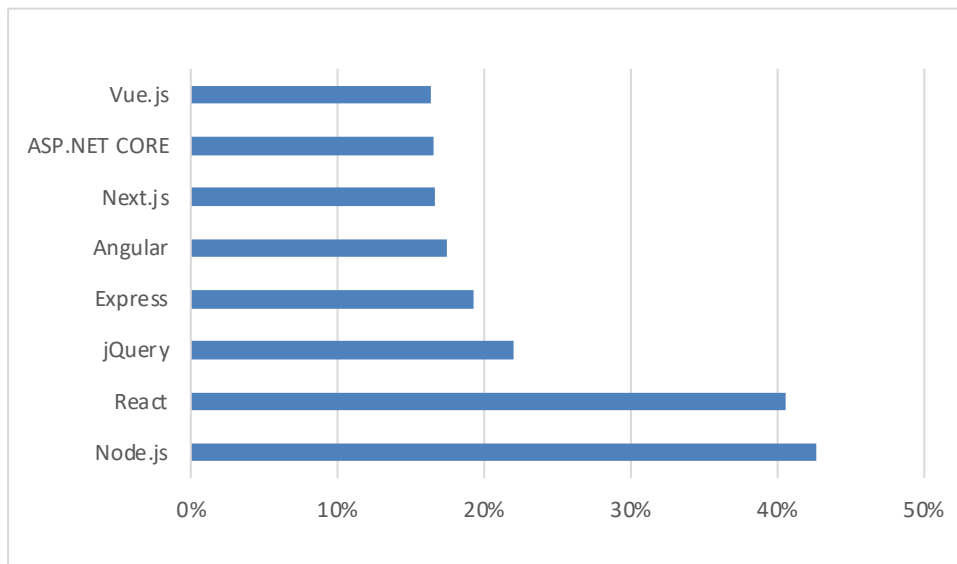


Figure 2 - Most used web frameworks among developers worldwide (Sourced from Statista, 2023)

In summary, the selection of Node.js for our backend, coupled with the implementation of a REST API, was a strategic decision that underpinned the successful delivery of our service across multiple client platforms. This approach not only catered to our immediate technical requirements but also provided the scalability and flexibility needed for future enhancements and growth of the application.

4.3 Frontend

4.3.1 Creating a User Interface in React

In the development of the MVP, a web platform was decided to be the primary medium for deployment. This decision was heavily influenced by the results of the preliminary survey, which indicated a significant preference among users for checking prices online before shopping. Specifically, a notable percentage of survey respondents reported using web platforms for this purpose, thereby validating this choice. However, with an eye toward future expansion and adaptability, the choice to implement this solution using React was made. This decision was based on several key factors:

1. **Integration with NodeJS:** React is known for its seamless integration with NodeJS, facilitating a robust and efficient development environment.
2. **Portability to Mobile Platforms:** Although our initial focus was on a web-based solution, React offers excellent portability to mobile platforms. This foresight was crucial, considering the growing prevalence of mobile usage.
3. **Mobile Responsiveness:** In the interim, before a dedicated mobile application could be developed, it was possible to make the website more mobile-friendly, thus catering to users who prefer accessing the platform via their smartphones.

Adding to that, as previously depicted in Figure 2, the second most used framework by developers worldwide in 2023 is React, enabling the reliance on online materials provided by a large community of developers, helping tackle any issues that will result from the frontend development.

After the selection of the technology stack, a basic frontend that showcases the capabilities of the platform was developed. Upon reflection, the essential functionalities of the first version that needed to be included were:

- The ability to search for products by their name.
- The ability to see the supermarket where the product is the cheapest, as well as the prices for other supermarkets.
- The ability to add products to a cart and get an overview (with products selected in the supermarket where the price is lower).
- The ability to search for categories.

This preliminary interface, albeit rudimentary, was pivotal in demonstrating the practical application of the solution, particularly its price comparison feature. However, recognizing the importance of user feedback in refining the product, it was decided that it was essential to gauge user responses.

Figure 3 represents an initial and rudimentary sketch that was created to establish a foundation for the web development of SmartCart.

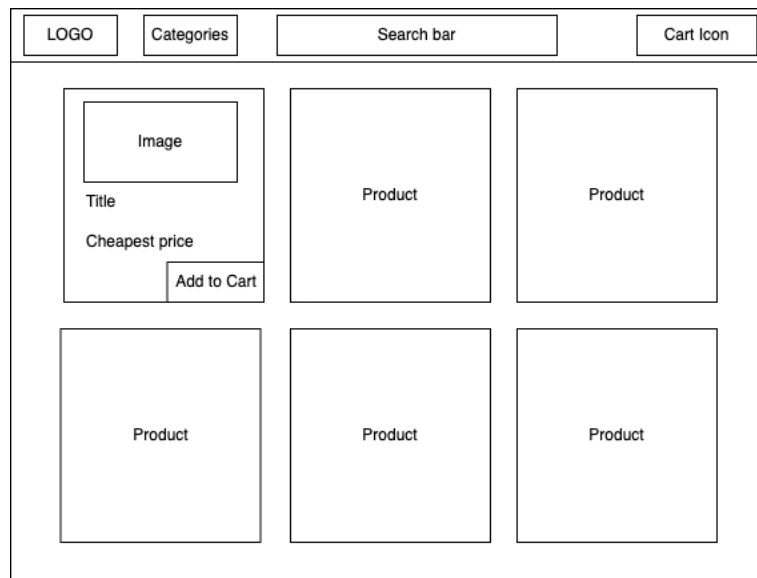


Figure 3 - Frontend's UI Initial Draft

To this end, a focused usability test was conducted with a select group of users. This testing phase aimed to rigorously assess various aspects of the product, such as usability, quality, and overall user experience. Feedback from this small yet representative sample of users was crucial in identifying areas for improvement. It provided valuable insights into user preferences, pain points, and the overall functionality of the platform.

This iterative process of development, testing, and refinement was integral to SmartCart's philosophy. It not only allowed to build a product that was closely aligned with user needs but also laid a solid foundation for future enhancements. By prioritizing user feedback and staying adaptable to technological advancements, an insurance that our solution remained relevant and user-centric was created, both in the present and in the foreseeable future.

5. Future Development and Competitiveness

SmartCart's strategic development has methodically established points of parity and difference to distinguish itself within the competitive field of grocery price comparison apps in Portugal.

