Beyond the Specs: Decoding Smartphone Pricing Strategies

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Contents

1 Introduction

The purpose of this report is to analyze the key explanatory variables that determine the price of a smartphone. By leveraging a dataset obtained through automated web scraping, we aim to uncover relationships between smartphone features, such as performance specifications, camera quality, and additional functionalities, and their respective price points. This analysis will provide valuable insights into the factors that drive smartphone pricing in the market, enabling more informed decisions for both consumers and manufacturers.

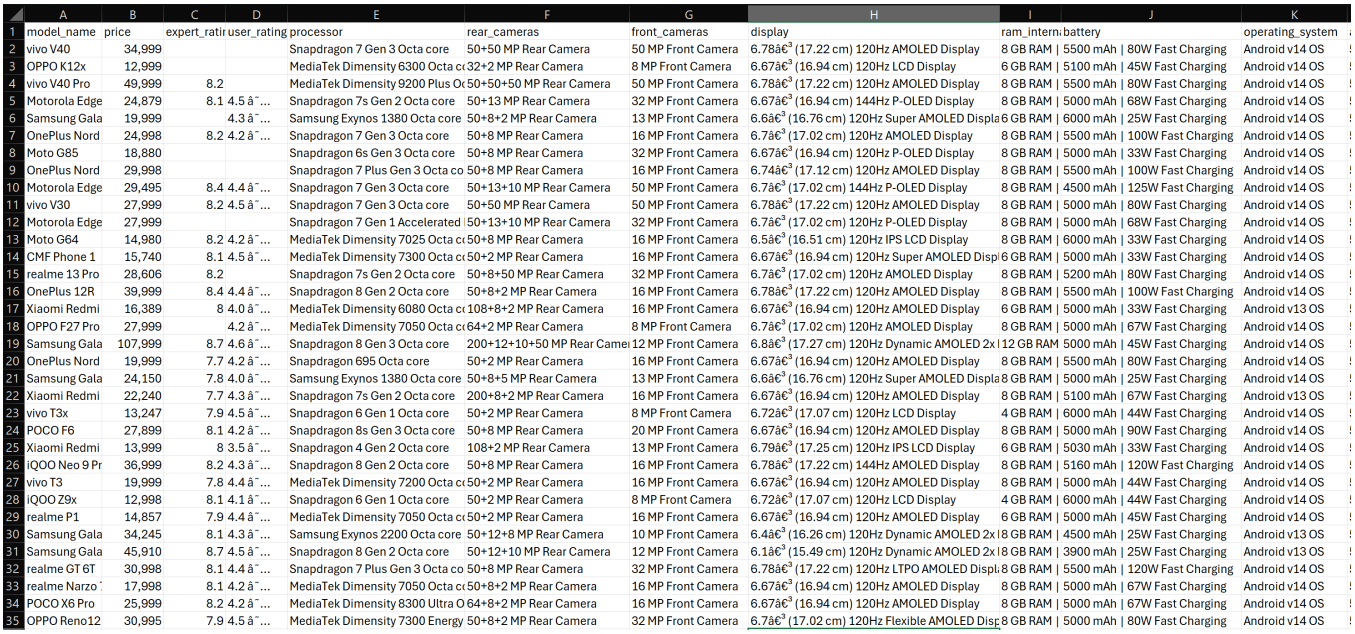
1.1 Objective

The objective of this report is to illustrate the process of obtaining, cleaning, and preparing a dataset for analysis. Specifically, the report focuses on a dataset extracted from an e-commerce platform that lists smartphone attributes. The ultimate goal is to transform the raw, unstructured data into a format suitable for detailed analysis and modeling.

1.2 Dataset Overview

The dataset under review has been obtained through an automated web scraping process. This involved extracting information from an e-commerce platform focused on smartphones. The scraping script, implemented using Python and Selenium, navigates the website's pages and captures the necessary data while applying a price filter to distinguish smartphones from feature phones. [Singh, nd]

The raw dataset is stored in a CSV file named `smartphones.csv` and it is showed on Fig 14. It contains information such as product names, prices, specifications, and other relevant details. The dataset may require significant preprocessing to address common challenges associated with such methods.



