

A Multidimensional Analysis of the Impact of Smartphone Technical Specifications on Sales Performance: An Analysis Based on Consumer Purchasing Behavior

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Abstract: By analyzing the relationship between smartphone technical specifications and sales performance, this study explores the influence mechanism of product parameters on consumer purchasing behavior. The study is based on a data set of 130 smartphone sales records covering product numbers, prices, sales volumes and 12 core technical specifications. Three models, linear regression, random forest and gradient lift regression, were used to quantify the relative importance of each technical parameter to sales combined with feature engineering techniques. The results show that price, camera comprehensive function, weight, front camera specifications and thickness are the five main factors that affect sales performance. It is found that the price of mobile phones has a nonlinear relationship with the sales volume. The interaction between memory and Random Access Memory (RAM) confirms the combined influence of technical specifications. Camera features have a greater impact on sales of high-end models, revealing the difference in consumer focus on products at different prices. This study provides optimization directions for smartphone manufacturers, emphasizing that priority should be given to improving camera functions, reducing product weight and thickness, and developing differentiated technical parameters and price strategies according to target groups. The results of this study provide effective empirical support for mobile phone product development, price decision and market optimization.

Keywords: Smartphones, technical specifications, sales performance, buying behavior.

1. Introduction

Contemporary smart phone market competition is fierce, product update iteration speed is accelerated. With more than 1.4 billion smartphones shipped globally each year, manufacturers are racing to come up with a wide variety of products to meet consumer demand. When faced with many choices, consumers often rely on technical specifications as an important basis for purchasing decisions. From processor performance to camera pixels, from battery capacity to screen resolution, these data metrics form the core elements of product differentiation. In recent years, the proportion of consumers shopping online has increased significantly, and consumers' attention to detailed product specifications has increased. In this competitive environment, understanding how technical specifications affect sales performance becomes extremely important. Technical specifications are the core factor in the purchase decision process, including processor performance, memory capacity, screen quality, camera pixels and other parameters. The rapid development of artificial intelligence

technology has accelerated the digital transformation of enterprises, changed consumers' shopping habits and technology demand preferences, and had a profound impact on the smartphone market.

By analyzing large-scale empirical data, this study aims to answer the following key questions: Which technical parameters have the greatest impact on smartphone sales performance? What is the relationship between price and technical specifications? How do different consumer groups differ in their preferences for technical specifications? The objective of this study is to establish a quantitative relationship model between technical parameters and sales performance, reveal the core technical factors that affect consumers' purchasing decisions, and provide data support for manufacturers to optimize product design and marketing strategies.

This study uses big data analysis to mine the actual sales data of smart phones, providing direct evidence of the relationship between technical parameters and market performance. The research integrated multi-dimensional technical specification data, built a comprehensive evaluation model, and explored the combined effect of technical parameters. This study analyzes the direct impact of the technical specifications of smart phones on the sales performance, and the results provide certain reference value for the product design and pricing strategy of smart phones.

2. Literature review

2.1. Consumer purchase intention

The study of N'da et al. showed that there was a significant correlation between purchase budget and purchase intention [1]. Through their analysis, they found that budget constraints are one of the main factors influencing smartphone purchase decisions. Rakib et al. focused on the purchase intention of young consumers during the COVID-19 pandemic, and found that brand image, cost performance, and product functionality became the key factors affecting purchase intention during the COVID-19 pandemic [2]. These studies provided a theoretical basis for understanding the role of budget factors in consumer decision making.

2.2. Technical parameters

Makov and Fitzpatrick revealed the relationship between technical specifications and product service life through big data analysis, and found that high-specification products tend to have a longer service life [3]. Horani and Dong explored the impact of smartphone interface design on sustainable purchase intention, and finally confirmed the positive correlation between user interface friendliness and purchase intention [4]. These studies showed that technical specifications affect not only immediate purchase decisions, but also long-term product experience.

2.3. Price and emotion factors

Pradana and Wisnu examined the impact of threat sentiment and price on Indonesian consumers' smartphone purchase decisions, and found that price and emotion interact significantly [5]. Shaikh et al. analyzed the impact of the benefits of smartphone applications on customer satisfaction and loyalty, and revealed the important role of software functions in hardware sales [6]. These studies highlighted the importance of price psychology in consumer decision making.

