
AN APPLICATION OF MARKOV-CHAIN PREDICTIONS FOR SMARTPHONE
MARKET SHARES IN TAIPEI METROPOLITAN AREA

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ABSTRACT

Smartphones are the most important portable information carriers for modern lives. However, as the smartphone market becomes saturated, competition among brands has become increasingly fierce. Therefore, this study surveyed the users in the Taipei and New Taipei cities to understand current brand preferences for smartphones, and further to predict the market share of various brands in the coming years. This study found that brand loyalty was highest in APPLE, followed by OPPO, SAMSUNG, and SONY; while Taiwanese domestic brands HTC and ASUS were relatively low. This study also found that, except APPLE, male and female favorite brands were HTC and SAMSUNG, respectively. Finally, this study also predicted the market share of brands in the next few years and found that the smartphone industry will show the trend of “large brands will become even larger,” and “small brands will become even smaller.”

KEY WORDS: Smartphones, Market shares, Markov-chain, Prediction.

INTRODUCTION

As the smartphone market becomes saturated, the market share of various smartphone brands may gradually stabilize. The choice of smartphones by most users today considers the functions and performance, such as online speed, pixel quality, memory efficiency, and camera features, etc., while many others may also consider the brand value of the smartphone. Therefore, this study aims to understand the current preferences of most users for smartphone brands in the Taipei metropolitan area, and to predict the market shares of each brand in the coming few years.

For the detailed survey area, this study is limited to smartphone users in the Taipei and New Taipei Cities. Moreover, the survey object is only for smartphones; any traditional mobile phones below 3G system are not included in the survey. Furthermore, this study will use questionnaire surveys to find out the current status of smartphone preferences of users in the Taipei metropolitan area, and use Markov-chain method to predict the market share of smartphone brands in the next few years.

Finally, this study could get some important results such as “the current market share of each brand,” “the status of gender preferences for brands,” “the current status of age preferences for brands,” and “the market share of the brands in the next few years.”

LITERATURES REVIEW

The Markov-chain model belongs to one of the random process prediction methods. Based on the state of the system during the past period, the consequent state of the system and the possibility of occurrence are estimated. It has been replicated in many areas, such as:

Wang and Wang (2018) collected decades of historical data of Chinese province Fujian coastal ports, and analyzed with a combined model of Grey theory with Markov-chain. Their results show that the average absolute error of the Grey model modified by a Markov process decreases from 5.4% to 0.04%. Through comparison, it can find that the result of a Grey Markov-chain is more accurate than that of single Grey prediction. Sathyapriya, et al. (2019) explored the use of Markov-chain in the. They found that Markov-chain could play a very important role in many fields of denim manufacturing. Liu, et al. (2019) used Markov-chain prediction on the complexity and randomness of the precipitation sequence in Beijing. Their results show that the sequence of precipitation in Beijing from 1951 to 2013 satisfies the Markov property. It suggested that it is reasonable to use the weighted Markov-chain model to predict the precipitation in Beijing. Wang, et al. (2019) predicted next location of mobile users by a multi-order fusion Markov model. Their experimental results on the real user trajectory dataset Geo-life show that the prediction performance of this model is good. Su, et al. (2019) reported a set pair analysis (SPA)-Markov-chain model for groundwater quality assessment and prediction. Their prediction results show that the proposed model is able to treat uncertainties in the groundwater quality assessment and is effective in short term groundwater quality prediction.

Moreover, the related literatures on the use of smartphones and the market share of each brand are summarized as follows:

Yeh, et al. (2016) hypothesized four determinants of smartphone brand loyalty based on the perspectives of consumer value and consumer-brand identification. Their study also explores the moderating effects of age and gender differences in the determination process of smartphone brand loyalty. Their results show that age enhances the emotional value-brand loyalty and social value-brand loyalty linkages, but weakens the brand identification-brand loyalty relationship. However, gender does not play a moderating role in the determination of smartphone brand loyalty. Appiah, et al. (2017) presented theoretical insight into the phenomenon of the brand switching behavior of consumers in the smartphone industry, with implications for how resistance could be built from an identity theory perspective. Their findings include switching behaviors and organizational responses to contexts affecting the strategic actions and interactions. Chen (2017) explored how service quality affects perceived value and customer retention on the five Taiwan-based mobile service providers. The empirical results corroborate that the direct effect of "service quality" is positively related to "perceived value," and perceived value is also positively related to "customer retention".