	A	B	C	D	E	F	G	H	I	J	K
1	model_name	price	expert_ratir	user_rating	processor	rear_cameras	front_cameras	display	ram_interna	battery	operating_system
2	vivo V40	34,999			Snapdragon 7 Gen 3 Octa core	50+50 MP Rear Camera	50 MP Front Camera	6.78â€³ (17.22 cm) 120Hz AMOLED Display	8 GB RAM	5500 mAh | 80W Fast Charging	Android v14 OS
3	OPPO K12x	12,999			MediaTek Dimensity 6300 Octa c	32+2 MP Rear Camera	8 MP Front Camera	6.67â€³ (16.94 cm) 120Hz LCD Display	6 GB RAM	5100 mAh | 45W Fast Charging	Android v14 OS
4	vivo V40 Pro	49,999	8.2		MediaTek Dimensity 9200 Plus Oc	50+50+50 MP Rear Camera	50 MP Front Camera	6.78â€³ (17.22 cm) 120Hz AMOLED Display	8 GB RAM	5500 mAh | 80W Fast Charging	Android v14 OS
5	Motorola Edge	24,879	8.1	4.5 â˜…	Snapdragon 7s Gen 2 Octa core	50+13 MP Rear Camera	32 MP Front Camera	6.67â€³ (16.94 cm) 144Hz P-OLED Display	8 GB RAM	5000 mAh | 68W Fast Charging	Android v14 OS
6	Samsung Gala	19,999		4.3 â˜…	Samsung Exynos 1380 Octa core	50+8+2 MP Rear Camera	13 MP Front Camera	6.6â€³ (16.76 cm) 120Hz Super AMOLED Displa	6 GB RAM	6000 mAh | 25W Fast Charging	Android v14 OS
7	OnePlus Nord	24,998	8.2	4.2 â˜…	Snapdragon 7 Gen 3 Octa core	50+8 MP Rear Camera	16 MP Front Camera	6.7â€³ (17.02 cm) 120Hz AMOLED Display	8 GB RAM	5500 mAh | 100W Fast Charging	Android v14 OS
8	Moto G85	18,880			Snapdragon 6s Gen 3 Octa core	50+8 MP Rear Camera	32 MP Front Camera	6.67â€³ (16.94 cm) 120Hz P-OLED Display	8 GB RAM	5000 mAh | 33W Fast Charging	Android v14 OS
9	OnePlus Nord	29,998			Snapdragon 7 Plus Gen 3 Octa co	50+8 MP Rear Camera	16 MP Front Camera	6.74â€³ (17.12 cm) 120Hz AMOLED Display	8 GB RAM	5500 mAh | 100W Fast Charging	Android v14 OS
10	Motorola Edge	29,495	8.4	4.4 â˜…	Snapdragon 7 Gen 3 Octa core	50+13+10 MP Rear Camera	50 MP Front Camera	6.7â€³ (17.02 cm) 144Hz P-OLED Display	8 GB RAM	4500 mAh | 125W Fast Charging	Android v14 OS
11	vivo V30	27,999	8.2	4.5 â˜…	Snapdragon 7 Gen 3 Octa core	50+50 MP Rear Camera	50 MP Front Camera	6.78â€³ (17.22 cm) 120Hz AMOLED Display	8 GB RAM	5000 mAh | 80W Fast Charging	Android v14 OS
12	Motorola Edge	27,999			Snapdragon 7 Gen 1 Accelerated	50+13+10 MP Rear Camera	32 MP Front Camera	6.7â€³ (17.02 cm) 120Hz P-OLED Display	8 GB RAM	5000 mAh | 68W Fast Charging	Android v14 OS
13	Moto G64	14,980	8.2	4.2 â˜…	MediaTek Dimensity 7025 Octa c	50+8 MP Rear Camera	16 MP Front Camera	6.5â€³ (16.51 cm) 120Hz IPS LCD Display	8 GB RAM	6000 mAh | 33W Fast Charging	Android v14 OS
14	CMF Phone 1	15,740	8.1	4.5 â˜…	MediaTek Dimensity 7300 Octa c	50+2 MP Rear Camera	16 MP Front Camera	6.67â€³ (16.94 cm) 120Hz Super AMOLED Displ	6 GB RAM	5000 mAh | 33W Fast Charging	Android v14 OS
15	realme 13 Pro	28,606	8.2		Snapdragon 7s Gen 2 Octa core	50+8+50 MP Rear Camera	32 MP Front Camera	6.7â€³ (17.02 cm) 120Hz AMOLED Display	8 GB RAM	5200 mAh | 80W Fast Charging	Android v14 OS
16	OnePlus 12R	39,999	8.4	4.4 â˜…	Snapdragon 8 Gen 2 Octa core	50+8+2 MP Rear Camera	16 MP Front Camera	6.78â€³ (17.22 cm) 120Hz AMOLED Display	8 GB RAM	5500 mAh | 100W Fast Charging	Android v14 OS
17	Xiaomi Redmi	16,389	8	4.0 â˜…	MediaTek Dimensity 6080 Octa c	108+8+2 MP Rear Camera	16 MP Front Camera	6.67â€³ (16.94 cm) 120Hz AMOLED Display	6 GB RAM	5000 mAh | 33W Fast Charging	Android v13 OS
18	OPPO F27 Pro	27,999		4.2 â˜…	MediaTek Dimensity 7050 Octa c	64+2 MP Rear Camera	8 MP Front Camera	6.7â€³ (17.02 cm) 120Hz AMOLED Display	8 GB RAM	5000 mAh | 67W Fast Charging	Android v14 OS
19	Samsung Gala	107,999	8.7	4.6 â˜…	Snapdragon 8 Gen 3 Octa core	200+12+10+50 MP Rear Came	12 MP Front Camera	6.8â€³ (17.27 cm) 120Hz Dynamic AMOLED 2x	12 GB RAM	5000 mAh | 45W Fast Charging	Android v14 OS
20	OnePlus Nord	19,999	7.7	4.2 â˜…	Snapdragon 695 Octa core	50+2 MP Rear Camera	16 MP Front Camera	6.67â€³ (16.94 cm) 120Hz AMOLED Display	8 GB RAM	5500 mAh | 80W Fast Charging	Android v14 OS
21	Samsung Gala	24,150	7.8	4.0 â˜…	Samsung Exynos 1380 Octa core	50+8+5 MP Rear Camera	13 MP Front Camera	6.6â€³ (16.76 cm) 120Hz Super AMOLED Displa	8 GB RAM	5000 mAh | 25W Fast Charging	Android v14 OS
22	Xiaomi Redmi	22,240	7.7	4.3 â˜…	Snapdragon 7s Gen 2 Octa core	200+8+2 MP Rear Camera	16 MP Front Camera	6.67â€³ (16.94 cm) 120Hz AMOLED Display	8 GB RAM	5100 mAh | 67W Fast Charging	Android v13 OS
23	vivo T3x	13,247	7.9	4.5 â˜…	Snapdragon 6 Gen 1 Octa core	50+2 MP Rear Camera	8 MP Front Camera	6.72â€³ (17.07 cm) 120Hz LCD Display	4 GB RAM	6000 mAh | 44W Fast Charging	Android v14 OS
24	POCO F6	27,899	8.1	4.2 â˜…	Snapdragon 8s Gen 3 Octa core	50+8 MP Rear Camera	20 MP Front Camera	6.67â€³ (16.94 cm) 120Hz AMOLED Display	8 GB RAM	5000 mAh | 90W Fast Charging	Android v14 OS
25	Xiaomi Redmi	13,999	8	3.5 â˜…	Snapdragon 4 Gen 2 Octa core	108+2 MP Rear Camera	13 MP Front Camera	6.79â€³ (17.25 cm) 120Hz IPS LCD Display	6 GB RAM	5030 mAh | 33W Fast Charging	Android v14 OS
26	iQOO Neo 9 Pr	36,999	8.2	4.3 â˜…	Snapdragon 8 Gen 2 Octa core	50+8 MP Rear Camera	16 MP Front Camera	6.78â€³ (17.22 cm) 144Hz AMOLED Display	8 GB RAM	5160 mAh | 120W Fast Charging	Android v14 OS
27	vivo T3	19,999	7.8	4.4 â˜…	MediaTek Dimensity 7200 Octa c	50+2 MP Rear Camera	16 MP Front Camera	6.67â€³ (16.94 cm) 120Hz AMOLED Display	8 GB RAM	5000 mAh | 44W Fast Charging	Android v14 OS
28	iQOO Z9x	12,998	8.1	4.1 â˜…	Snapdragon 6 Gen 1 Octa core	50+2 MP Rear Camera	8 MP Front Camera	6.72â€³ (17.07 cm) 120Hz LCD Display	4 GB RAM	6000 mAh | 44W Fast Charging	Android v14 OS
29	realme P1	14,857	7.9	4.4 â˜…	MediaTek Dimensity 7050 Octa c	50+2 MP Rear Camera	16 MP Front Camera	6.67â€³ (16.94 cm) 120Hz AMOLED Display	6 GB RAM	5000 mAh | 45W Fast Charging	Android v14 OS
30	Samsung Gala	34,245	8.1	4.3 â˜…	Samsung Exynos 2200 Octa core	50+12+8 MP Rear Camera	10 MP Front Camera	6.4â€³ (16.26 cm) 120Hz Dynamic AMOLED 2x	8 GB RAM	4500 mAh | 25W Fast Charging	Android v13 OS
31	Samsung Gala	45,910	8.7	4.5 â˜…	Snapdragon 8 Gen 2 Octa core	50+12+10 MP Rear Camera	12 MP Front Camera	6.1â€³ (15.49 cm) 120Hz Dynamic AMOLED 2x	8 GB RAM	3900 mAh | 25W Fast Charging	Android v13 OS
32	realme GT 6T	30,998	8.1	4.4 â˜…	Snapdragon 7 Plus Gen 3 Octa co	50+8 MP Rear Camera	32 MP Front Camera	6.78â€³ (17.22 cm) 120Hz LTPO AMOLED Displ	8 GB RAM	5500 mAh | 120W Fast Charging	Android v14 OS
33	realme Narzo	17,998	8.1	4.2 â˜…	MediaTek Dimensity 7050 Octa c	50+8+2 MP Rear Camera	16 MP Front Camera	6.67â€³ (16.94 cm) 120Hz AMOLED Display	8 GB RAM	5000 mAh | 67W Fast Charging	Android v14 OS
34	POCO X6 Pro	25,999	8.2	4.2 â˜…	MediaTek Dimensity 8300 Ultra O	64+8+2 MP Rear Camera	16 MP Front Camera	6.67â€³ (16.94 cm) 120Hz AMOLED Display	8 GB RAM	5000 mAh | 67W Fast Charging	Android v14 OS
35	OPPO Reno12	30,995	7.9	4.5 â˜…	MediaTek Dimensity 7300 Energy	50+8+2 MP Rear Camera	32 MP Front Camera	6.7â€³ (17.02 cm) 120Hz Flexible AMOLED Disp	8 GB RAM	5000 mAh | 80W Fast Charging	Android v14 OS

Figure 1: Raw data after webscrapping

Several potential issues have been identified in the raw data:

- **HTML Artifacts:** The raw data may contain unwanted HTML tags or malformed entries, which need to be cleaned.
- **Missing or Incomplete Data:** Dynamic content loading or website structure changes could result in missing values in some rows.
- **Duplicate Entries:** Pagination across multiple pages might have introduced redundant entries into the dataset.
- **Inconsistent Formatting:** Data such as prices might use different formats, including varying currency symbols or separators.

