Analysis of Factors Influencing Smartphone Prices

Jingchen Cui[1][a], Xinyu Wang[2,*][b] and Yichen Zheng[3][c]
[1]School of Mathematics, Southwest Jiaotong University, Chengdu 610097, China
[2]School of Statistics and Mathematics, Beijing Jiaotong University, Beijing, 100044, China
[3]School of Statistics and Mathematics, Shandong University of Finance and Economics, Jinan, 250002, China
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Abstract: As a necessity of modern life, the price of smartphones is affected by multiple factors, such as hardware cost, technological innovation, and marketing strategy. To deeply investigate the common role of various factors on smartphone pricing, this study is based on a dataset containing 980 basic attributes of smartphones, improves the data quality through preprocessing steps such as dealing with missing values and deleting outliers, and filters out the significant variables by using backward stepwise regression. On this basis, this study constructs a multiple linear regression model by linear regression method, conducts regression analysis and concludes that factors such as processor speed, Random Access Memor (RAM) size and internal storage capacity have a positive impact on smartphone price, while factors such as user rating, processor cores and battery capacity have a negative impact. The results of the study not only provide consumers with a scientific basis for purchasing decision-making but also provide theoretical support for manufacturers to optimise product pricing strategies and improve market competitiveness, which is of great significance in promoting the healthy development of the smartphone market.

1 INTRODUCTION

With the advancement of technology and consumer demand, the smartphone market has shown a booming trend. Major mobile phone brands continue to compete for market share through technological innovation and marketing strategies. Consumers' attention has gradually shifted to product features, performance, and cost-effectiveness. (Wang & Wang, 2022). In this context, it is of great practical significance to study the influencing factors of smartphone prices in depth. For consumers, clarifying the influencing factors of price will help them better understand the differences between products at different price levels so that they can make the best choice according to their own needs and budgets. For enterprises, mastering these key factors not only helps to develop a scientific pricing strategy but also provides a strong basis for new product development and marketing, helping enterprises to occupy a favourable position in the fierce market competition and achieve sustainable profitability (Qin & Ren, 2021).

At present, the price of smartphones is affected by multiple factors, such as production costs and technological innovation, and price-related research is a hot topic in current market research, which has been studied by many scholars. Ahmed, Ahmad, & Bashir (2022) analyzed the effect of mobile phone attributes on price through the Hedonic price model and found that 4G mobile phones are significantly more expensive than 3G mobile phones and that consumers are willing to pay this premium for faster data transfer speeds and more reliable network technology. Tanveer et al. (2021) noted that price has a significant effect on mobile phone purchasing behaviour among young people, while factors such as convenience, Liu & Mo (2021) used event-related potentials (ERPs) to investigate the potential neural mechanisms of the price of the reviewer's mobile phone on consumers' purchase intention, and found

[a] https://orcid.org/0009-0003-3609-6665
[b] https://orcid.org/0009-0003-3088-5778
[c] https://orcid.org/0009-0005-8294-8966

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that the price of the reviewer's mobile phone had a positive effect on consumers' purchase intention.

The academics also looked at how to build more accurate price models to better predict and analyse mobile phone prices.

Chen (2024) improved the hedonic price index model by incorporating LASSO regression and the RYGEKS index method, effectively addressing multicollinearity issues among variables. Xu (2022) adopted multiple machine learning classification algorithms for mobile phone price categorization and prediction, identifying logistic regression as the optimal model. Han, Li, & Du (2022) proposed an adaptive price adjustment method based on a Dual Deep Fuzzy Network (DDFN) for the second-hand mobile phone market, ensuring accuracy and reliability in recycled device price adjustments. Existing studies demonstrate that mobile phone pricing is influenced by complex multidimensional factors, necessitating the adoption of advanced modeling approaches to enhance price prediction accuracy.

This study focuses on the pricing mechanism of smartphones, exploring in depth the key factors affecting smartphone pricing by referring to industry reports and analysing multi-dimensional data. Aiming at the problems of insufficient model accuracy and time lag in existing research on price influencing factors, this study constructs a more comprehensive linear regression model by analysing relevant pricing factors. The study aims to provide a two-way reference for consumers and enterprises and promote the healthy development of the smartphone market.

2 LINEAR REGRESSION METHODS AND DATA SOURCES AND PRE-PROCESSING

Linear regression methods are mainly used to study the linear relationships between variables and to model them for prediction and data analysis (Maulud and Abdulazeez, 2020). This study constructs a multiple linear regression model with smartphone price as the response variable and each key factor affecting mobile phone price as the predictor, and analyses the correlation between these factors and smartphone price.