METHDDOLOGY

In statistical theory, the discussion of the Bernoulli trial must make the following assumptions, that is, the outcome of each trial is independent of the results of its previous trials. However, the Markov-chain, which is different from the Bernoulli trial, indicates that there is some connection between one test and the next. Many earlier studies have shown that Markov-chains can be widely used in many fields, including business, psychology, sociology, and biology, etc.

Generally speaking, a Markov-chain or Markov process can be described as the situation that will occur in the next stage is determined by the previous state. A Markov experiment at any stage is a transition from one of a limited number of states at this stage for a possibly different state. In such process, the probability of transitioning from a certain state to another specific state is only related to the state in which it is currently located and does not change over time (Sullivan, 2011). A convenient way to express the aforementioned probability is to write it as a matrix. The result is shown in the following matrix P , where p_{ij} represents the probability of moving from state i to state j in an observation, and N is the number of states. This matrix is also called the transition matrix of the Markov experiment.

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1N} \\ p_{21} & p_{22} & & \vdots \\ \vdots & & & \\ p_{N1} & \cdots & & p_{NN} \end{bmatrix}$$

In a Markov-chain of N states, the initial probability distribution refers to a $1 \times N$ order column vector $v^{(0)}$, the i -th element of which is the occurrence probability of the state i in the initial stage of the test. As for the Markov-chain probability distribution $v^{(k)}$ after the k phase is

$$v^{(k)} = v^{(k-1)} P$$

or can be further expressed as

$$v^{(k)} = v^{(0)} P^k$$

Where P^k is the k -th power of the transformation matrix P and $v^{(0)}$ is the initial probability distribution.

NUMERICAL STUDY

In this study, a total of 165 questionnaires was distributed, and 162 were left as valid samples. The main survey population was within 60 years old, of which 30 were under 19, 112 were 20-39, and 20 were 40-59 years old. In terms of gender, there are 81 men and 81 women.

Table 1 shows the relationship between the current brands used (left side of the table) and the brand

expected to be used next time (up side of the table). The brand loyalty of each brand in can be further shown in Table 2 and Figure 1. It can be found from brand loyalty that most people using smartphones now have the highest loyalty to Apple, followed by OPPO, SAMSUNG, and SONY, while HTC and ASUS are low, especially for ASUS with the loyalty of zero in this survey.

Table 1 Results for current and expected brands

	APPLE	SAMSUNG	HTC	SONY	OPPO	ASUS
APPLE	91	1	2	0	1	0
SAMSUNG	9	9	2	0	0	0
HTC	16	1	7	0	1	1
SONY	1	1	2	3	0	0
OPPO	3	0	0	0	3	0
ASUS	4	0	2	1	1	0

Table 2 Brands loyalty

	Loyalty (Probabilities)
APPLE	0.96
SAMSUNG	0.45
HTC	0.27
SONY	0.43
OPPO	0.50
ASUS	0.00