The foundational *points of parity* lie in the *categorical* credibility and the core functionality of the app (Keller et al., 2002) namely, the price comparison feature. This essential service provides the basis for SmartCart's entry into the market, matching the basic offerings of competitors like Super Save. In the *competitive* domain, SmartCart achieves additional points of parity by mirroring Super Save's value-added services (Keller et al., 2002) such as updating information daily with regards to the leading supermarkets like Continente, Pingo Doce, and El Corte Ingles. Moreover, strategic partnerships, that the competitor Super Save's is planning with Lidl, will be also sought to broaden the range of supermarkets within the app and match with Super Save's differentiation points. These aspects reinforce SmartCart's position as a credible and reliable player in the market, ensuring users have access to the latest pricing information and a wide range of shopping options. By matching and sometimes surpassing industry standards in these key areas, SmartCart achieves **vertical differentiation**—essentially setting a higher bar for quality and service in the app's category (Tremblay & Polasky, 2002).

The *points of difference* emerge from user-driven feedback gathered during Lean Cycle 1 and 2, which have informed the app's unique offerings (Keller et al., 2002). Specifically, building on the progress made and insights gained from Lean Cycle 1, features such as personalizing user experience with saved favourite supermarkets or product preferences, clearer indications of item availability, and the anticipated 'click and collect' option are earmarked for future releases. These developments are not only aimed at enhancing user convenience but also at expanding the app's functionality in a way that directly correlates with users' willingness to pay, thus creating new avenues for revenue. With the feedback from Lean Cycle 2, the development trajectory will include advanced location-based services, employing GPS technology to alert users to nearby deals, marrying the convenience of

location with cost-effectiveness. The user interface will undergo a significant overhaul to make the price comparison process more intuitive, potentially reinstating clearer pricing features from earlier versions and integrating more effective visual navigation aids. These enhancements are not only geared towards improving user satisfaction but also serve as key differentiators that set Smartcart apart from its competitors. By focusing on these points of difference, Smartcart is developing a **horizontal differentiation** strategy that emphasizes the functional aspects of the app, aligning closely with the evolving demands of the market achieving a *competitive advantage* (Tremblay & Polasky, 2002). Ultimately, a multifaceted monetization strategy will be implemented, exploring a freemium model complemented by carefully curated in-app advertising, ensuring that advertisements enhance rather than interrupt the user experience. This approach will seek to balance profitability with user satisfaction, providing value at every tier of service offered.

The path forward for the app is one of deliberate and strategic enhancement, where user feedback and competitive analysis inform each step. The Lean principle of 'Pursue Perfection' underpins these efforts, ensuring that each iteration brings us closer to an ideal solution that resonates with users and stands out in the digital marketplace. These strategic enhancements are designed to propel SmartCart beyond parity with Super Save, offering an innovative, user-focused shopping tool that excels in both functionality and user experience.

6. Conclusion

The primary objective of this thesis was to delve into the dynamics of how price transparency, along with various other factors, are adversely affecting the grocery shopping experiences of consumers in Portugal. This investigation was underpinned by a comprehensive review of the existing literature and an empirical research approach. The findings from this review and research were quite illuminating, presenting a detailed list of consumer challenges. There was substantial evidence

indicating that these problems were significant and necessitated immediate attention and the development of effective solutions.

In response to the challenges identified, a strategic approach was adopted to devise a solution. This involved the creation of a MVP, utilizing the principles of the Lean methodology. This methodology emphasizes rapid prototyping, a customer-centric approach, and iterative product development based on user feedback. The application of this methodology facilitated the evolution of the MVP, culminating in a preliminary draft of a potential solution. This initial version of the solution shows promises for further refinement and enhancement, aiming to more comprehensively address and alleviate the problems faced by grocery shoppers in Portugal.

However, as the project progressed, it became evident that certain areas required additional focus and development. A critical aspect that necessitated further exploration was the expansion and monetization strategy of the platform. During the research phase, one of the salient challenges identified was the consumers' general hesitance to pay for such services. This reluctance poses a significant barrier to the platform's sustainability and success. Therefore, future efforts need to be directed towards developing a viable business model that aligns with consumer preferences and willingness to pay. This model should strive to ensure the platform's financial sustainability while continuing to address and improve the grocery shopping experience effectively. In summary, this report highlights the potential for innovative solutions in enhancing grocery shopping experiences but also underscores the need for sustainable business strategies to ensure these solutions' long-term viability and impact.

7. References

- A. Ahmad, K. Li, C. Feng, S. M. Asim, A. Yousif and S. Ge, "An Empirical Study of Investigating Mobile Applications Development Challenges," in IEEE Access, vol. 6, pp. 17711-17728, 2018, doi: 10.1109/ACCESS.2018.2818724.
- Amin, A., Arefin, S., Hossain, I., Islam, R., Sultana, N., Hossain, N. (2021) Evaluating the Determinants of Customers' Mobile Grocery Shopping Application (MGSA) Adoption during COVID-19 Pandemic. Journal of Global Marketing, Vol. 35, No. 3.
- Aoki, K.; Obeng, E.; Borders, A. L.; Lester, D. H. (2019) Can brand experience increase customer contribution: How to create effective sustainable touchpoints with customers? Journal of Global Scholars of Marketing Science, Vol. 29; No. 1.
- Amaral, J. V. and Guerreiro, R. (2019) Factors explaining a cost-based pricing essence. Journal of Business & Industrial Marketing, Vol. 34, No. 8.
- Arsenault, C. (2023) The Pros and Cons of 8 Popular Databases. Keycdn.
<https://www.keycdn.com/blog/popular-databases>.
- Askalidis, G. (2018) The Impact of Large Scale Promotions on the Sales and Ratings of Mobile Apps: Evidence from Apple's App Store.
- Barnard, H. (2023) The cost-of-living crisis and poverty in Europe. Progressive Yearbook 2023, pp. 99-105. Publisher: Foundation for European Progressive Studies.
- Barry, C. (2023) Food prices are squeezing Europe. Now Italians are calling for a pasta protest. Online: <https://apnews.com/article/food-prices-europe-inflation-pasta-strike-386319f11769d4070d5fa34d02b000dd>. Last Accessed: 01/10/2023.
- Bidargaddi, N., Pituch, T., Maaieh, H., Short, C., Strecher, V. (2018) Predicting which type of push notification content motivates users to engage in a self-monitoring app. Preventive Medicine Reports, Vol. 11, pp. 286-273.
- Boehlje, M. (2021) The value of data/information and the payoff of precision farming. Purdue University. <https://ag.purdue.edu/commercialag/home/resource/2021/02/the-value-of-data-information-and-the-payoff-of-precision-farming/>.
- Brian, M. (2020). Amazon's smart shopping cart knows what you're buying. Online: <https://www.engadget.com/amazon-dash-cart-smart-sensor-camera-shopping-080416665.html> (Last Accessed: 01/12/20223).
- Buchholz, K. (2022) The Link Between Soaring Food Prices and Political Instability. Online: <https://www.statista.com/chart/27110/food-prices-political-instability/>. Last Accessed: 01/10/2023.
- Carpenter, J. M., & Moore, M.: 2006, Consumer demographics, store attributes, and retail format choice in the US grocery market. International Journal of Retail & Distribution Management, 34(6), 434-452.