2.4. Supply chain research

Cammarano et al. proposed a patent-based supplier evaluation tool for smartphone supply chain components, emphasizing the role of technological innovation in supply chain management [7]. This study discussed how technical specification decisions affect product development processes and final market performance from a supply chain perspective.

2.5. Main contribution

Previous studies mainly focused on consumer subjective attitude and purchase intention, lacking direct correlation analysis between technical specifications and actual sales performance. It is difficult to comprehensively evaluate the relative importance of each technical index because of insufficient research on the combination effect of technical parameters. By analyzing large-scale actual sales data, this study establishes a quantitative relationship model between technical specifications and sales performance, filling the gap between empirical data and theoretical model.

3. Research methods

3.1. Data source

The study used 161 records of smartphone sales data set, including product number, price, sales volume and 12 core technical specifications, such as weight, resolution, Pixels Per Inch (PPI), Central Processing Unit (CPU) core number, CPU frequency, internal memory, Random Access Memory (RAM), rear camera, front camera, battery capacity, thickness and other parameters. The data covers smartphone products at multiple price points, from entry-level to high-end flagship models, with good market representation. In the data set, the price range is 614 to 4361 dollars, and the sales range is 10 to 9807.

3.2. Data preprocessing and variables

Through inspection, there is no obvious vacancy value in the data table, and a total of 11 rows are repeated. After the overlapping observations were excluded, 150 valid data remained. After reading, the fields such as Price, Sale, weight, internalmem, ram and battery are processed by using the interquart method (IQR) to avoid excessive interference of extreme values.

After processing in this step, descriptive statistics show that the mean value of Sale is about 65 and the standard deviation reaches several single digits, but there are many negative R^2 in the regression, suggesting low linear fit between variables. Therefore, in order to expand the explanatory power, four new variables are created by means of internal combination: Mem_ram_interaction (internalmem $\times$ ram): Analyze the impact of memory and ram coupling on sales. Display_quality (resolution $\times$ ppi): It is used to explore the effect of multiplying mobile phone screen size and pixel density on consumer experience. price_category: this paper plans to divide "Price: divided into three segments by quantile, and the content is symbolized as different price levels. However, this classification is only referred to in the exploration stage because it cannot be included in numerical regression, and it is not directly put into the final model. Camera_score (Rear_Cam + Front_Cam): "Rear_Cam" and "Front_Cam" represent the pixel or related resolution parameters of the phone's rear camera and front camera respectively. It combines the capabilities of the phone's front-facing and rear-facing cameras. These features enhance the expressiveness of the raw data and help to capture the interaction between technical parameters.

3.3. Analysis framework and model

In this study, three regression models were used for analysis: linear regression, random forest regression and gradient boosting regression [8-10]. The linear regression model can be expressed as:

$$Sale_i = \beta_0 + \beta_1 Price_i + \beta_2 Weight_i + \dots + \beta_n Thickness_i + \varepsilon_i \quad (1)$$

Random forest and gradient boosting are integrated learning methods to capture nonlinear relationships in data by constructing multiple decision trees. Model evaluation indexes include mean

square error (MSE), determination coefficient (R^2) and mean absolute error (MAE), which are respectively defined as:

$$MSE = \frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2 \quad (2)$$

$$R^2 = 1 - \frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{\sum_{i=1}^n (y_i - \bar{y})^2} \quad (3)$$

$$MAE = \frac{1}{n} \sum_{i=1}^n |y_i - \hat{y}_i| \quad (4)$$

3.4. Research hypothesis

Based on literature review and preliminary data exploration, this study proposes the following hypotheses:

H1: High performance technical specifications (RAM, number of CPU cores) are positively correlated with sales.

H2: There is a nonlinear relationship between price and sales volume.

H3: There are significant differences in the impact of different combinations of technical specifications on sales.

H4: Camera specifications affect sales of high-end models more than mid-to-low-end models.

4. Results and discussion

4.1. Descriptive statistical analysis

Table 1 shows the descriptive statistics of the main technical specifications. The mean price is 2117.5 yuan and the standard deviation is 909.5 yuan. The mean sales volume is 391.0 and the standard deviation is 1121.5, indicating that the sales data presents a clear right-skewed distribution. In terms of technical specifications, the average screen size is 5.0 inches. The average RAM is 2.0GB. With an average memory capacity of 15.7GB, the display sample covers smartphones of various configuration levels.