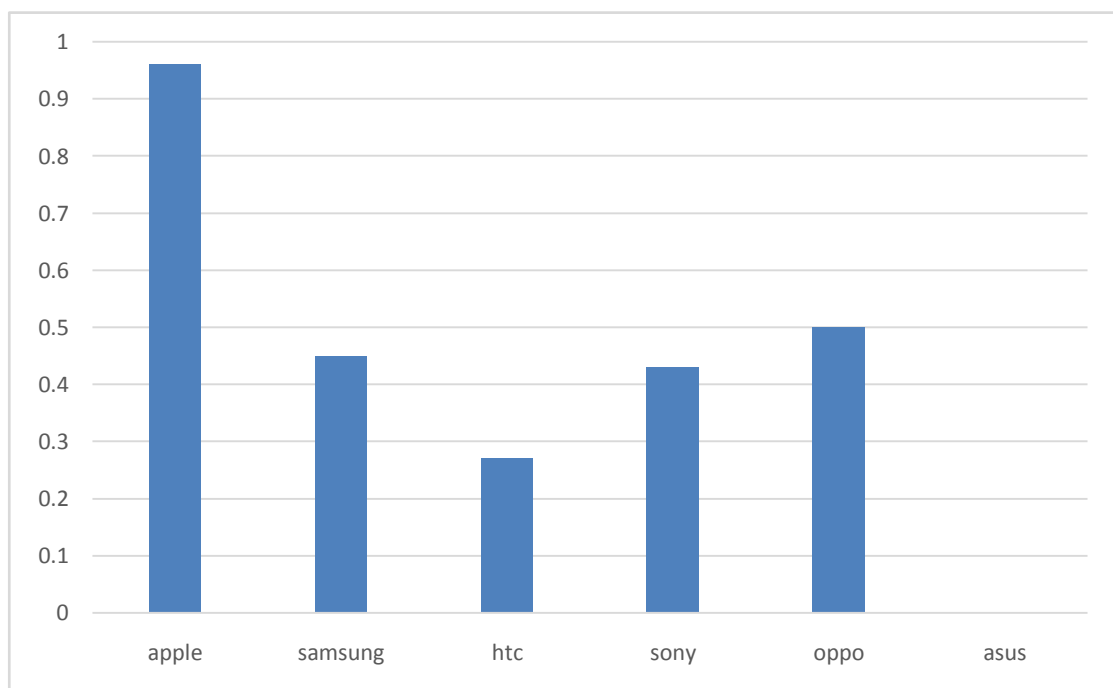


Fig.1 Brands loyalty

As for Figure 2, it shows the current use of smartphone brands by different genders. It can be found that there is no much difference in the number of brand users, regardless of men and women, and both of them are led by Apple. Besides that, women preferred SAMSUNG and is by and men preferred HTC.

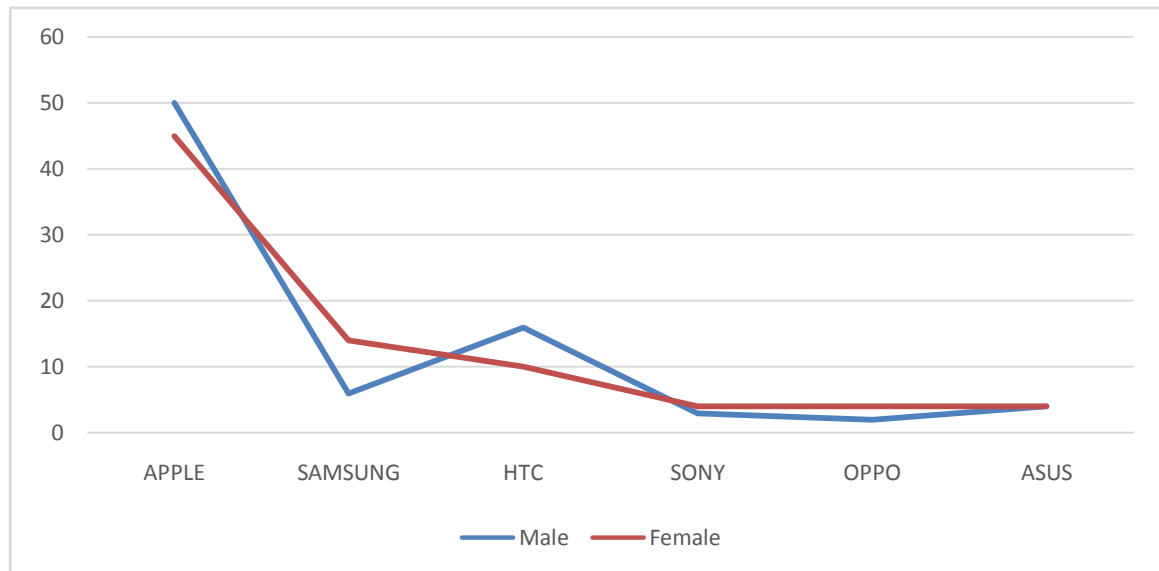


Fig.2 Brand favorites by gender

As for Figure 3, it shows the current use of smartphone brands by users of different ages. It can be found that regardless of age, Apple always makes the lead. More specifically, in the Taiwan domestic brands, the 40-59 years old group has a more obvious preference for HTC than other younger groups, and the 0-19 years old group has a more obvious preference for ASUS than other older groups.

