Using Differential Model to Find the Best Time to Buy the IPhone

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Abstract. This research is important can help consumers find the best time to buy a new type of iPhone and help companies and manufacturers change their method to decide the price of their products. The data of the price and time are collected, and other variables like the market's reaction are concerned. The main method is using a differential model that can find local minimums of the price curves of each kind of iPhone. All the variables are turned to a single one through building up functions. The result shows the time period between the end of the second month and the beginning of the fifth month is suitable for buying, and the fourth month is the best time. The suggestion for consumers is not to be too impatient to buy it. The suggestion for manufacturers is to produce and sell in a proper amount and price. The suggestion for market studiers is to build a similar or even better model to predict the price of similar products. Therefore, this research has great significance.

Keywords: Model, Price, Time, Economics, Mathematics.

1. Introduction

In contemporary society, global circulation of commodities happens everywhere, and large brands sell their products to the consumers all over the world. There are some brands which have a series of goods and keep publishing new versions of their products. An essential question for consumers to consider is when to buy them.

In this essay, the author wants to use iPhone as an example to show the general rules of price fluctuations of an iPhone. First, when a new type of iPhone is released to the market, its price may rise to an unreasonable height that far exceeds the cost of assembling a phone. However, after a few months, the price might decrease in large amount. Although it might be a good idea to buy the phone later in order to save money, it is closed to the date that the next version of iPhone will be released. Overall, the main problem consumers find when they choose their phones is to estimate the time to buy that balances the price and the timeliness. People may make mistakes on the opportunity of purchasing. A pape for reference said, 'the closer in time one is to having a possession, the more difficult it is to delay gratification.' It can be linked to a terrible piece of news fourteen years ago. Back to the time when iPhone 4 was published and many Chinese people pursued that as a symbol of richness. A student named Wang sold one of his kidneys in the black market and used the money touy an iPhone 4. That was a sad message that that student made a wrong decision on the time to buy the product, and he did not learn how to delay gratification [1-3].

The purpose of the research in this essay is to build up a mathematical model to indicate the best time to buy the products. It has positive effects on both the consumers and the market. First, this model can help consumers have a better consumption view. There are still a large number of people who blindly waste money on the same brand without considering whether there is a need of the product right away. Also, many people have the behavior of keeping saving money by seldom buying, even when facing difficulties without a certain kind of product. In such case, some products have already lost their competitiveness in the market when they are bought. It is important for people nowadays to make a wise decision onthe time of buying products. For other companies, especially those that have a series of high-tech products like electronic devices, this model can also be helpful, since they can develop their pricing strategy by decreasing the price sold in the first month or the last few months before the next product is released. It may also be helpful for studiers of economy and

business management since they can learn how the consumers and brands think of the price of the product.

The research will answer how to use a mathematical model to predict how the price of the new version of iPhone change with time. The author used statistics graphs and use the derivatives to calculate the final result. Also, the author will answer why the estimated best time to buy the iPhone influence consumers' final decision and help them to develop a correct view towards a new product.

The essay will be divided into several parts. First,the author will show the raw data of the releasing date and the price during different time periods of different types of iPhone these years, and assume how the market affects the price of iPhone. Next, the author will introduce the mathematical model in detail, including its variables and parameters, and will use differential function to find the average decreasing rate of the price. After that, the author will use historical data to verify the model and find if there is some way that it can be improved and adjusted. Then, the best time to buy the iPhone will be determined. At the end of this essay, it will include suggestions for consumers, for manufacturers as well as market studiers about the price of the product and different market strategies. There will also be a conclusion part that how this research contributes to economy market managing and the direction of future research.