Ceci, L. (2023) Number of apps available in leading app stores as of 3rd quarter 2022. Online: <https://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/>. (Last Accessed: 10/11/2023).

Costa, M. (2022) Quatro supermercados e um fabricante multados em 132 milhões por concertação de preços. Online: <https://www.dn.pt/dinheiro/quatro-supermercados-e-um-fabricante-multados-em-132-milhoes-por-concertacao-de-precos-14927626.html> (Last Accessed: 16/11/2023).

Das, B. K. (2014) Ukraine: Stand-off Threatens Europe Breadbasket. *International Journal of Social Science*: 3(3): 375-381.

DEMING CYCLE (PDCA). (2000). In: Swamidass, P.M. (eds) *Encyclopedia of Production*

Edsall D. et al (n.d.) Fresh food at the intersection of trust and transparency. Deloitte Insights. <https://www2.deloitte.com/xe/en/insights/industry/retail-distribution/fresh-food-trends-produce-traceability-concerns.html>

EU Science Hub (2023) Global Food Crises – mid-year update 2023: hunger and malnutrition levels remain alarmingly high. Online: https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/global-food-crises-mid-year-update-2023-2023-09-15_en. Last accessed: 10/10/2023

Eurostat (2022) E-commerce statistics for individuals. Online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=E-commerce_statistics_for_individuals#Eshopping:_largest_increase_among_young_internet_users. (Last Accessed: 1/11/2023)

Eurostat (2023) Housing, food & transport: 61% of households' budgets. Online: <https://ec.europa.eu/eurostat/web/products-eurostat-news/w/DDN-20230327-2>. Last Accessed: 20/10/2023

F. Vannieuwenborg, L. Mainil, S. Verbrugge, M. Pickavet and D. Colle, "Business models for the mobile application market from a developer's viewpoint," 2012 16th International Conference on Intelligence in Next Generation Networks, Berlin, Germany, 2012, pp. 171-178, doi: 10.1109/ICIN.2012.6376022.

FAO (2023) World Food Situation. Online: <https://www.fao.org/worldfoodsituation/fao-food-price-index/en> Last Accessed: 10/10/2023

Gaur, V. et al (2020) Building a transparent supply chain. *Harvard Business Review*. <https://hbr.org/2020/05/building-a-transparent-supply-chain>

Guzman, D. C. (2022) Climate Crisis Is Driving Food Nationalism and Changing Global Trade. Online: <https://time.com/6195984/climate-change-food-security-trade/>. (Last Accessed: 12/10/2023)

Harris, A. M., Brookshire, R., Chin, G. A. (2016) Identifying factors influencing consumers' intent to install mobile applications. *International Journal of Information Management*, Vol. 36, No. 3, pp. 441-450.

He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Jingwei, L., Bryan, A. B. (2021) Future global urban water scarcity and potential solutions. *Nat Commun* 12, 4667.

Henry, W. et al (n.d.) Using blockchain to drive supply chain transparency. Deloitte. <https://www2.deloitte.com/us/en/pages/operations/articles/blockchain-supply-chain-innovation.html>

Husain, A. (2022) The Ukraine War is Deepening Global Food Insecurity — What Can Be Done?. Online: <https://www.usip.org/publications/2022/05/ukraine-war-deepening-global-food-insecurity-what-can-be-done> (Last Accessed: 10/12/2023)

IGD (2023) New IGD forecast – food price inflation to ease off, slowly. Online: <https://www.igd.com/articles/article-viewer/t/new-igd-forecast--food-price-inflation-to-ease-off-slowly/i/30895>. Last Accessed: 22/10/2023

Joorabchi, M. E.; Mesbah, A.; and Kruchten, P. "Real Challenges in Mobile App Development," 2013 ACM / IEEE International Symposium on Empirical Software Engineering and Measurement, Baltimore, MD, USA, 2013, pp. 15-24, doi: 10.1109/ESEM.2013.9.

Kalaitzandonakes, M., B. Ellison and J. Coppess. "How Us Consumers Say They're Coping With Rising Food Prices: Results From the Gardner Food and Agricultural Policy Survey." *farmdoc daily* (13):10, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign

Keller, K.; Sternthal, B.; Tybout, A. (2002) Three Questions You need to Ask About Your Brand. Online: <https://hbr.org/2002/09/three-questions-you-need-to-ask-about-your-brand> (Last Accessed: 12/12/2023)

Kursova, D. (2017). What exactly is Node.js and why should you use it? FreeCodeCamp. <https://www.freecodecamp.org/news/what-exactly-is-node-js-and-why-should-you-use-it-8043a3624e3c/>

Lam, T., Heales, J., Hartley, N., Hodgkinson, C. (2020) Consumer Trust in Food Safety Requires Information Transparency. *Australasian Journal of Information Systems*, Vol. 24.

Liker, J. (2004), *The Toyota Way*, Esensi, McGraw-Hill, New York, NY.

Lloyds Bank (2023) The distribution network in Portugal. Online: <https://www.lloydsbanktrade.com/en/market-potential/portugal/distribution>. (Last Accessed: 20/11/2023)

Lobell, B. D. and Field, B. C. (2007) Global scale climate–crop yield relationships and the impacts of recent warming. *Environ. Res. Lett.* 2 014002

Lopes, A.; Valentim, N.; Moraes, B.; Zilse, R.; Conte, T. (2018) Applying user-centered techniques to analyze and design a mobile application. Journal of Software Engineering Research and Development, No. 5.

Marr, B. (2022) The Biggest Future Trends In Agriculture And Food Production. Online: <https://www.forbes.com/sites/bernardmarr/2022/01/28/the-biggest-future-trends-in-agriculture-and-food-production/?sh=526f3076107a> (Last Accessed: 12/10/2023)

Martins, P. (2022) New competition rules may allow price fixing. The Portugal News. <https://www.theportugalnews.com/news/2022-01-10/new-competition-rules-may-allow-price-fixing/64535>

McCorriston S. (2013) Final report summary – TRANSFOP (Transparency of Food Pricing). Europa.eu. <https://cordis.europa.eu/project/id/265601/reporting>

Medina, A. (2021) The Portuguese Food Retail Sector. United States Department of Agriculture Foreign Agricultural Service. Online: https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=The%20Portuguese%20Food%20Retail%20Sector_Madrid_Portugal_03-11-2021. (Last Accessed: 20/11/2023)

MongoDB with Node.js (n.d.). MongoDB. <https://www.mongodb.com/languages/mongodb-with-nodejs>

Nekmahmud, M. (2022) Food consumption behavior, food supply chain disruption, and food security crisis during the COVID-19: the mediating effect of food price and food stress, Journal of Foodservice Business Research.