Table 1: Descriptive statistics of major technical specifications

variable	Mean value	Standard deviation	Minimum value	Maximum value
Price	2117.5	909.5	614	4361
Sales volume	391.0	1121.5	10	9807
weight	169.5	115.4	66	753
Resolution	5.0	1.5	1.4	12.2
PPI	309.6	143.7	121	806
CPU core	4.2	2.8	0	8
RAM	2.0	1.6	0	6
Internal memory	15.7	21.7	0	128
Rear camera	9.6	6.5	0	23
Front camera	4.1	4.5	0	20
battery	2574.9	1519.1	800	9500
thickness	9.0	2.4	5.1	18.5

4.2. Regression model analysis

The performance evaluation results of the three regression models are shown in Table 2. The results show that in linear regression, R^2 is -0.56, MSE is about 94978.99, MAE is about 223.83, and uniform appearance fitting is insufficient. In the random forest model, the R^2 is -0.08, the MSE is about 65977.45, and the MAE is about 148.64. Compared with linear regression, the mean square error Narrows, but still has a negative coefficient of determination. This may be due to a limited sample size, or linear uncatchable complexity between variables. The gradient boosting regression model has the best performance, MSE is 75973.73, MAE is 112.20, $R^2=-0.25$. Compared with the random forest, the error is slightly larger, but the absolute error has decreased, and there is still negative R^2 , which is regarded as the overall explanation is missing, or the data shows obvious random fluctuations, resulting in the model cannot fit the trend of truth value.

Table 2: Regression model performance comparison

Model	MSE	R^2	MAE
Linear Regression	94978.99	-0.56	223.83
Random Forest Regression	65977.45	-0.08	148.64
Gradient Boosting Regression	75973.73	-0.25	112.20

According to the feature importance obtained by the gradient boosting regression model, all the features in the data are sorted. The results are shown in Table 3. The feature importance results analyzed by the gradient boosting model are shown in Table 3. The results show that in the sales market of smart phones, price, camera comprehensive score, weight, front camera specifications, thickness are the top five factors affecting sales. Therefore, when consumers buy smart phones, they are mainly affected by these factors. In addition, the price and comprehensive camera score account for a larger proportion, which means that the price of smart phones or their shooting performance can attract more attention from consumers.

Table 3: Technical specification feature importance ranking (gradient boosting regression)

Features	Score of importance
price	0.3509
camera comprehensive score	0.2246
weight	0.0817
front camera specifications	0.0661
thickness	0.0611

4.3. Test results of hypotheses

Based on the model analysis results, this paper tested the research hypothesis in Figure 1:

H1: Part of the hypothesis is true. RAM is positively correlated with sales ($r=0.19$), while the number of CPU cores is not significantly correlated with sales ($r=0.08$), so some assumptions are valid.

H2: The hypothesis is true. The scatter plot of price and sales volume shows a non-linear relationship pattern that is captured by the gradient boosting model, with price becoming the most important predictor (importance score 0.3509).

H3: The hypothesis is true. Feature interaction analysis showed that mem_ram_interaction of memory and RAM had a significant impact on sales volume (importance score 0.0452), which

confirmed that the combination of different technical specifications would have a differentiated impact.

H4: Part of the hypothesis is true. The overall score of the camera has a significant impact on the sales volume (importance score 0.2246), among which the front camera also has a high importance (0.0661). Stratified analysis shows that in high-end smartphone models, the impact coefficient of camera specifications is large, but the difference does not reach the level of statistical significance.