2. Case Description

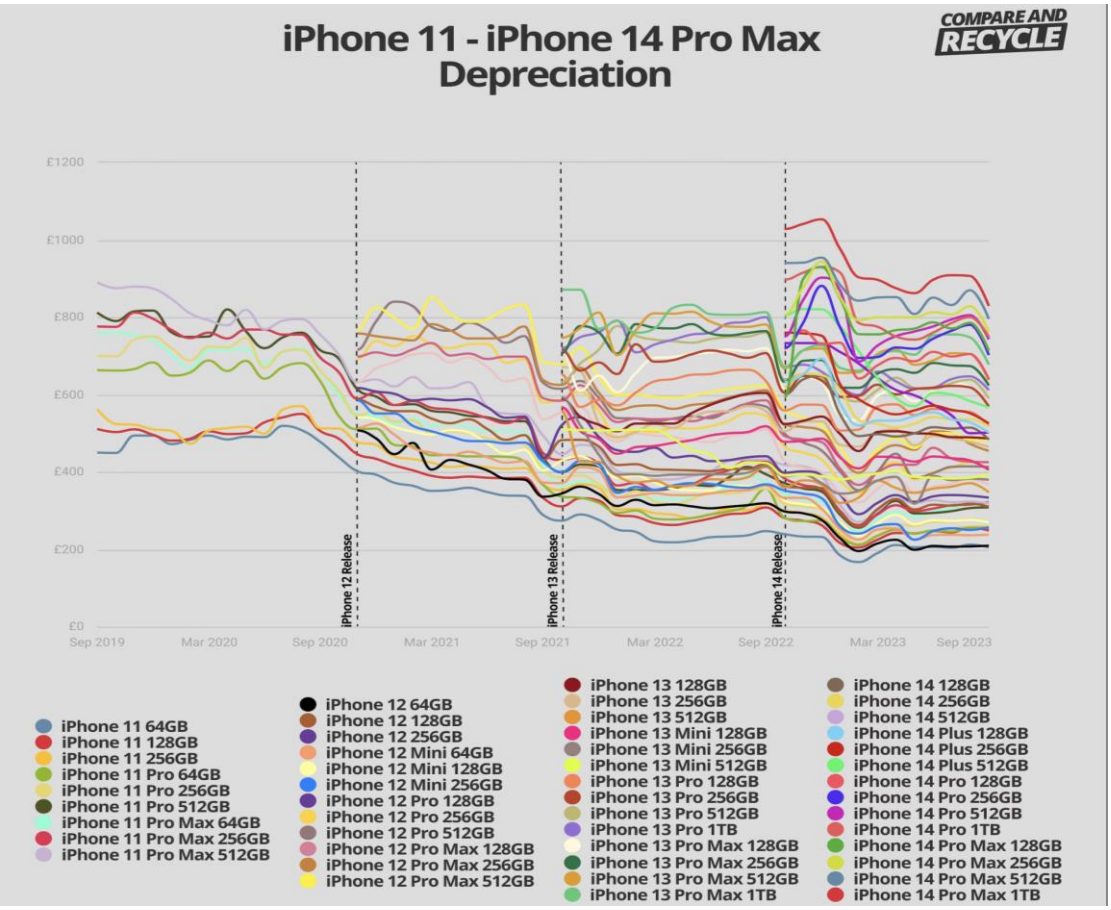

Figure 1. The price depreciation of iPhone these years

2.1. Collecting Data

For the data of the price depreciation, the most specific one is from a website from the UK which shows how the average price of every type of iPhones from iPhone 7 change in the country in the figure 1. There are also some other sources of raw data such as websites from the US. The author failed to find market reports from Google Scholar or Jstor. The final decision is to use the data from the British website [4].

2.2. Tendency of the Price

Generally, in the first month after a new device is released, the price of the new type of phone is at its highest point. In the second to the fifth month, the price went down directly. In the sixth to the eleventh month, it's still decreasing but at a relatively lower rate. In a year after, when the second product is released, the former one drop in an extremely fast speed.

2.3. Reaction of the Market

From the graph, there is some rise and fall. That is because the market can change the of the the new iPhone in several ways. For example, the supply chain of the product matters. The price of phones is more likely to increase when the original material and the price to hire assemblers increases, or when the production and production efficiency decreases. For instance, the production of iPhone 12 decreased about 20% because of the COVID-19 pandemic, bhe demand of new phones never stopped growing. So, the initial price of iPhone 12 went significantly higher than iPhone 11. Second, the phone definitely has innovations and new functions than the older ones, but the significance and consumers' satisfaction is different between generations. For example, a lot of people believe iPhone 12 is a huge success because the lighter weight and its innovation of wireless charging and 5G cellular network have been widely praised among consumers. However, iPhone 13 did not have as much development as iPhone 12. In the previous websites talked in 2.1, the price of iPhone 12 surprisingly increased a little when iPhone 13 is published. The third way to influence the price is the reaction of the competitors on the market. Samsung released its Galaxy S21 4 months after iPhone 12. S21 had a better camera and some other advantages. It is easy to assume that a number of people who had waited the iPhone price to drop in January bought Samung instead. Another example is in September 2023, when iPhone 15 and Huawei Mate 60 is released to Chinese market at the same time. Huawei is the biggest electronic device company in China and uses Android system. Huawei Mate 60 was regarded as the most successful one in performance and creativity among all Huawei products at that time. Both Apple and Huawei created many advertisements on Chinese social medias. Many bloggers used the method of lottery of transmit having reward to encourage users to help advertise it. To win the business battle, Apple needed to decrease its money to ensure its high-cost performance. Despite these, we should view the general changes [5-9].