Numminen, E.; Sallberg, H.; Wang, S. (2022) The impact of app revenue model choices for app revenues: A study of apps since their initial App Store launch. Economic Analysis and Policy, Vol. 76, pp. 325-336.

Payne, A., Frow, P. & Eggert, A. (2017) The customer value proposition: evolution, development, and application in marketing. J. of the Acad. Mark. Sci. 45, 467–489

Pereira, D. (2020) Key Activities. The Business Model Analyst. <https://businessmodelanalyst.com/key-activities-business-model-canvas/>

Pereira, D. (2020) Key Resources. Business Model Analyst. <https://businessmodelanalyst.com/key-resources-business-model-canvas/>

Pekic, B. (2022) 'Super Save' App Enables Portuguese To Compare Supermarket Prices. Online: <https://www.esmmagazine.com/technology/super-save-app-enables-portuguese-to-compare-supermarket-prices-180831>. (Last Accessed: 16/11/2023)

Planet Tracker (2022) The politics of food protectionism, nature dependency and hunger. Planet Tracker. <https://planet-tracker.org/the-politics-of-food-protectionism-nature-dependency-and-hunger/>

Repko, M.; Lucas, A. (2023) Inflation is cooling, but prices on many items are going to stay high for months. Online: <https://www.cnn.com/2023/01/25/inflation-is-cooling-but-high-prices-will-stick-around.html>. Last Accessed: 10/10/2023

Rese, M. (2006) Successful and sustainable business partnerships: How to select the right partners. *Industrial Marketing Management*, Vol. 35, No. 1, pp 72-82.

Roma, P. and Ragaglia, D. (2016) Revenue models, in-app purchase, and the app performance: Evidence from Apple's App Store and Google Play. *Electronic Commerce Research and Applications*, Vol 17, pp. 173-190.

Sloan, A. E. (2023) The Top 10 Food Trends of 2023. Online: <https://www.ift.org/news-and-publications/food-technology-magazine/issues/2023/april/features/the-top-10-food-trends-of-2023>. (Last Accessed: 1/11/2023)

Soh, C., Markus, M., Goh, K. (2006) Electronic Marketplaces and Price Transparency: Strategy, Information Technology, and Success. *MIS Quarterly*, Vol. 30, No. 3 (Sep., 2006), pp. 705-723 (19 pages)

Sohag, K.; Islam, M. M.; Zikovic, I. T.; Mansour, H. (2023) Food inflation and geopolitical risks: analyzing European regions amid the Russia-Ukraine war. *British Food Journal*, Vol. 125, No. 7, pp. 2368-2391

Super Save (2022) Super Save. Online: <https://supersave.pt/>. (Last Accessed: 16/11/2023)

Tan, E. (2017) How to Maintain a High Star Rating for Your App & Why it Matters. Online: <https://www.gamedeveloper.com/business/how-to-maintain-a-high-star-rating-for-your-app-why-it-matters>. (Last Accessed: 11/10/2023)

TheStar (2023) Balancing food inflation and subsidy reforms. Online: <https://www.thestar.com.my/business/business-news/2023/09/11/balancing-food-inflation-and-subsidy-reforms> (Last Accessed: 20/10/2023)

Tremblay, V. J.; Polasky, S. (2002) Advertising with Subjective Horizontal and Vertical Product Differentiation. *Review of Industrial Organization* 20: 253–265, 2002

Ulussever, T. (2023) Estimation of Impacts of Global Factors on World Food Prices: A Comparison of Machine Learning Algorithms and Time Series Econometric Models. *Foods*. 2023 Feb; 12(4): 873

Upland (n.d.) 25% of Users Abandon Apps After One Use. Online: <https://uplandsoftware.com/localytics/resources/blog/25-of-users-abandon-apps-after-one-use/>. (Last Accessed: 20/10/2023)

Vailshery, L. (2023). Most used web frameworks among developers worldwide, 2023. Statista. <https://www.statista.com/statistics/1124699/worldwide-developer-survey-most-used-frameworks-web/>

Verdon, J. (2022) The Pandemic Changed How We Shop For Groceries, Adobe Report Shows. Online: <https://www.forbes.com/sites/joanverdon/2022/03/15/the-pandemic-changed-how-we-shop-for-groceries-adobe-report-shows/?sh=76881bfe4bb1>. Last Accessed: 15/10/2023

Why Use MongoDB and When to Use It? (n.d.). MongoDB. <https://www.mongodb.com/why-use-mongodb>

Womack, J. and Jones, D. (1996), Lean Thinking: Banish Waste and Create Wealth in Your Organisation, Simon and Shuster, New York, NY, p. 397.

8. Appendices

8.1 Customer Survey

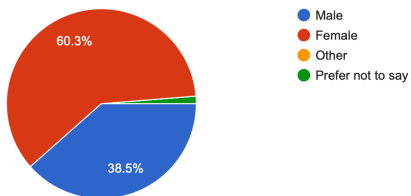
1. Select your gender * Mark only one oval. ☐ Male ☐ Female ☐ Other ☐ Prefer not to say	3. Select your employment status * Mark only one oval. ☐ Unemployed ☐ Student ☐ Full-time ☐ Part-time ☐ Other: _____	6. How many people belong to your household? * Mark only one oval. ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 +
2. Select your age group * Mark only one oval. ☐ Under 18 ☐ 18 - 24 ☐ 25 - 29 ☐ 30 - 39 ☐ 40 - 49 ☐ 50 - 59 ☐ 60 +	4. Select your education level * Mark only one oval. ☐ High-school diploma ☐ Bachelors diploma ☐ Masters degree ☐ PhD ☐ Other: _____	7. How often do you go grocery shopping in a month? * Mark only one oval. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
	5. Please select the option that best describes your current location * Mark only one oval. ☐ Urban ☐ Suburban ☐ Rural ☐ Prefer not to say	8. Which supermarket or grocery store do you usually shop at? * Tick all that apply: ☐ Continente ☐ Pingo Doce ☐ Auchan ☐ Lidl ☐ Aldi ☐ Minimpreço ☐ Mercadona ☐ Intermarché ☐ E.Leclerc ☐ El Corte Inglés ☐ Other: _____
9. Do you usually buy groceries online? * Mark only one oval. ☐ Yes ☐ No	12. Do you usually prefer to buy off-brand or regular branded products? * Mark only one oval. ☐ Off-brand ☐ Regular brand	16. What features would be the most important to include in this tool? * Tick all that apply: ☐ Pricing History ☐ Shopping Lists ☐ Budgeting ☐ Savings Calculator ☐ Promotion Aggregator ☐ Other: _____
10. How much do you spend on groceries per month? * Mark only one oval. ☐ < 100€ ☐ 100€ - 199€ ☐ 200€ - 299€ ☐ 300€ - 399€ ☐ 400€ +	13. How easy is it for you to find the most cost-effective grocery shopping products? * Mark only one oval. 1 2 3 4 5 Very ☐ ☐ ☐ ☐ ☐ Very Easy	17. Would you be willing to pay for these features? * Mark only one oval. ☐ Yes, a one-time installation fee ☐ Yes, a monthly subscription fee ☐ No, I would not pay for it
11. What is the most important factor when considering a supermarket? * Tick all that apply: ☐ Location ☐ Price ☐ Quality ☐ Product Variety ☐ Promotions ☐ Customer Service ☐ Parking and Accessibility ☐ Other: _____	14. Do you usually find the same products priced differently in different supermarkets? * Mark only one oval. ☐ Yes ☐ No	18. Do you usually compare prices before going grocery shopping? * Mark only one oval. ☐ Yes ☐ No ☐ Not certain
	15. How useful do you think a pricing comparison tool for different supermarkets would be? * Mark only one oval. 1 2 3 4 5 Not ☐ ☐ ☐ ☐ ☐ Very Useful	19. What are your preferred ways of doing so? Mark only one oval. ☐ Supermarket's Websites ☐ Advertising Brochures ☐ Other: _____