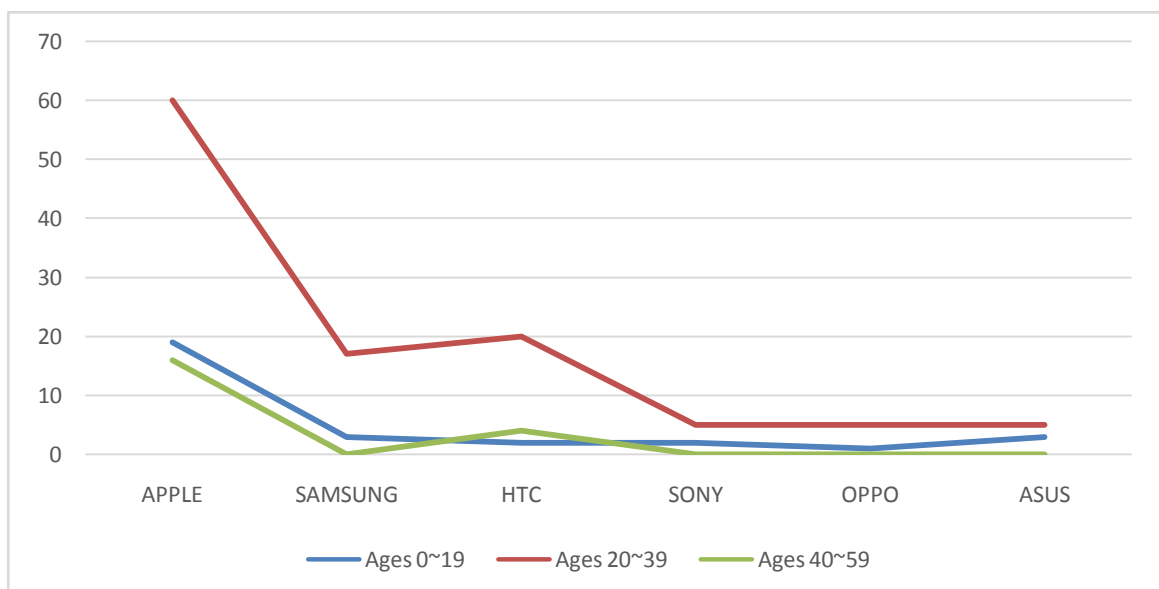


Fig.3 Brand favorites by ages

Furthermore, in the survey of this study, 2018 is the zero period of the Markov-chain. The initial probability matrix of the Markov-chain is shown in Table 3 and Figure 4, while the transition matrix is shown in Table 4.

Table 3 Initial probabilities of Markov-chain

	Probabilities of initial stage (year 2018)
APPLE	0.59
SAMSUNG	0.12
HTC	0.16
SONY	0.04
OPPO	0.04
ASUS	0.05