Field	**Issue Description**	**Category**
model_name	Some mobile names contain variant info.	Consistency
model_name	Some Motorola phones only have model name, not brand name.	Validity
price	Contains ‘,‘ between numbers.	Validity

Field	Issue Description	Category
expert_rating	Missing values.	Completeness
user_rating	Missing values.	Completeness
processor	Missing values.	Completeness
processor	Some values only have core or processor brand info.	Accuracy
rear_camera	Multiple cameras all represented in the same cell using '+'.	Validity
front_camera	Missing values.	Completeness
display	Some values only mention the type of display (e.g., LCD).	Accuracy
ram_internal _memory	Missing values.	Completeness
ram_internal _memory	Some values only mention storage info.	Accuracy
battery	Some values only provide battery info without charging details.	Accuracy
operating_system	Missing values.	Completeness
additional_features	Missing values.	Completeness
review and review_link	Missing values.	Completeness
review	Contains incomplete reviews.	Validity

Table 1: Data Issues Summarize

2 Data Cleaning

2.1 Cleaning Process

The cleaning process for the smartphone dataset was conducted using R. Below are the key steps performed:

- **Removing Duplicates:** Duplicate rows were removed using the `distinct()` function to ensure each observation is unique.
- **Handling Missing Values:**
  - Blank cells in all character columns were replaced with `NA` using the `na_if()` function.
  - Rows with missing values in critical columns (`processor`, `front_cameras`, and `operating_system`) were dropped.

  - Missing values in the `additional_features` column were imputed with the placeholder `"No add features"`.

- **Column Adjustments:**
  - Irrelevant columns, such as `review` and `review_link`, were removed.
  - The `user_rating` column was split into two new columns: `avg_user_rating` (average user rating) and `num_ratings` (number of ratings).

- **Feature Engineering:**
  - Extracted `processor_brand` and `num_cores` from the `processor` column, mapping core counts to numeric values.
  - Created variables for cameras: `num_rear_cameras`, `main_rear_camera`, `num_front_cameras`, and `main_front_camera`.
  - Extracted `display_size`, `refresh_rate`, and `display_type` from the `display` column, categorizing display types.
  - Split `ram_internal_memory` into `ram` and `storage`, converting storage values to GB.

- **Battery Details:** Extracted `battery_capacity` and `charging` details from the `battery` column.

- **Additional Features:** Converted strings in the `additional_features` column into boolean variables, such as `has_fingerprint`, `has_5g`, and `has_nfc`.

- **Other Adjustments:**
  - Extracted the `brand` from the `model_name`.
  - Split the `operating_system` column into `os_type` and `os_version`.
  - Converted the `price` column from Indian Rupees to Euros using an exchange rate of 0.01106.

- **Final Steps:**
  - Filled missing values in critical columns (e.g., `num_cores`, `refresh_rate`) with median values.
  - Dropped unnecessary columns, such as `user_rating`, `rear_cameras`, etc.

– Ensured numerical and categorical columns had the correct data types.

The cleaned dataset was saved as a new CSV file for subsequent analysis.

2.2 Final Dataset after Cleaning

The final dataset has been cleaned and prepared for analysis, including 1960 obeservations. Duplicate entries have been removed, ensuring the uniqueness of each record. Missing values in critical columns, such as processor details and camera specifications, have been addressed either by imputing default values or dropping incomplete rows. Key features have been extracted and standardized for consistency, such as converting storage units to GB, normalizing currency values to Euros, and deriving additional variables like the number of cameras, processor brand, and high-resolution camera counts. The Final dataset after cleaning is presented on Table 2

Variable Name	**Description**
model_name	Name of the model
battery_capacity	Battery capacity in mAh
avg_user_rating	Average user rating (0 to 5)
num_rear_cameras	Number of rear cameras (0 to 5)
main_front_camera	Front camera quality (in megapixels)
display_type	Type of display (e.g., AMOLED, OLED)
storage_gb	Storage capacity (in GB)
has_nfc	NFC availability (1: Yes, 0: No)
price	Price in Euros
os_type	Operating system (e.g., Android, iOS)
processor_brand	Processor brand (e.g., Qualcomm, MediaTek)
display_size	Screen size (in inches)
ram_gb	RAM size (in GB)
has_fingerprint	Fingerprint sensor availability (1: Yes, 0: No)
refresh_rate	Refresh rate (in Hz)
has_5g	5G capability (1: Yes, 0: No)

Table 2: **Final Dataset**

Furthermore, variables like display type and operating system have been categorized for easier analysis. Feature engineering has significantly enriched the dataset, enabling deeper insights into smartphone attributes, such as identifying devices with advanced features like NFC, 5G, and fingerprint sensors. These transformations ensure the dataset is ready for statistical analysis and machine learning applications, while also maintaining clarity and usability. Overall, the cleaning process has produced a structured, consistent, and feature-rich dataset that meets analytical needs effectively.

3 Analysis Plan

The primary goal of the Analysis section is to explore the factors that drive smartphone pricing and explain their impact on market value. Specifically, our research seeks to answer the question: What are the key determinants of smartphone prices?

We hypothesize that a smartphone's features significantly impact its value. Research has shown that attributes such as screen size, camera quality, and battery life affect pricing. Most empirical studies have used the hedonic pricing method, which estimates the value of a good or service by breaking down its price into the value of its individual characteristics. In other words, a product is considered as a bundle of features, each contributing to its price. To test this hypothesis, we will first examine whether features are indeed the primary determinant of price and then assess the role of other factors, such as brand perception.

Beyond technical features, brand premium also plays a significant role in smartphone valuation. This refers to the additional value attributed to a product solely due to its brand name, independent of its technical specifications. Brand premium arises from factors such as reputation, trust, and social status, enabling certain brands to charge higher prices or retain greater resale value compared to competitors with similar features.

To investigate this, we began with a correlation analysis to identify variables that could influence price. Next, we conducted a univariate analysis of categorical and continuous variables, followed by a bivariate analysis to explore interactions between price and key variables. Finally, we used regression analysis to explore brand effects, dividing our sample into three price groups based on the average price per brand. This allowed us to determine whether the differences between these groups could be explained by specific

characteristics.

4 Results and Visualizations

4.1 Descriptive Analysis

In this section, we are going to describe and analyze the variables that are likely to affect the price of smartphones.