8.2 Customer Survey Results

*Please note that results for English and Portuguese respondents are presented separately

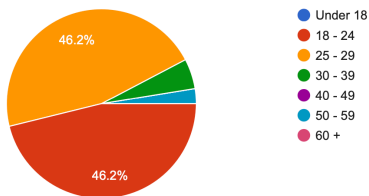
Select your gender

78 responses



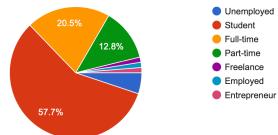
Select your age group

78 responses



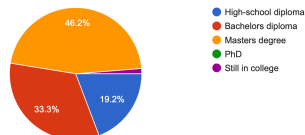
Select your employment status

78 responses



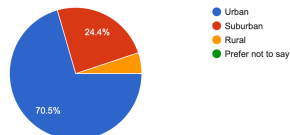
Select your education level

78 responses



Please select the option that best describes your current location

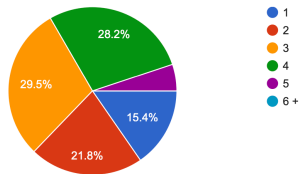
78 responses



How many people belong to your household?

[Copy](#)

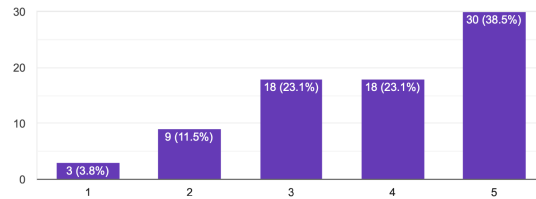
78 responses



How often do you go grocery shopping in a month?

[Copy](#)

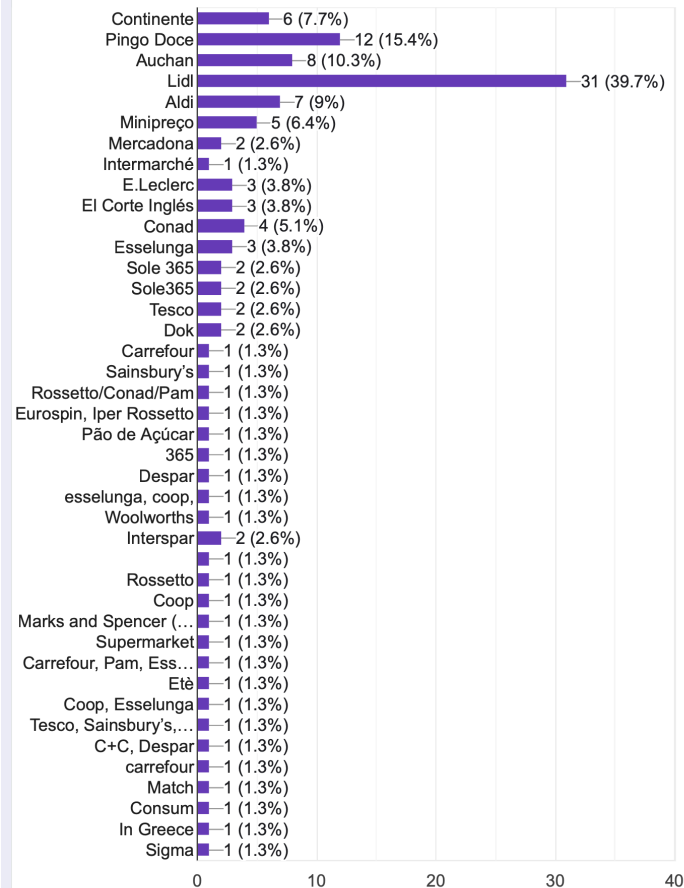
78 responses



Which supermarket or grocery store do you usually shop at?

[Copy](#)

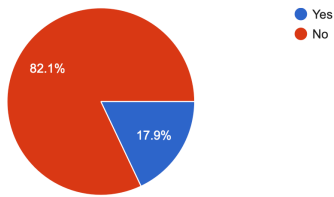
78 responses



Do you usually buy groceries online?

[Copy](#)

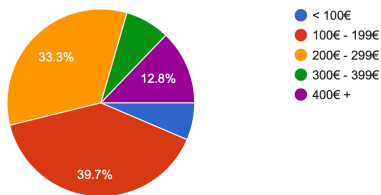
78 responses



How much do you spend on groceries per month?

[Copy](#)

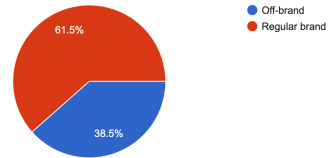
78 responses



Do you usually prefer to buy off-brand or regular branded products?

[Copy](#)

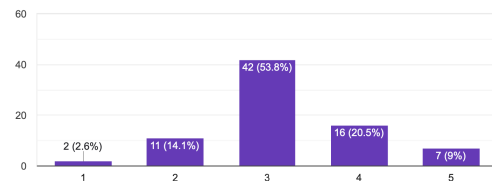
78 responses



How easy is it for you to find the most cost-effective grocery shopping products?

[Copy](#)

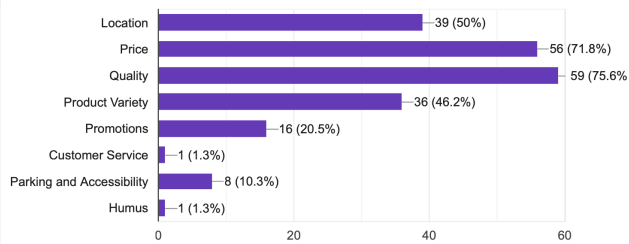
78 responses



What is the most important factor when considering a supermarket?