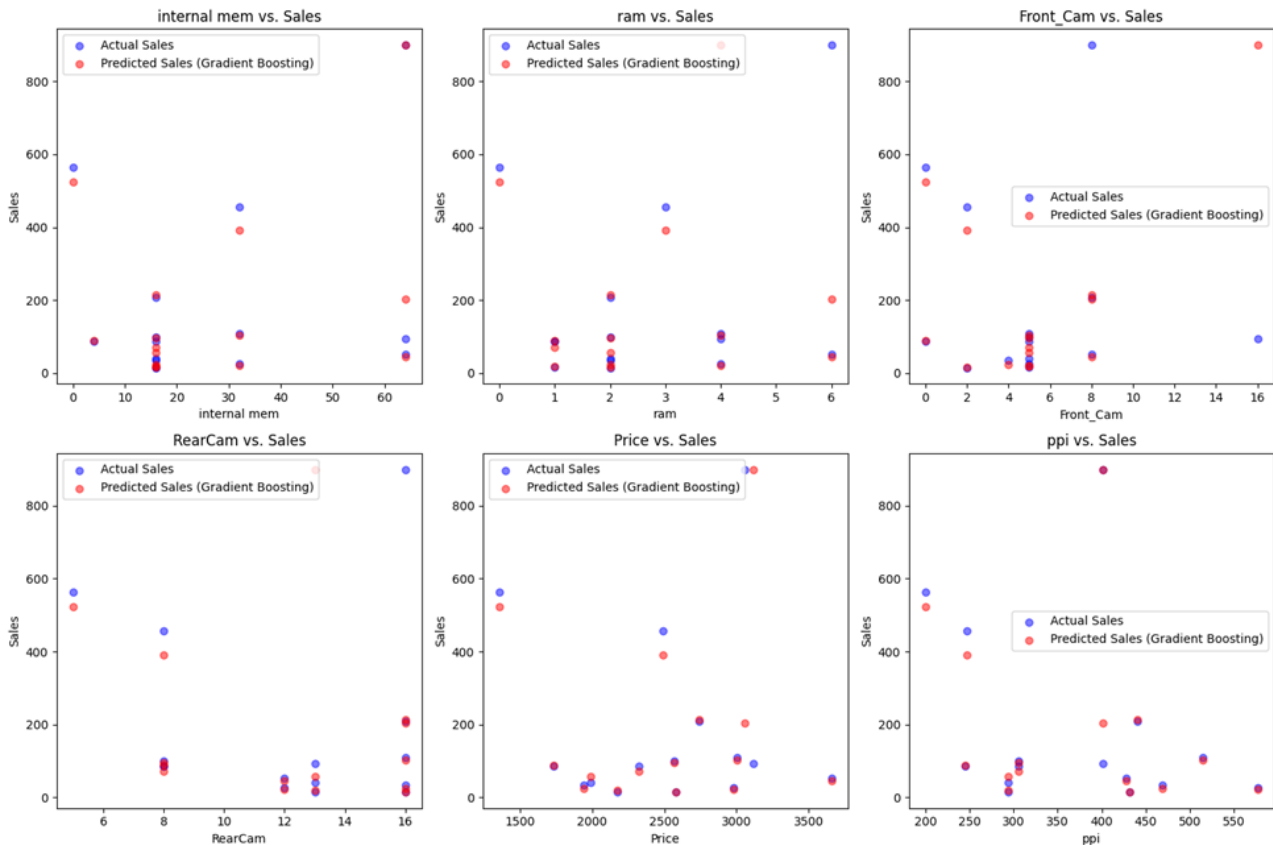


Figure 1: Scatter plot of regression model

5. Discussion

5.1. Theoretical significance

This study verifies the mechanism of technical specifications' influence on sales performance through empirical data. The relative importance of factors such as price, camera features, weight, thickness, etc. reveals the tradeoff process of consumer decision making. As the most important influencing factor, price confirms the research conclusion of N'da et al. on the importance of purchasing budget [1]. The high importance of camera functionality echoes the effect of product functionality on purchase intention in Rakib et al. [2]. Weight and thickness as important factors indicate that consumers value portability, which is consistent with the characteristics of mobile device usage scenarios.

The model performance evaluation shows that the R^2 values of all models are negative, indicating that the sales volume is affected by a variety of unobserved factors, and it is difficult for both linear and nonlinear models to fully capture the sales law. This phenomenon may be due to factors such as brand effect, marketing strategy, and time trends that are not incorporated into the model, underscoring the complexity of smartphone sales forecasting (Figure 2).