4.1.1 Prices

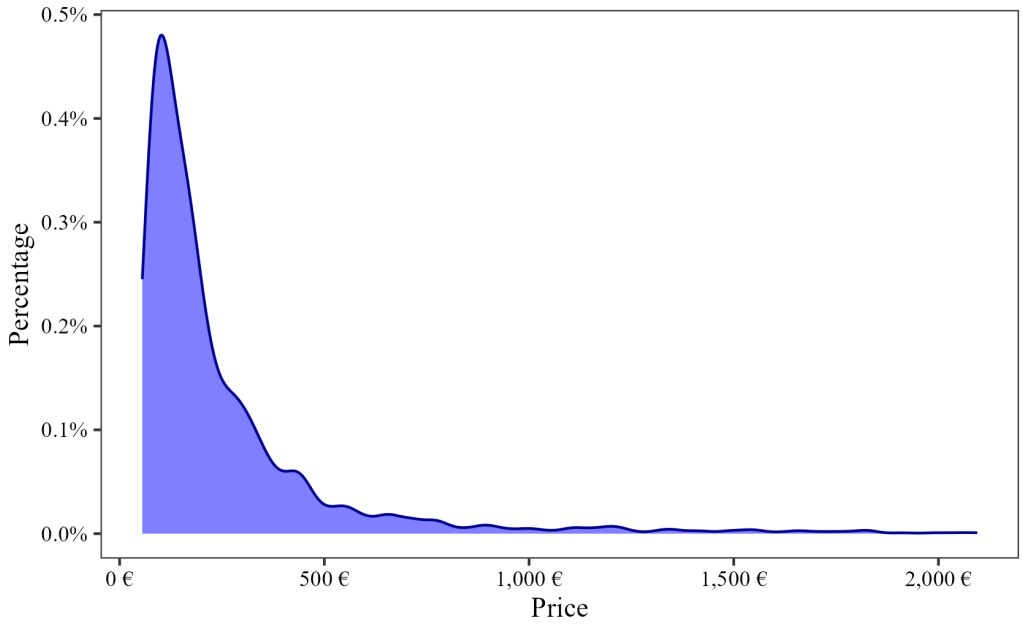


Figure 2: Distribution of prices

In our analysis, we aim at uncovering the determinants of smartphones' valuation. To this extent, we will use their price as our dependent variable. As shown in Figure 2, the price variable is highly right skewed, meaning that some smartphones are sold at disproportionately higher price than others.

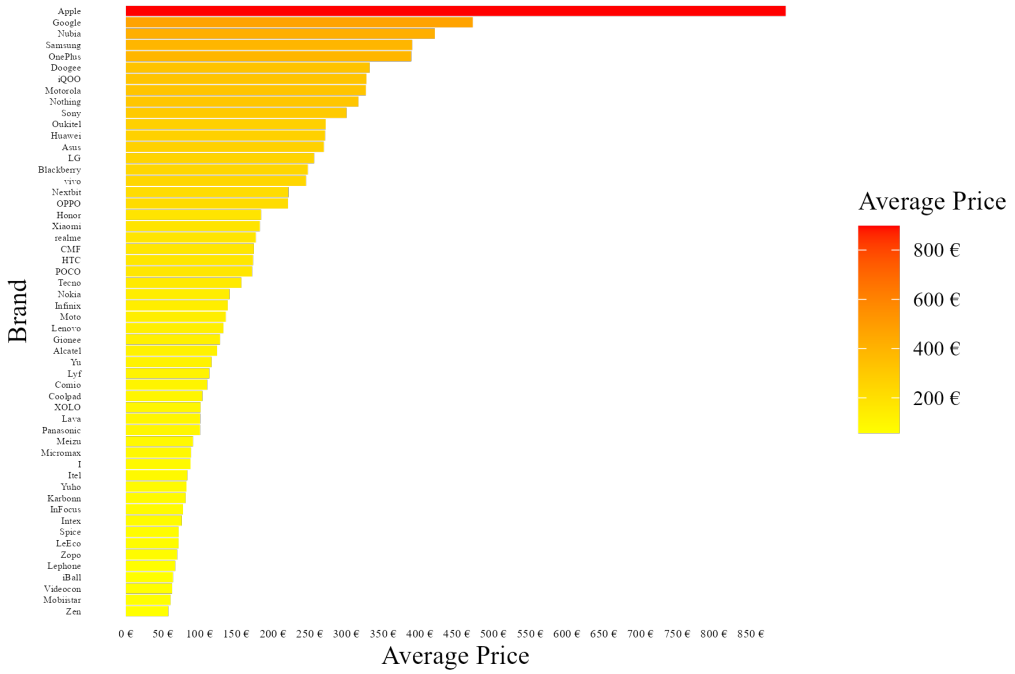


Figure 3: Average Price per Brand

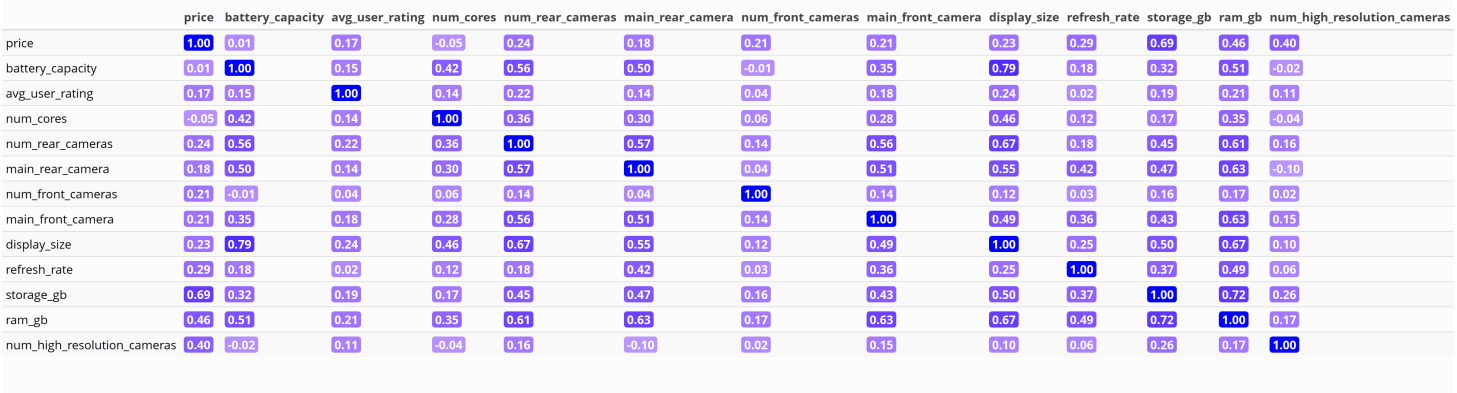
Figure 3 provides a visual representation of the average prices of mobile devices by different manufacturers. The vertical axis lists the brands in descending order from top to bottom, based on the average price, while the horizontal axis displays the average price in euros. Each bar's color represents a different price range, with red indicating the highest average prices (€800 and above) and yellow indicating the lowest (€200 and below).

Notably, Apple leads the chart with the highest average price, followed by Google and Nubia. These brands have significantly higher average prices compared to others like Samsung and OnePlus, which also lean towards the higher end of the spectrum. The chart progressively moves towards more affordable brands, such as Xiaomi and OPPO, positioned in the middle, and eventually to less expensive brands like Micromax and Zen at the bottom of the chart.

A notable observation from the graph is that Apple stands out significantly in terms of prices. This can be attributed to the company's strong brand perception, customer loyalty, and overall goodwill, allowing it to command

premium prices for its products. However, an important factor to consider is Apple's market strategy: unlike many competitors, Apple discontinues older models relatively quickly, removing them from the market rather than keeping them available at reduced prices. In contrast, other brands often continue to sell older models at lower prices, affecting the overall average price in this analysis.