[Copy](#)

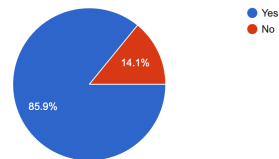
78 responses



Do you usually find the same products priced differently in different supermarkets?

[Copy](#)

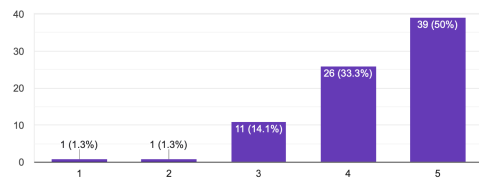
78 responses



How useful do you think a pricing comparison tool for different supermarkets would be?

[Copy](#)

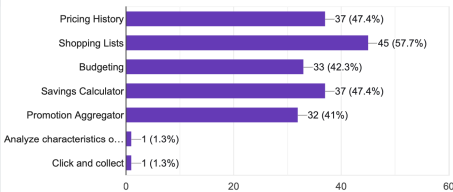
78 responses



What features would be the most important to include in this tool?

[Copy](#)

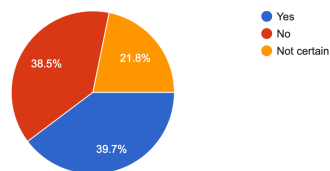
78 responses



Do you usually compare prices before going grocery shopping?

[Copy](#)

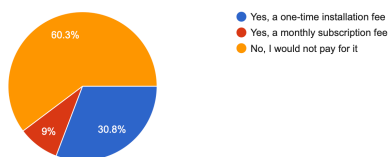
78 responses



Would you be willing to pay for these features?

[Copy](#)

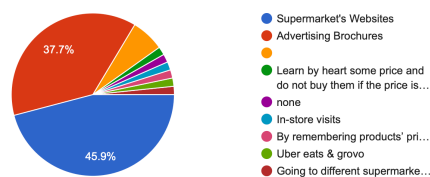
78 responses



What are your preferred ways of doing so?

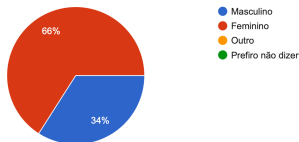
[Copy](#)

61 responses



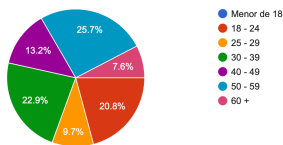
Selecione o seu género

144 responses



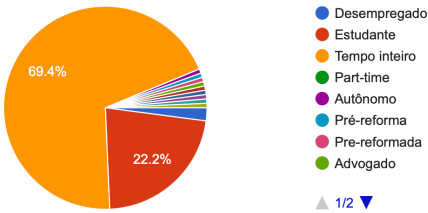
Selecione a sua faixa etária

144 responses



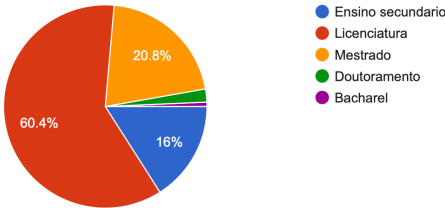
Selecione o seu estado de emprego atual

144 responses



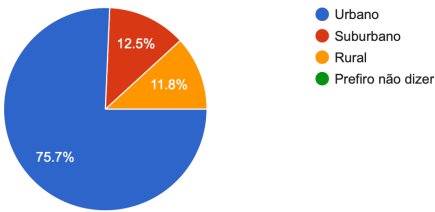
Selecione as suas habilitações literárias

144 responses



Selecione a opção que melhor descreve a sua localização

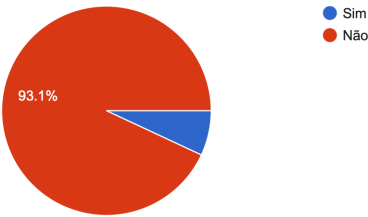
144 responses



Costuma fazer compras de supermercado online?

Copy

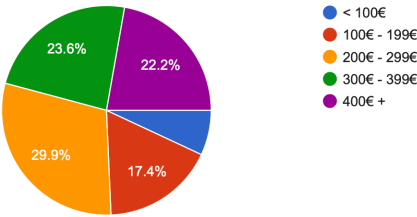
144 responses



Quanto costuma gastar por mês no supermercado?

Copy

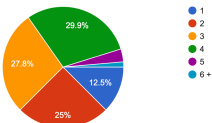
144 responses



Quantas pessoas fazem parte do seu agregado familiar?

Copy

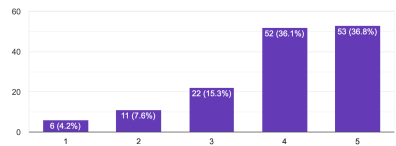
144 responses



Quantas vezes por mês vai às compras?

Copy

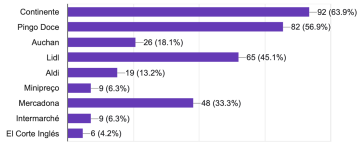
144 responses



Em que supermercado(s) costuma fazer compras?

Copy

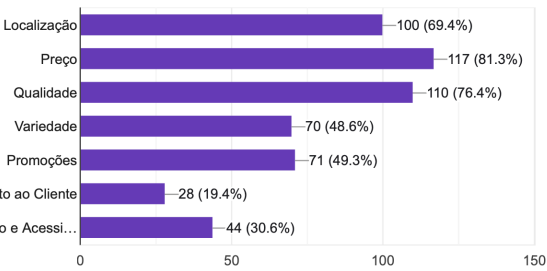
144 responses



Quais são os fatores mais importantes a considerar num supermercado?

Copy

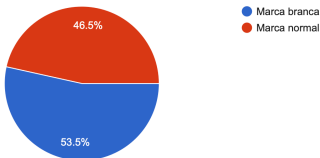
144 responses



Costuma comprar com mais frequência produtos de marca branca ou normal?

Copy

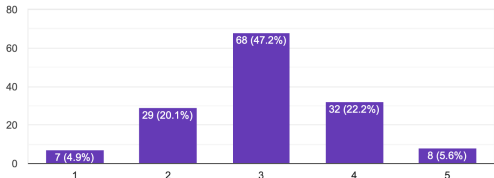
144 responses



Quão fácil é para si encontrar produtos com um bom custo-benefício?

Copy

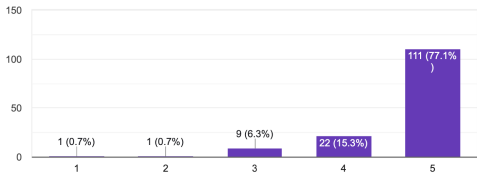
144 responses



Quão útil seria uma ferramenta que permitisse comparar os preços do mesmo produto nos diferentes supermercados?