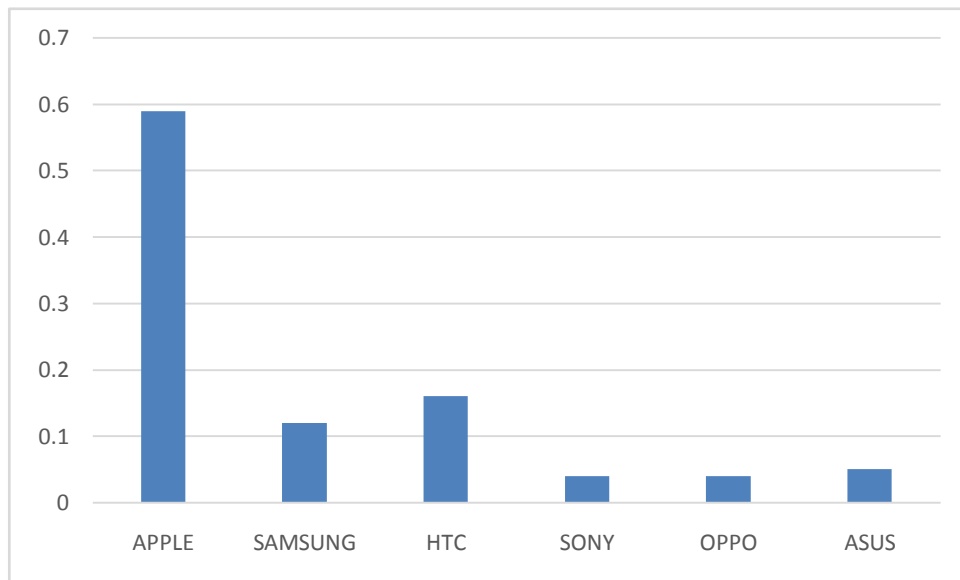


Fig.4 Market share in 2018

Table 4 Transition matrix of Markov-chain

	APPLE	SAMSUNG	HTC	SONY	OPPO	ASUS
APPLE	0.96	0.01	0.02	0	0.01	0
SAMSUNG	0.45	0.45	0.1	0	0	0
HTC	0.61	0.04	0.27	0	0.04	0.04
SONY	0.14	0.14	0.29	0.43	0	0
OPPO	0.5	0	0	0	0.5	0
ASUS	0.5	0	0.25	0.125	0.125	0

Assuming that the smartphone is replaced every two years in average, the market shares of

smartphone brands after the first period (2020), the second period (2022), and the third period (2024) is predicted shows that in Figure 5, Figure 6, and Figure 7, respectively. It can be found that the market share of brands presents the big will become even bigger, and the brands with a lower market share will be more difficult in the future.