This study uses a comprehensive dataset from the Kaggle website, which presents an all-encompassing collection of information on all the latest smartphones existing in the market, which can be used for in-depth analysis of the factors affecting smartphone pricing (Kaggle, 2023). The dataset was created by Abhijit Dahatonde and contains basic attributes of 980 different types of smartphones, covering a wide range of information such as brand, model, configuration, etc (Kaggle, 2023).

Before analyzing the collected dataset, data preprocessing was conducted to enhance data quality and ensure analytical reliability. First, missing data were addressed through mean or median imputation based on variable distributions. Subsequently, price values were converted from Indian Rupees (INR) to US Dollars (USD) using the exchange rate to standardize numerical variables for quantitative analysis. Finally, outliers were identified and addressed through rigorous statistical inspection, with two anomalous data rows removed to mitigate their distorting effects. This preprocessing resulted in a refined dataset containing 978 validated observations for each attribute.

3 INDICATORS SELECTION

The dependent variable of the multiple linear regression model constructed by this research is the price of smartphones. The predictor variables include the average customer rating, the number of cores in the processor, the processing speed of the processor, etc. Table 1 shows the naming and interpretation of the variables:

Table 1: The naming and explanation of variables

Variables	Explanation of Indicators
y	The price of the smartphone in USD
x_1	The average customer rating
x_2	The number of cores in the processor
x_3	The processing speed of the processor
x_4	The battery capacity
x_5	The wattage of the fast-charging feature
x_6	The amount of RAM
x_7	The internal storage capacity
x_8	The diagonal screen size
x_9	Indicates whether the phone supports expandable storage
x_{10}	The height of the screen resolution
x_{11}	The width of the screen resolution
x_{12}	Indicates whether the phone has 5G support or not
x_{13}	The screen refresh rate
x_{14}	The number of rear cameras
x_{15}	The resolution of the primary rear camera
x_{16}	The resolution of the front camera

Since insignificant variables would reduce the goodness of fit of the model, this study employed backward stepwise regression to gradually eliminate the insignificant variables, thereby enhancing the reliability of the model. Set the significance level to 0.05, Table 2 lists the excluded variables:

Table 2: The Excluded Variable

	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}
p	0.839	0.707	0.526	0.838	0.217

As can be seen from Table 2, the P values of the five variables in the table are all greater than 0.05, which indicates that the influence of x_{12}, x_{13}, x_{14}, x_{15}, x_{16} is not significant and thus has been excluded.

4 MODEL CONSTRUCTION AND REGRESSION ANALYSIS

Based on the backward stepwise regression method, factors significantly influencing the price of smart phones are selected to construct a multiple linear regression model. The regression equation is as follows:

$$y = -76.027 \times x_1 - 78.904 \times x_2 + 220.091 \times x_3 - 0.036 \times x_4 - 1.885 \times x_5 + 9.899x_6 + 1.532 \times x_7 + 98.088 \times x_8 - 105.903x_9 + 0.100x_{10} + 0.205x_{11} + \varepsilon \quad (1)$$

The regression analysis of the model was conducted using R software. With the significance level set at 0.05, the regression results are presented in Table 3.

Table 3: Linear regression analysis results

	B	Standard error	Beta	t	p
x_1	-76.027	10.966	-1.154	-6.933	0.000
x_2	-78.904	9.216	-1.192	-8.562	0.000
x_3	220.091	22.823	1.048	9.643	0.000
x_4	-0.036	0.007	-0.344	-5.045	0.000
x_5	-1.885	0.271	-0.194	-6.954	0.000
x_6	9.899	3.868	0.136	2.559	0.011
x_7	1.532	0.080	0.524	19.058	0.000
x_8	98.088	15.990	1.241	6.135	0.000
x_9	-105.903	19.637	-0.163	-5.393	0.000
x_{10}	0.100	0.017	0.441	5.850	0.000
x_{11}	0.205	0.026	0.442	7.965	0.000
R^2	0.845				
Adjusted R^2	0.843				
F	F (11,967) =478.891, p=0.000				

According to the data analysis in Table 3, the processing speed of the processor(x3), the amount of RAM(x6), and the internal storage capacity(x7) have a positive impact on smartphone prices, which reflects the significance of processor performance and storage capacity in determining the prices of smartphones. Similarly, Ahmad, Ahmed, & Ahmad (2019) also confirmed that storage capacity plays an important role in determining the price of smartphones.

Meanwhile, the screen size(x8) is also positively correlated with the smartphone prices. This might be because larger screen sizes lead to higher costs for smartphones, and large-screen phones have advantages in terms of visual experience and operational space. Tanveer et al. (2021)'s research results are in line with this finding. Moreover, the screen resolution(x10, x11) also has a significant positive impact on prices, which might indicate that consumers prefer smartphones with clearer screens.