4.1.2 Correlation analysis



	price	battery_capacity	avg_user_rating	num_cores	num_rear_cameras	main_rear_camera	num_front_cameras	main_front_camera	display_size	refresh_rate	storage_gb	ram_gb	num_high_resolution_cameras
price	1.00	0.01	0.17	-0.05	0.24	0.18	0.21	0.21	0.23	0.29	0.69	0.46	0.40
battery_capacity	0.01	1.00	0.15	0.42	0.56	0.50	-0.01	0.35	0.79	0.18	0.32	0.51	-0.02
avg_user_rating	0.17	0.15	1.00	0.14	0.22	0.14	0.04	0.18	0.24	0.02	0.19	0.21	0.11
num_cores	-0.05	0.42	0.14	1.00	0.36	0.30	0.06	0.28	0.46	0.12	0.17	0.35	-0.04
num_rear_cameras	0.24	0.56	0.22	0.36	1.00	0.57	0.14	0.56	0.67	0.18	0.45	0.61	0.16
main_rear_camera	0.18	0.50	0.14	0.30	0.57	1.00	0.04	0.51	0.55	0.42	0.47	0.63	-0.10
num_front_cameras	0.21	-0.01	0.04	0.06	0.14	0.04	1.00	0.14	0.12	0.03	0.16	0.17	0.02
main_front_camera	0.21	0.35	0.18	0.28	0.56	0.51	0.14	1.00	0.49	0.36	0.43	0.63	0.15
display_size	0.23	0.79	0.24	0.46	0.67	0.55	0.12	0.49	1.00	0.25	0.50	0.67	0.10
refresh_rate	0.29	0.18	0.02	0.12	0.18	0.42	0.03	0.36	0.25	1.00	0.37	0.49	0.06
storage_gb	0.69	0.32	0.19	0.17	0.45	0.47	0.16	0.43	0.50	0.37	1.00	0.72	0.26
ram_gb	0.46	0.51	0.21	0.35	0.61	0.63	0.17	0.63	0.67	0.49	0.72	1.00	0.17
num_high_resolution_cameras	0.40	-0.02	0.11	-0.04	0.16	-0.10	0.02	0.15	0.10	0.06	0.26	0.17	1.00

Figure 4: Correlation Matrix

The correlation matrix displayed of figure 4 provides valuable insights into the relationships between various smartphone features and their price. The strongest positive correlation with price is seen in storage capacity (0.69), RAM (0.46), and battery capacity (0.32), indicating that devices with higher storage and RAM tend to be more expensive. Display size also shows a notable correlation (0.23), suggesting that larger screens contribute to a higher price point. Interestingly, the number of high-resolution cameras (0.40) also has a moderate correlation, reflecting the trend of premium smartphones incorporating better camera technology.

Another key observation from the matrix is the strong correlation between battery capacity and display size (0.79), suggesting that larger displays necessitate bigger batteries for sufficient power management. The number of rear cameras and main rear camera resolution (0.57) also exhibit a strong positive

relationship, implying that smartphones with multiple rear cameras generally feature higher-resolution sensors. Similarly, RAM and storage (0.72), as well as RAM and main rear camera resolution (0.63), highlight the interconnection between processing capabilities and imaging technology in premium devices.

On the other hand, some features display weak or even negative correlations with price, such as the number of processor cores (-0.05), which suggests that simply having more cores does not necessarily lead to a higher-priced smartphone. Additionally, the number of front cameras (0.06) has minimal correlation with price, reinforcing the idea that manufacturers prioritize rear camera quality over the number of front-facing cameras in determining premium pricing. These insights can help guide product development and marketing strategies, ensuring that high-value features are emphasized in premium smartphones.

4.1.3 Screen technologies

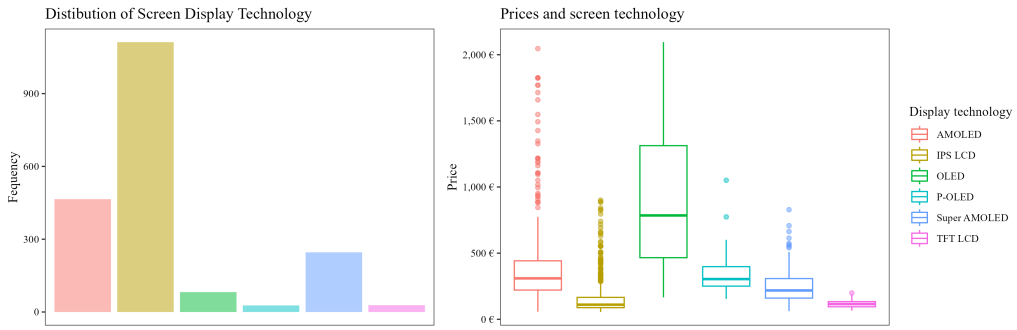


Figure 5: Screen Display Technology

The screen display has been considered an important variable because this tool brings customers the quality and experience of customers in terms of brightness, color accuracy, contrast, and sharpness [BuildFire, 2024]. Furthermore, Screen Display could be an important determinant on price variation and willingness to pay in our analysis.

In that sense, we have five different types of screen displays, AMOLED (Active Matrix Organic Light-Emitting Diode) which is common in premium

and flagship smartphones, P-OLED (Plastic OLED) found in high-end and foldable devices, Super AMOLED mostly used in Samsung's premium smartphones, IPS LCD (In-Plane Switching Liquid Crystal Display) used in mid-range and some budget phones, OLED (Organic Light-Emitting Diode) normally found in high-end phones, TVs and smartwatches, TFT LCD (Thin-Film Transistor LCD) mostly used in budget smartphones and older models. In terms of user preference, IPS LCD is the most widely used, likely due to its balance between quality and affordability. It is followed by AMOLED and Super AMOLED, which are favored for their superior contrast, vibrant colors, and energy efficiency.

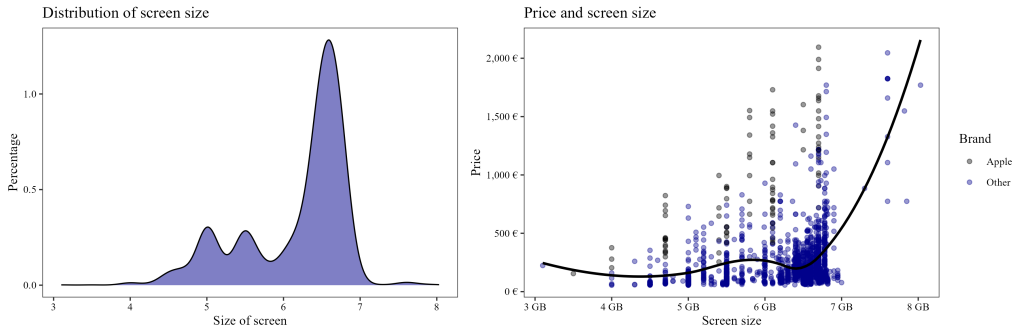


Figure 6: Screen Size

Figure 6 shows the distribution of screen size. Most smartphones measure between 6 and 7 inches, independently of the brand. The average and volatility of prices increase when the screen size increases.