3. Problem Analysis

3.1. Setting up the Model

The model chosen for this problem is differential function. The first raw model to measure the value of buying an iPhone by dividing its price with the number of months before the second or the third new phone is released. Then PEOPLE realized that the graph of the price depreciation looks like an exponential function with negative exponent more. Therefore, it's better to use $\sqrt{x}$ as fundamental and x is the number of months. The higher this figure is, the more value to buy the phone. In addition, the calculated value for the last few months for the former model is too high. Using $\sqrt{x}+1$ is the best idea. The final figure of the first and the last month is about the same, which are both not worthy [10].

The final equation is $\frac{p}{\sqrt{t}+1}$, while p is the price of the phone, and t is the time to the next phone. PEOPLE will also draw the graph of different generations on LoggerPro to see how the value changes. Typically, the lower this value is, the better the time is to buy the phone.

Then, PEOPLE will differentiate this equation. First, we know that the rule of differentiating fraction is in the equation (1):

$$f'\left(\frac{a}{b}\right)=\frac{b'a-a'b}{b^2} \tag{1}$$

$(\sqrt{t}+1)'$ is $\frac{1}{2}t^{-\frac{1}{2}}$Therefore, the differential equation can be written as $\frac{\frac{1}{2}t^{-\frac{1}{2}}p\prime+(\sqrt{t}+1)p}{t+2\sqrt{t}+1}$The price, p, can be described using logarithm function of t. The function is about $-50\ln(t+1)+600$.

3.2. Result

After some complex differential calculation, the result shows the third and fourth month may be the best time to buy the iPhone.

The data PEOPLE found on the website can prove this. Most phones at this time have a local minimum during the period between the fourth and the fifth month (table 1).

Table 1. The Situation of Certain Months in the First Year

Month	Number
2~3	11
3~4	14
4~5	20
5~6	15
others	17

The main disadvantage of this model is unabling to quantify the level of innovation and the result competitor's reaction. It is too simple to give an exact prediction of when to buy the phone. Also, the coefficient and constant in that model is mainly guessed to match the need of keeping the value of the first and the last month the same. For improvement, it will include quantitive data of innovation by calculating the sum of the importance of every change the new iPhone has.

Through the study, the proper time to buy a new iPhone can be between the end of the second month and the beginning of the sixth month. The best time is in the fourth month, and the third and the fifth month are also good choices.

4. Suggestions

4.1. Suggestions to Consumers

The suggestion the author wants to give to the consumers is not to buy the iPhone so immediately, especially when they do not have a clear understanding of the new functions or developments. They will not only lose a certain amount of money, but also feel regreted if the usage of the phone is not as shocking as they thought. When the time goes on, the consumers can decide whether to buy. The factors of what the innovation of this phone, the number of production and the comparison between iPhone and the new phones of the other brands can all be considered to be the reason of buying. Then, when it is the last few months before the second new phone, it is not appropriate for consumers to buy the phone. However, when the second new phone does not have any development the consumers want, it is reasonable to buy the older one.

However, the things the consumers persue varies. According to a research mentioned in a journal article, 34 college students were asked what aspects they care about when they need to buy differs in a wide range. For the consumers who eagerly want to have a taste of the new functions, they may buy the phones immediately after it is released. For those who only look at the price, they often buy the phone after more than two or three years, or even buy second-hand phones. Therefore, the most conclusive factor is the thoughts of individuals. This paper is just used for suggestions to consumers. They can save more money to get the best service if they think of a series of variables.

4.2. Suggestions to Companies and Manufacturers

For the Apple official, it should be noticed that the change in price can also change the market demand. Lower price usually means higher demand. If the company wants to have high demand earlier or later, it should adjust the release price. The company can also decide to sell the products to

different kinds of potential customers at different times. For example, luxury brands like Chanel and LV always sell their latest products for an extremely high price, even some of them are not widely praised by consumers. People who are affordable at this stage are richmen or crazy fans of the brand. The company then knows who the basis of consumption is.

4.3. Suggestions to Market Reasearchers

For market researchers, they can understand the behavior of consumers by learning about the data from the sales of products. They can possibly predict how the market changes if they include more independent variables in their own studies.

5. Conclusion

The main discovery in this research is using maths differential model to predict the best time to buy the iPhone that balances the price and the usage perfectly. The research may have influence in suggesting the consumers realize the relationship between time and price changes, so they will develop a more sensitive mind to decide whether to buy and when to buy. The decision of initial price can also be concerned carefully. For manufacturers and designers, this interprets what kinds of consumers are their basis. For the further research in the future, the author will focus on the other types of high-tech products such as electric cars and automatic vacuum cleaners. Other independent variables like general economy change between countries and the change of global supply chain will also be included.

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