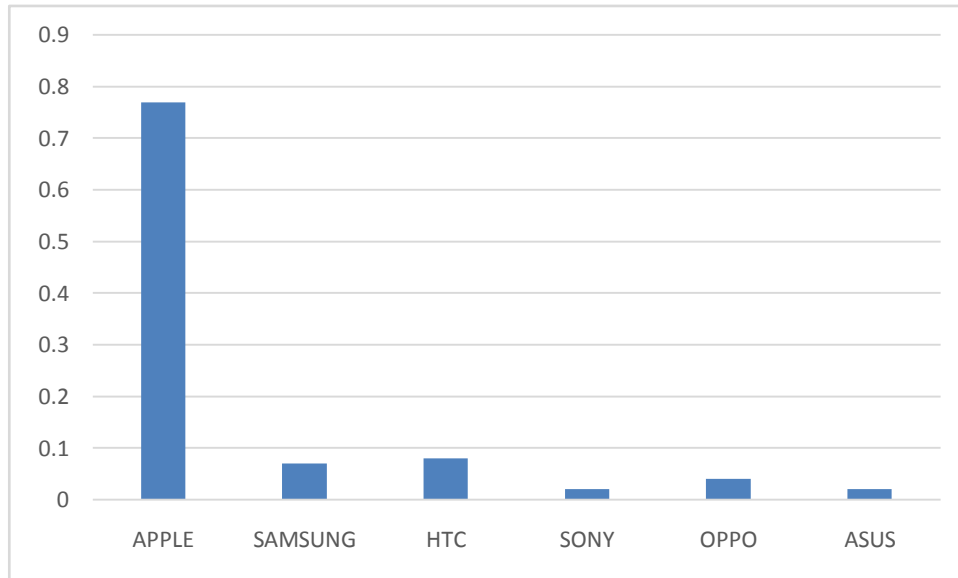


Fig.5 Estimated market share by2020

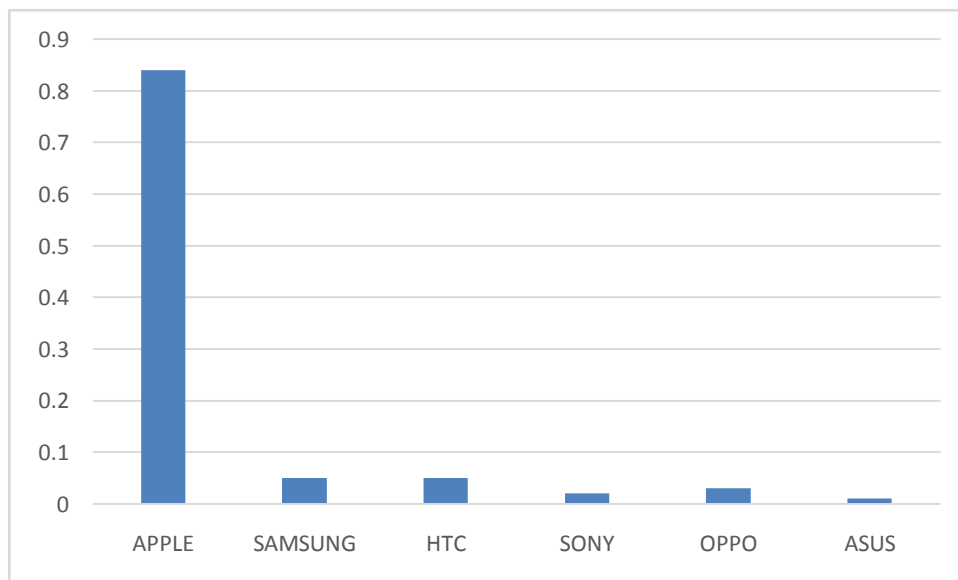


Fig.6 Estimated market share by2022

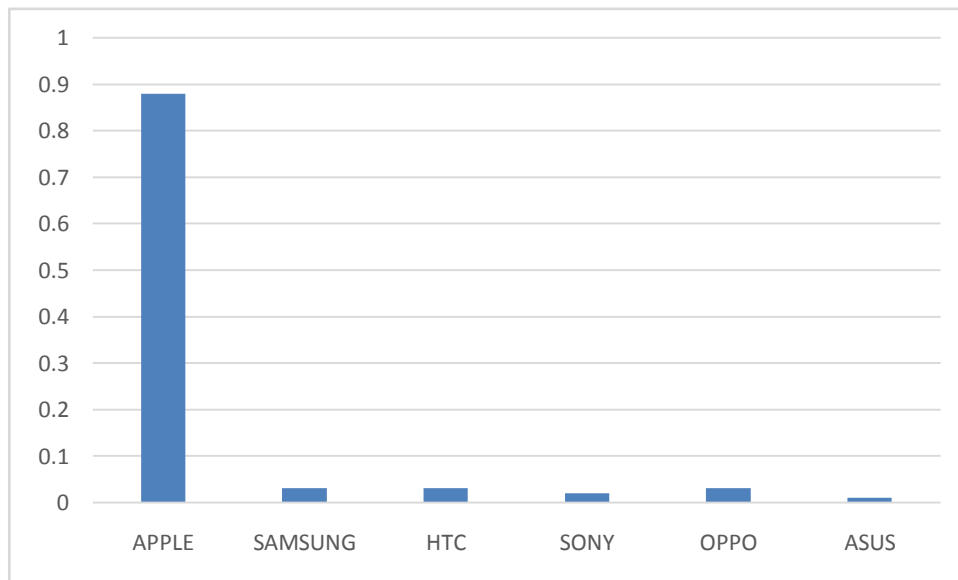


Fig.7 Estimated market share by2024

CONCLUSION REMARKS:

This study found that APPLE had the highest brand loyalty in the Taipei metropolitan area, followed by OPPO, SAMSUNG, SONY, HTC and ASUS. Therefore, the attraction of Taiwan domestic brands HTC and ASUS needs to be strengthened. This study also found that male and female first favorite brands are both APPLE, while the second favorite brand is HTC for male and SAMSUNG for female users. Moreover, this study found that APPLE tops the favorite brands in all ages.

Furthermore, according to the predictions of brand market shares in the next few years, it can be found that smartphone brands will show a trend of “big will become even bigger.” Therefore, brands with lower current market shares will face even harder competition in the future.

Finally, based on the findings and conclusions of the study, two recommendations are made for further studies. First, 162 valid samples have been obtained in this study; it is suggested that latter studies can increase the sample size to get more accurate analysis conclusions. Second, due to the trends of an aging population in Taiwan, the elderly users seem to have a more and more significant influence in the smartphone market. It is suggested that further studies can increase the number of samples for elderly users to get more conclusive analysis results.

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