4.1.4 Cameras

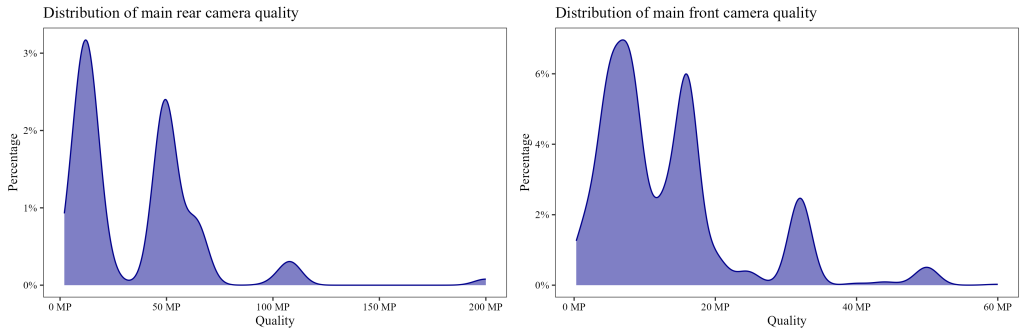


Figure 7: Camera Quality Distribution

Figure 7 shows the distribution of rear and front camera quality. Rear cameras cluster around 48-50 MP and 12 MP, the latter being common in Apple devices. Front cameras mostly range between 8-20 MP, suggesting manufacturers optimize for video calls and selfies rather than extreme resolutions.

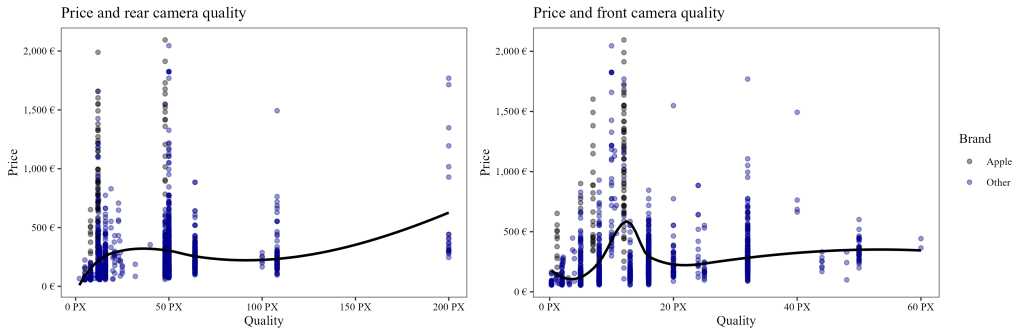


Figure 8: Camera Quality and Price

Figure 8 illustrates the relationship between camera quality and price. Higher megapixels do not necessarily imply higher prices. Most smartphones under €500 have 48 MP or 12 MP rear cameras, while high-end devices (above €1,000) often feature lower MP but superior sensors and processing. Apple devices, despite lower MP counts, maintain high pricing, indicating that factors like sensor quality and brand premium significantly influence price.

These results suggest that while camera resolution impacts pricing, software optimization and sensor quality also play a crucial role.

4.1.5 Storage and RAM

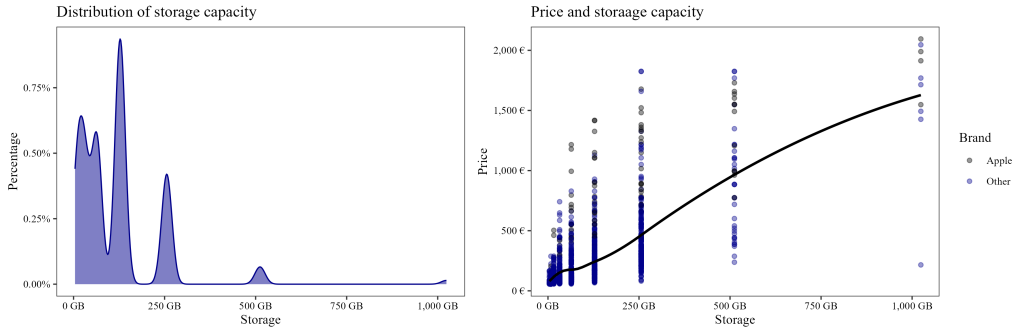


Figure 9: Storage Capacity

Figure 9 illustrates the distribution of storage capacity, with peaks around 128 GB and 256 GB, reflecting common configurations. Higher storage models (512 GB and above) are less frequent but correlate with higher prices, as seen in the price-storage relationship plot.

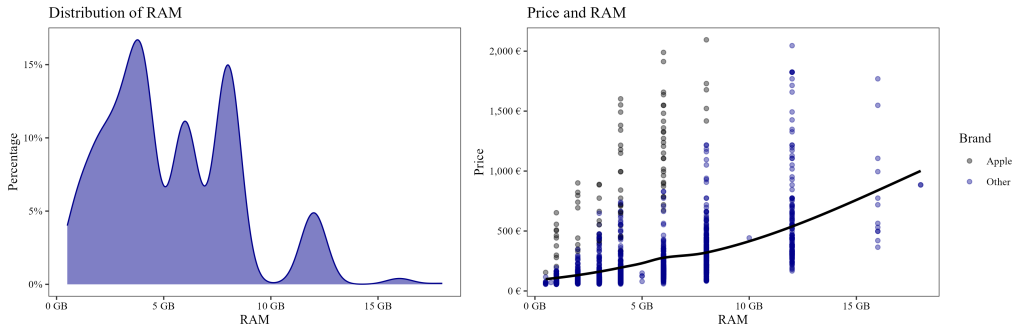


Figure 10: RAM

Similarly, Figure 10 shows RAM distribution, where most devices cluster around 4-8 GB, typical for mid-range and high-end smartphones. The price-RAM plot confirms a positive correlation, with higher RAM leading to higher

prices. However, Apple devices maintain premium pricing despite lower RAM, suggesting that factors beyond memory size, such as optimization and ecosystem integration, play a role in price determination.

4.1.6 Battery Capacity

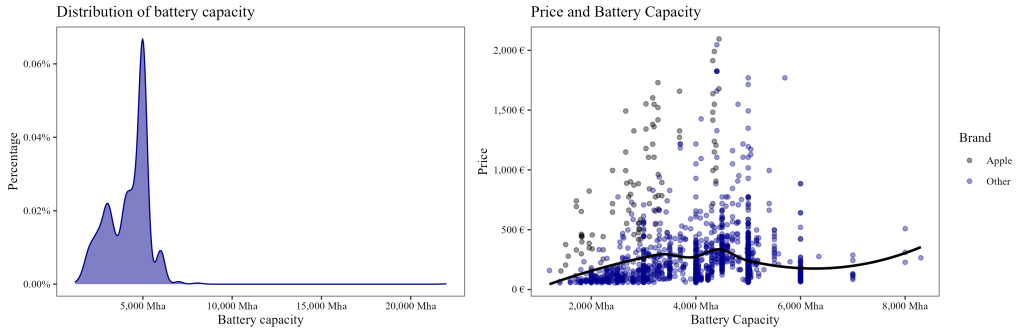


Figure 11: Battery Capacity

Figure 11 shows the distribution of battery capacity, with most smartphones clustering around 4,000–5,000 mAh, which has become the standard for modern devices. Very few models exceed 6,000 mAh, indicating that extreme battery sizes are uncommon.

The price-battery relationship plot reveals a weak correlation. While higher battery capacity generally aligns with mid-range pricing, premium devices, particularly Apple models, maintain high prices despite having lower battery capacities. This suggests that factors like software optimization, processor efficiency, and fast-charging capabilities play a more significant role in premium smartphone pricing than battery size alone.

These results indicate that while battery capacity influences pricing, it is not the primary determinant, as brand perception and overall hardware-software integration are also key factors.