Obviously, this study also has some key factors that are negatively correlated with the price of smartphones. Specifically, the average customer rating(x1) has a negative correlation with the smartphone prices. This discovery reflects the trend that the higher the average rating of a smartphone, the lower its price. This might imply that consumers prefer smartphones with better value for money. It is also worth noting that the number of cores in the processor(x2) and the battery capacity(x4) also have a negative impact on the smartphone prices. Generally speaking, the more cores a smartphone processor has or the larger its battery capacity is, the heavier the smartphone will be. This outcome implies that consumers may prefer the slim and portable models. In addition, the wattage of the fast-charging feature(x5) is also in an inverse relationship with the smartphone prices, which might reflect that there is a trend for low-priced smartphones to adopt fast-charging technology. Finally, whether the smartphone supports expandable storage(x9) is also negatively correlated with its price. Mid-range and low-end smartphones often enhance their cost-effectiveness and appeal by supporting storage expansion. Chen (2023) reported a similar conclusion.

5 ADAPTIVE TEST OF THE MODEL

Table 4: Model summary

R	R^2	Adjusted R^2	RMSE	MAE	RMR
0.919	0.845	0.843	203.812	132.403	205.074

As can be seen from Table 4, the correlation coefficient R is 0.919, indicating a strong positive correlation between these influencing factors and the price of smartphones. The coefficient of determination R^2 is 0.845, which indicates that this model can account for 85.3% of the variation in smartphone prices. Adjusted R^2 is an adjustment to R^2, and its value is 0.843, indicating that this model has a relatively good goodness of fit. It is also worthy of attention that the values of Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Relative Mean Residual (RMR) are relatively small, indicating that the prediction accuracy of this model is relatively high.

Figure 1 presents the standardized residual plot and P-P plot. From Figure 1, it can be observed that the distribution of residuals is basically per the normal distribution, which indicates that the reliability of the model is relatively high.

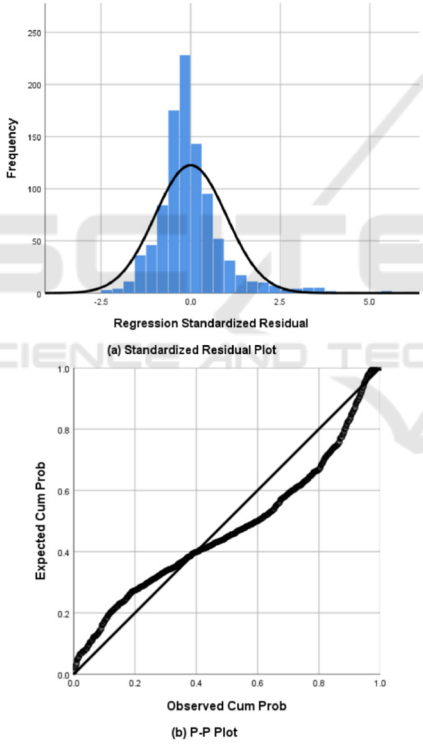

Figure 1: Residual diagnosis chart (Photo/Picture credit: Original).

Table 5: ANOVA form

	Sum of squares	df	Mean square	F	p-value
Regression	221310274.906	11	20119115.901	478.891	0.000
Residual error	40625502.027	967	42011.895		
Total	261935776.933	978			

As shown in Table 5, the model passed the F test ($F=478.891$, $p=0.000<0.05$), which indicates that the construction of the model is meaningful. Therefore, the multiple linear regression model constructed in this study has a very good explanatory power for understanding how different characteristics affect the prices of smartphones.

6 CONCLUSION

Through linear regression analysis, this study has revealed the key factors influencing the prices of smartphones. The positive impacts of the processor speed, the amount of RAM, the internal storage capacity, the screen size and the screen resolution indicate that consumers prefer phones with superior performance and are willing to pay higher prices for them. On the other hand, the negative impacts of the average customer rating、the number of cores in the processor, the battery capacity, charging power and the support for storage expansion by smartphones reveal another important feature of the current smartphone market. That is, when consumers purchase smartphones, they pay more attention to the overall practicality and cost-effectiveness of the devices rather than the mere accumulation of single functions. It is worth noting that although the model constructed in this study has a relatively good explanatory power, its R^2 value is less than 1. This indicates that there are still other unaccounted influencing factors that need to be captured. Future researchers should adopt a more comprehensive approach to construct a new model.

Based on the findings of this study, smartphone manufacturers should focus their attention on the core functions of their products and formulate reasonable pricing strategies to meet consumers' pursuit of cost-effectiveness and practicality of functions. Meanwhile, manufacturers should avoid overloading the product configuration. Instead, they should attract consumers by optimizing product design and functional combination, thereby maximizing profits.

AUTHOR CONTRIBUTIONS

All the authors of this article have made the same contribution. The names of the authors are listed in the order of the initial letters of their surnames.

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