Copy

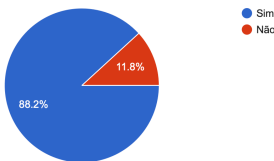
144 responses



Costuma encontrar os mesmos produtos com preços diferentes nos diferentes supermercados?

Copy

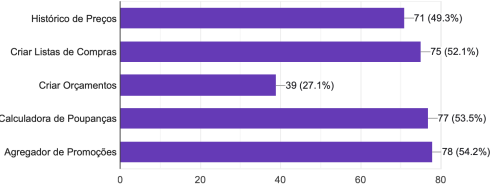
144 responses

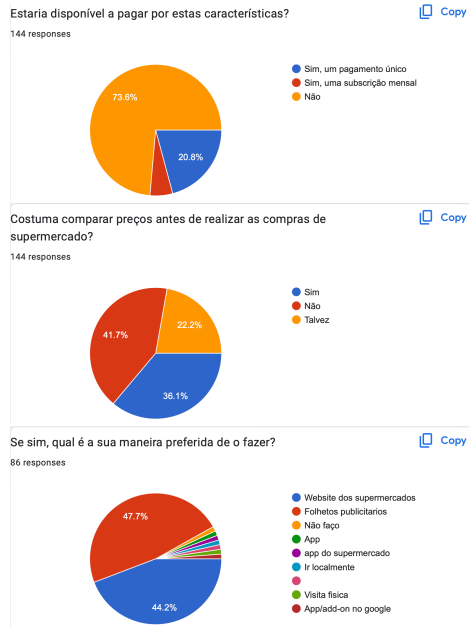


Que características considera mais importantes para incluir nesta ferramenta?

Copy

144 responses





9.3 Lean Survey

1. Select your Gender *

Mark only one oval.

- ☐ Female
- ☐ Male
- ☐ Other
- ☐ Prefer not to say

3. How useful did you find the price comparison feature? *

Mark only one oval.

- 1 2 3 4 5
- Not ☐ ☐ ☐ ☐ ☐ Very Useful

4. If you scored the previous question below 3, can you please elaborate?

2. Select your age group *

Mark only one oval.

- ☐ Under 18
- ☐ 18-24
- ☐ 25-29
- ☐ 30-39
- ☐ 40-49
- ☐ 50-59
- ☐ 60+

5. How easy was it to compare prices between different supermarkets? *

Mark only one oval.

- 1 2 3 4 5
- Not ☐ ☐ ☐ ☐ ☐ Very easy

6. If you scored the previous question below 3, can you please elaborate?

7. Did you experience any lag, crashes, or slow loading times while using the app? *

8. Were there any parts of the interface that felt confusing or unintuitive? *

Usability

9. How easy was it to navigate through the app? *

Mark only one oval.

1 2 3 4 5
Not ☐ ☐ ☐ ☐ ☐ Very easy

10. If you scored the previous question below 3, can you please elaborate?

11. How intuitive are the menu options and features? *

Mark only one oval.

1 2 3 4 5
Not ☐ ☐ ☐ ☐ ☐ Very intuitive

12. If you scored the previous question below 3, can you please elaborate?

13. Could you describe your journey through the app? Were there any points where you didn't know what to do next? *

Satisfaction

14. How satisfied are you with the app's performance? *

Mark only one oval.

1 2 3 4 5
Not ☐ ☐ ☐ ☐ ☐ Very satisfied

15. If you scored the previous question below 3, can you please elaborate?

16. How effectively does the app solve the problem it is designed for? *

17. What areas/functionalities do you think need improvement? *

19. Would you be willing to pay for this application? *

Mark only one oval.

☐ Yes, a one-time installation fee
☐ Yes, a monthly subscription fee
☐ No, I would not pay for it
☐ Other: _____

18. Would you recommend this application to family/friends? *

Mark only one oval.

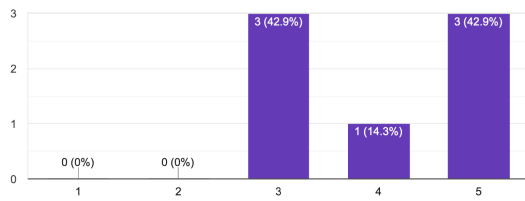
☐ Yes
☐ No
☐ Maybe

9.4 Lean Survey 1.0 Results

How useful did you find the price comparison feature?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

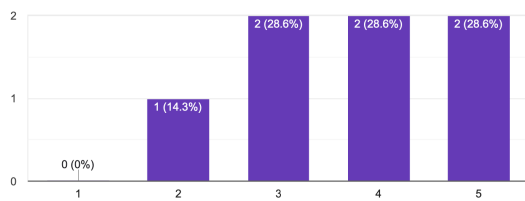
1 response

The UI could use improvement

How easy was it to compare prices between different supermarkets?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

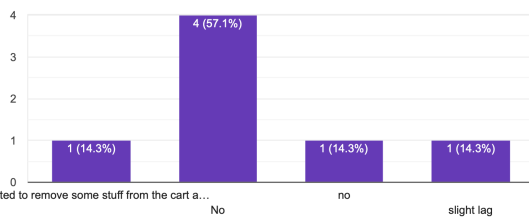
1 response

Comparing prices on the product's page needs to be more appealing and intuitive

Did you experience any lag, crashes, or slow loading times while using the app?

[Copy](#)

7 responses



Were there any parts of the interface that felt confusing or unintuitive?

7 responses

No, just graphic/design could improve

more products should be displayed horizontally rather than having a long vertical list and the outlook is not that nice

No, but the UI could use some improvement

When the item is added it would be nice to see a notification that pops on the screen with "the item was added successfully"

Home page should be organized by categories

Cart page needs to be more intuitive (removing products, seeing what supermarket is cheaper, etc)

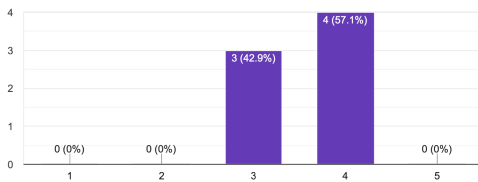
Home page was very confusing

Usability

How easy was it to navigate through the app?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

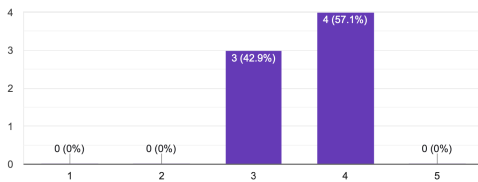
0 responses

No responses yet for this question.

How intuitive are the menu options and features?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

1 response

I believe that dividing the menu with main categories it would be clearer. When going on the main categories that the subcategories should appear, otherwise it just looks messy

Could you describe your journey through the app? Were there any points where you didn't know what to do next?