4.2 Inferential Analysis

4.2.1 Regression Model Equation

The estimated regression model is given by:

$$
\begin{aligned}
\log(\text{price}) = \beta_0 &+ \beta_1 \cdot \text{os\_type} + \beta_2 \cdot \text{num\_cores} \\
&+ \beta_3 \cdot \text{main\_rear\_camera} + \beta_4 \cdot \text{main\_front\_camera} \\
&+ \beta_5 \cdot \text{display\_size} + \beta_6 \cdot \text{refresh\_rate} \\
&+ \beta_7 \cdot \text{ram\_gb} + \beta_8 \cdot \text{storage\_gb} \\
&+ \beta_9 \cdot \text{num\_high\_resolution\_cameras} + \epsilon
\end{aligned} \tag{1}
$$

This multiple linear regression model analyses how the technical characteristics of smartphones influence their price, using the logarithm of price as the dependent variable. With an R^2 of 67.8%, the model explains a significant part of the variability in prices, indicating that the variables included play a key role in pricing. Among the most influential factors are operating system, RAM, display configuration and the number of high-resolution cameras.

The operating system has a significant impact on price, with iOS increasing in price by 147.6% compared to Android, reflecting Apple's strategy of positioning its devices as premium products. In contrast, other operating systems do not have a significant impact on price. In terms of hardware, more processor cores (+4.23% per core) and more RAM (+12.1% per GB) significantly increase the price, indicating that these features are key for consumers. Storage also has a positive effect on price, although smaller compared to RAM.

Regarding screen specifications, a larger display size reduces the price by 16.8% per inch, suggesting that more expensive models prioritise panel quality over size. On the other hand, a higher refresh rate (+0.46% per Hz) does increase the price, indicating that 90Hz or 120Hz displays are perceived as a significant improvement.

In the case of cameras, the number of high-resolution cameras (+19.5% per additional camera) has a strong positive impact on price, reflecting the market trend of adding multiple lens to justify higher costs. However, a higher rear camera resolution slightly reduces the price (-0.11% per MP), indicating that the number of megapixels is not the only determining factor in camera quality. In contrast, a better front camera (+0.47% per MP) does increase the price, suggesting that brands are investing more in optimising them.

Table 3: Regression Results

	Model 1
Intercept	4.3932^{***}
	(0.1319)
Operating System (iOS)	1.4765^{***}
	(0.0565)
Operating System (Other)	0.1427
	(0.2979)
Number of Cores	0.0423^{***}
	(0.0088)
Display Size (inches)	-0.0012^{**}
	(0.0004)
Refresh Rate (Hz)	0.0047^{***}
	(0.0012)
RAM (GB)	-0.1684^{***}
	(0.0208)
Storage (GB)	0.0046^{***}
	(0.0006)
Main Rear Camera (MP)	0.1211^{***}
	(0.0061)
Main Front Camera (MP)	0.0012^{***}
	(0.0001)
High-Resolution Cameras	0.1952^{***}
	(0.0310)
R^2	0.6783
Adj. R^2	0.6766
Num. obs.	1960

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

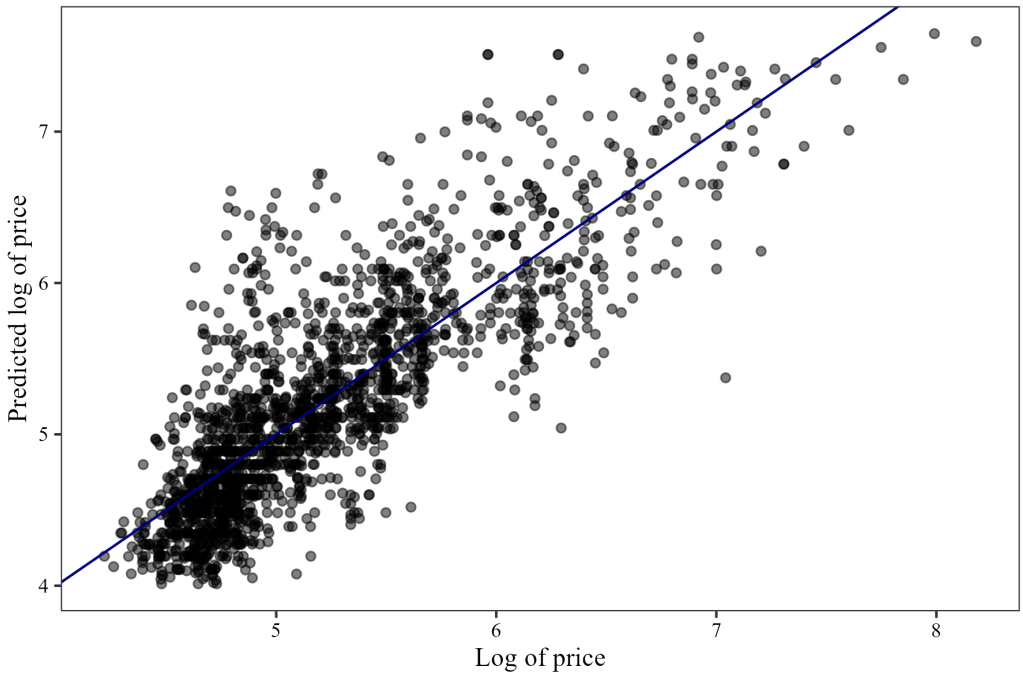


Figure 12: Accuracy of Predictions

4.2.2 Average price brand analyse

To analyse how the general characteristics of smartphones influence pricing at the brand level, brands were classified into three price categories ('low', 'medium' and 'high') based on the average price of their products. The low category was assigned to brands with an average price below €200, medium to those with an average price between €200 and €350, and high to those with an average price above €350. These ranges were chosen based on patterns observed in the market and the need to capture differences in pricing strategy among brands, rather than following the traditional classification by phone segments.

The 200€ threshold allows differentiating brands with a predominantly affordable price strategy, such as Alcatel, Tecno, Infinix, Realme, Xiaomi, Nokia and Lenovo, from those with a more balanced offer between low and mid-range prices. In contrast, the €200-350 range includes brands with an intermediate average price, which are not completely budget-friendly but not premium either, like Huawei, Oppo, Vivo, and Sony. Finally, the €350

threshold distinguishes brands with a premium or value-added strategy, such as Apple, Samsung, Google Pixel and Nubia.

The goal of this classification is not just to divide brands by price levels, but to understand how each brand weights different features in its pricing strategy. While many brands offer phones in different ranges, this approach allows us to analyse whether certain features have more or less impact on price within a brand. In other words, it seeks to identify whether some brands prioritise aspects such as processor, screen or number of cameras differently compared to others, regardless of the range of the device. This provides a clearer view of how manufacturers set their prices and which attributes they consider most important in their product portfolio.