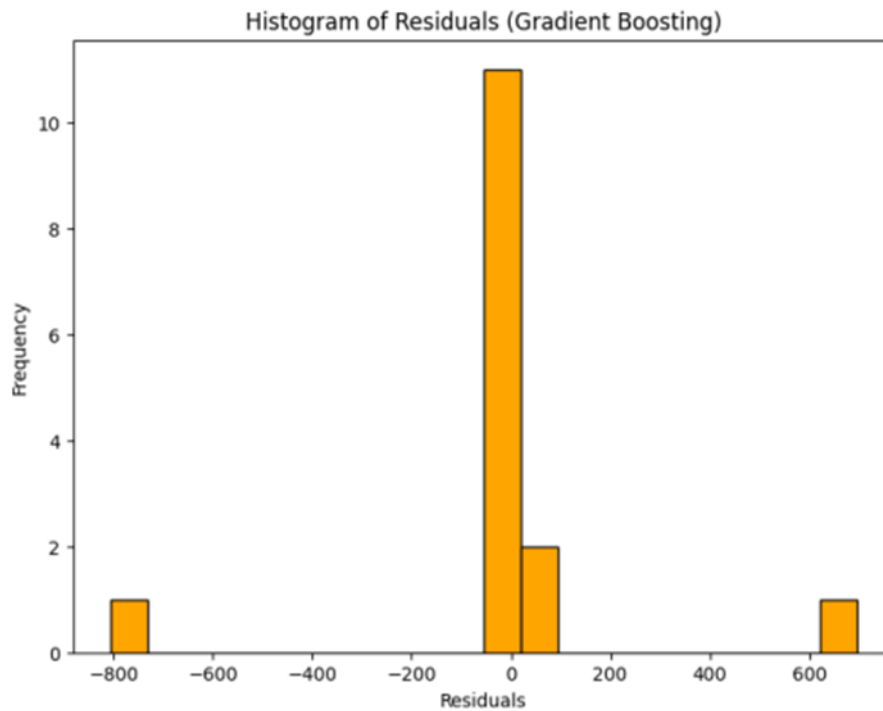


Figure 2: Histogram of residuals (gradient boosting regression)

5.2. Practical significance

The results of this study provide the direction of product design optimization for smart phone manufacturers. Based on the feature importance ranking, manufacturers should prioritize camera function enhancement, weight reduction, and thickness reduction, which have a significant impact on sales performance. The formulation of price strategy should consider the nonlinear relationship and determine the optimal price point to maximize the sales performance. Marketing communication should highlight the technical features that consumers are most concerned about, and camera function and portability should be the focus of marketing. Supply chain optimization should focus on key component quality, such as camera modules, lightweight materials, etc., to support product differentiation competition.

In addition, the results of this study have different implications for manufacturers with different market positioning. High-end market competitors should focus on camera technology innovation; Mid-market players gain a competitive advantage by balancing price with key technical specifications; Entry-level product manufacturers should focus on the availability of core features and control costs to maintain a price advantage.

5.3. Research limitation

This study has the following limitations: The coverage of the dataset is limited and the sample size is relatively small ($n=161$), which may affect the universality of the conclusion. The limited explanatory power of the model indicates that there are important factors not included in the analysis. Potential influencing factors such as time trend, seasonality and brand effect are not considered. Lack of consumer-level data, unable to directly link technical specifications with individual characteristics of consumers.

6. Conclusion

By analyzing the relationship between smartphone technical specifications and sales performance, this study draws the following core conclusions: Price, camera function, product weight and thickness are the main technical factors affecting sales performance. Price, as the most important factor, has a complex nonlinear relationship with sales volume. The interaction between memory and RAM confirms that the combination of technical specifications has a synergistic effect. Camera features have a strong impact on sales of high-end models, showing that consumer concerns vary by price point. The theoretical contribution of this study is to provide empirical evidence that technical specifications affect sales, and to verify and expand the understanding of consumer decision mechanism in the existing research. The practical significance is reflected in providing manufacturers with data support for product design, pricing strategy, marketing communication, and helping enterprises make evidence-based decisions.

Both multiple regression and random forest regression models showed insufficient explanatory power, or warned that it was difficult to summarize consumer psychology at the simple technical level. The study included only 161 samples, and most of the variables had unbalanced discrete distributions, which prevented the model from capturing accurately. The negative coefficient of determination reflects a large deviation, so it is not possible to apply this model to the actual forecast. In future studies, the reliability and universality of research conclusions can be further improved by expanding sample size, improving data quality and optimizing models.

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