7 responses

you should put categories in the principal home page, instead of the variety of products, so I can choose the category that I need before the first visualization. Then, you can add a map to search which markets are the closest to me

It is pretty easy but not that "good looking"

No, but for saving 30 cents on tuna I am not gonna make 2 shopping trips instead of 1

Yes, after adding the stuff to the cart it would be nice to have a click and collect option or a way to prepare your order. It is time-consuming to create a cart online and if an actual purchase could go through the app it would be very useful

Overall good, but needs polishing

No, navigation was good

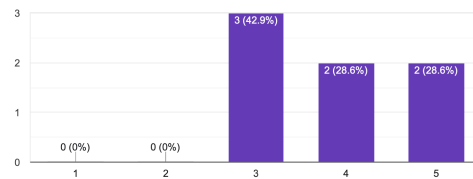
Was unsure where to start given previous answer to the home page

Satisfaction

How satisfied are you with the app's performance?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

0 responses

No responses yet for this question.

How effectively does the app solve the problem it is designed for?

7 responses

Give the possibility to make a list for products that I have selected collecting them for each market.
So when I am going to go in Auchan, I could visualize just products that are convenient there.

It is effective but the outlook is crucial

It gives you an indication that Auchan is generally cheaper at the moment. So yeah, very

It lets me compare the prices effectively so it is effective

Works well enough to compare prices

In my opinion, I would like to see notifications

Easy enough to compare prices for some products

What areas/functionalities do you think need improvement?

7 responses

More markets and a ray of action for my specific zone/ my preference.

Outlook

The cart option could make a subtotal for the different shopping trip options. eg. Contiente subtotal vs Auchan subtotal (simple sum of prices, maybe also indicate if a shop does not have an item

design overall and functionality

Overall design of the app

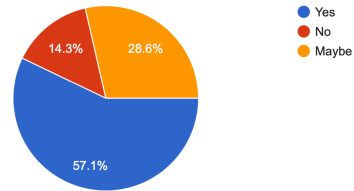
UI

UI, Home page, cart

Would you recommend this application to family/friends?

 Copy

7 responses

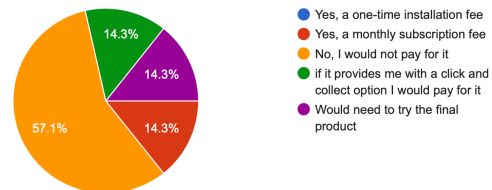


Willingness to pay

Would you be willing to pay for this application?

 Copy

7 responses

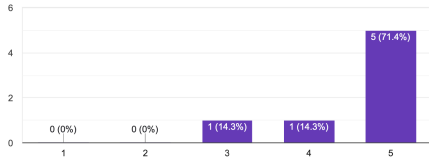


9.5 Lean Survey 2.0 Results

How useful did you find the price comparison feature?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

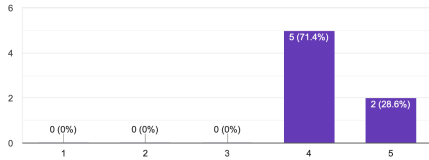
1 response

In most cases convenience of the location comes before price

How easy was it to compare prices between different supermarkets?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

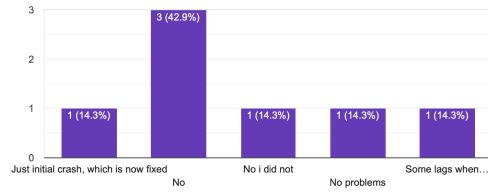
0 responses

No responses yet for this question.

Did you experience any lag, crashes, or slow loading times while using the app?

[Copy](#)

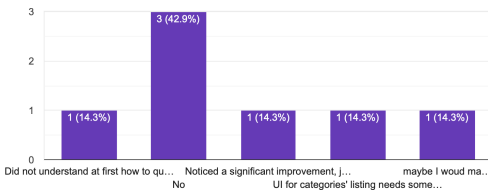
7 responses



Were there any parts of the interface that felt confusing or unintuitive?

[Copy](#)

7 responses



Could you describe your journey through the app? Were there any points where you didn't know what to do next?

7 responses

Very simple and usefull

No issues

Mainly just the way the categories are presented (difficult to understand child categories)

No

No pain points

All clear, looked for a product, saw prices

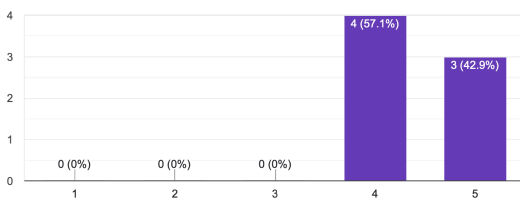
at first glance I did not understand that when i was adding stuff to the cart it would automatically pick the cheapest option

Satisfaction

How satisfied are you with the app's performance?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

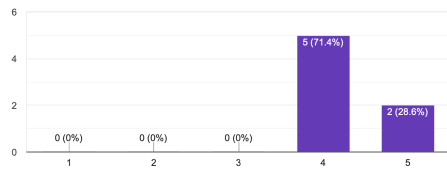
0 responses

No responses yet for this question.

How easy was it to navigate through the app?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

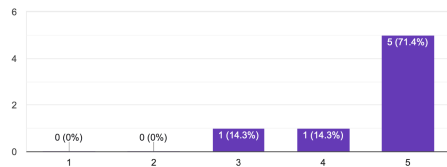
0 responses

No responses yet for this question.

How intuitive are the menu options and features?

[Copy](#)

7 responses



If you scored the previous question below 3, can you please elaborate?

0 responses

No responses yet for this question.

How effectively does the app solve the problem it is designed for?

7 responses

You can decide if it's convenient for you to stop in a market or go into another one.
Very efficient. Would be good to get a larger number of supermarkets and compare total expenditure considering distance to nearest supermarket
Good for price comparison, but unsure if it would be used on the day to day
Very well
Good enough, uncertain about using it regularly
Quite good
It is very good and the cart outlook is very intuitive and organized. I like that i can see the division of the supermarkets in the cart

What areas/functionalities do you think need improvement?

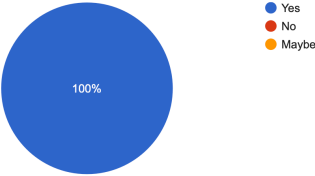
7 responses

I think it's ok
UI is much better, but still needs to be further improved to have a more professional feel
None
More features! Feels a bit "empty" right now
More features
Transparency that the prices are updated
Improvements on the design and layout for the prices under each product. Just to make it more clear

Would you recommend this application to family/friends?

 Copy

7 responses



Willingness to pay

Would you be willing to pay for this application?

 Copy

7 responses