Table 4: Regression Results

	High	Medium	Low
Intercept	3.7090^{***}	5.2053^{***}	3.5206^{***}
	(0.3317)	(0.2629)	(0.1562)
Number of Cores	-0.0905^{***}	0.0014	0.0453^{***}
	(0.0196)	(0.0191)	(0.0076)
Display Size	0.4988^{***}	-0.1759^{***}	-0.0052
	(0.0756)	(0.0441)	(0.0328)
RAM (GB)	0.0614^{***}	0.1061^{***}	0.0813^{***}
	(0.0122)	(0.0132)	(0.0075)
Storage (GB)	0.0016^{***}	0.0012^{**}	0.0001
	(0.0002)	(0.0004)	(0.0002)
Refresh Rate	0.0036^{**}	0.0047^{***}	0.0045^{***}
	(0.0013)	(0.0010)	(0.0006)
Battery Capacity	-0.0004^{***}	-0.0000	-0.0001^{***}
	(0.0000)	(0.0000)	(0.0000)
High-Resolution Cameras	0.3161^{***}	0.0733	0.3079^{***}
	(0.0524)	(0.0574)	(0.0378)
Main Rear Camera	0.0030^{**}	-0.0008	0.0022^{***}
	(0.0011)	(0.0011)	(0.0004)
Main Front Camera	-0.0062^{*}	0.0025	0.0118^{***}
	(0.0028)	(0.0020)	(0.0016)
R^2	0.6654	0.5861	0.6734
Adj. R^2	0.6584	0.5782	0.6706
Num. obs.	435	483	1042

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

For brands with high average prices, the price increases significantly with larger screen size (+49.9% per inch), the number of high-resolution cameras (+31.6% per additional camera), and the amount of RAM (+6.1% per GB). More storage also increases the price, though with a smaller effect. On the other hand, more processor cores reduce the price (-9.05% per additional core), suggesting that high-end models prioritize efficiency over core count because the chip architecture is more important than the number of cores. Similarly, larger battery capacity decreases the price (-4% per 1000 mAh), likely because premium devices optimize power consumption prioritizing fast charging and software efficiency rather than simply increasing battery capacity. Finally, high-resolution cameras significantly increase the price, with each additional camera raising it by 32.6%. However, while the resolution of the rear camera has a positive effect on price, a better front camera slightly reduces it. This may be because, in some brands, megapixel count does not necessarily correlate with photo quality and other factors such as sensors, image processing and artificial intelligence increase quality. As seen in Apple devices, where cameras have fewer megapixels but produce high-quality images. These qualitative aspects of photography are not captured by the model.

For mid-range brands, price is mainly influenced by RAM (+10.6% per GB), internal storage (+0.12% per GB), and screen refresh rate (+0.47% per additional 100 Hz). However, unlike high-end models, a larger screen size reduces the price (-17.6% per additional inch), suggesting that in this segment, panel technology is prioritized over size. Variables such as the number of processor cores, battery capacity, the number of high-resolution cameras, and the resolution of both front and rear cameras do not have a significant impact on price. This indicates that these factors are not key price drivers within this category. Instead, brands dominating this price range focus their marketing strategies on highlighting RAM and refresh rate as justifications for higher prices. In contrast, battery capacity and camera configuration, while important, are not major price differentiators as they tend to be standardized in this segment.

For low average price brands, price increases with a higher number of processor cores (+4.53% per core), amount of RAM (+8.13% per GB), and especially with the number of high-resolution cameras (+30.8% per additional camera), indicating that manufacturers use these features as key price differentiators. In addition, a higher screen refresh rate (+0.45% per Hz) and better front camera resolution (+11.8% per 10 MP) also increase the price. In contrast, storage and screen size do not have a significant impact on price,

as they tend to be standardised in this segment. With respect to battery, higher battery capacity reduces price, reflecting that more accessible phones tend to include larger batteries because they compensate for less efficient hardware. In this segment, brands emphasise visible features (more cameras with higher resolution (+MP), more RAM, more Hz) because they influence consumer perception.

4.2.3 Potential bais in brand effect

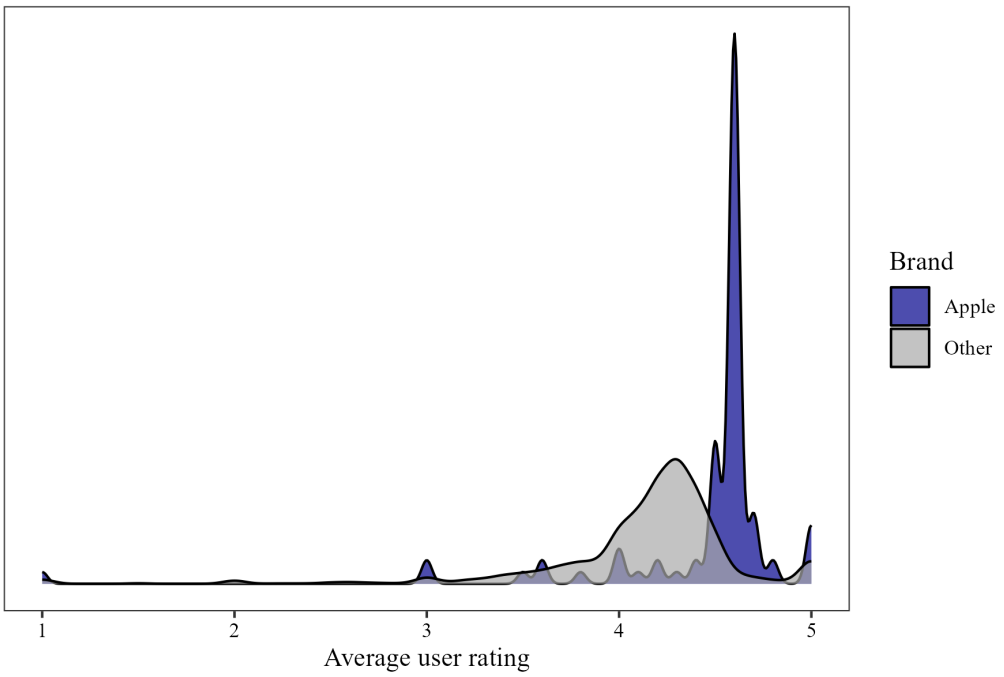


Figure 13: Average User Rating.

An important insight from the previous results is that belonging to some brand allows manufacturers to charge their models more. However, this can be explained by a number of unobservables. For example, we found that Apple's smartphones are more expensive than the others but they are also the only ones to work on IOS.

Therefore, one would argue that brand itself doesn't affect the price but rather does the specific features of brands, like IOS for Apple. This result

does not seem satisfactory. Indeed, we hypothesized prices to be explained by brand image.

Indeed, Apple's models are more expensive but at the same time the average rating from users is higher on Apple than on other types of smartphones, as shows the figure 13. Therefore, Apple has a stronger image and customer loyalty than other brands and can charge its models more expensive.

5 Conclusion

The analysis conducted in this report provides valuable insights into the determinants of smartphone pricing. Through a rigorous process of data collection, cleaning, and modeling, we have identified key features that significantly impact the price of smartphones.

The regression model, demonstrates that technical specifications explain a significant portion of price variability. Our results highlight that the operating system, RAM, display specifications, and the number of high-resolution cameras are among the most influential factors in price determination. However, brand value also plays a crucial role, as evidenced by the analysis of average price per brand. Apple consistently leads in pricing, followed by other premium brands such as Google and Nubia, reflecting the impact of brand perception beyond technical specifications, Apple devices command a substantial price premium compared to Android devices, reinforcing the strong brand perception associated with Apple.

A segmented analysis of price categories revealed that different factors drive pricing strategies in high-end, mid-range, and low-end smartphones. High-end models prioritize screen quality and high-resolution cameras over battery capacity and processor cores, while mid-range brands emphasize RAM and refresh rate. In contrast, low-end models rely on visible features such as a higher number of processor cores and cameras to attract consumers.

These findings have important implications for both manufacturers and consumers. For manufacturers, understanding the key price drivers allows for optimized product positioning and marketing strategies. For consumers, this study provides guidance on which features truly add value to a smartphone and which might be less critical in terms of price justification.

Overall, this study underscores the importance of both technical specifications and brand perception in smartphone pricing. Future research could explore additional variables such as software optimization, ecosystem integration, and long-term device performance to provide a more comprehensive understanding of market trends and consumer preferences.

Figure 14: Grading this project

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