The Development Prospect of Cleaning Robot in Chinese Market in the Next Ten Years

Siwei Zhang

College of Arts and Sciences, The Ohio State University, Columbus, OH 43210, US
zhang.9039@buckeyemail.osu.edu

ABSTRACT

The accelerating social pace of development has greatly occupied the disposable time of Chinese women at home. As a new type of household cleaning equipment, sweeping robot is gradually needed by more and more families. This paper first expounds on the pressure of modern women's lives and the great impact of cleaning robots born in the technological environment on people's lives. Based on the analysis of the cleaning robots sales in China in the past eight years, the author predicts the sales situation of cleaning robots in China in the next ten years and analyzes the market purchasing rules of this new product. In this paper, the Bass diffusion model is mainly used for prediction, and appropriate nonlinear regression is used to estimate the parameters. The forecast results indicate that the market share of Cleaning robots in China will further expand in the next decade and reach a peak in 2023. Finally, the author combines the development trend of China's leading cleaning robot enterprises with the parameters of the Bass model and further analyzes the industry's future development trend.

Keywords: *Cleaning Robot, New Productse, Purchase rule, Bass model, business analysis*

1. INTRODUCTION

With the rapid development of Chinese society, increasing urban women face more pressure from family, work and society than before. Among them, pressure from family members accounts for the largest proportion. Based on the traditional Chinese concept, women have to take more responsibilities in the family, such as educating children and controlling family expenditure and domestic labor. Interviews with 39 married couples in China found that although 90 percent of the wives had full-time jobs, they still had to do most of the housework.[1] The emergence of family service robots can well help women relieve pressure from the family. Take cleaning robots, for example. The emergence of cleaning robots has liberated women's hands, no longer letting cleaning occupy their time at home and saving the time arguing over whom to clean. It is undeniable that the popularity of cleaning robots has gained more free time for people and greatly helped harmonious families.

Since the first cleaning robot, RoboScrub was developed in the early 1990s by Denny and Windsor Industries.[2] Today, more than 20 years later, cleaning robot technology has become more mature. As the largest market globally, China's current penetration rate of cleaning robots is less than 5%, which also means a huge market potential.

The main purpose of this study is to make a reasonable forecast of the sales of cleaning robots in China in the next ten years based on the Bass model. Based on the forecast data, this paper summarizes the acceptance degree and market purchasing rules of service-oriented intelligent robots of Chinese households in the future. With the existing business model of leading cleaning robot enterprises in China, reasonable suggestions are put forward.

2. METHOD

The proliferation of an innovative product often requires a special process. Rogers believes that the mass media and word of mouth influence proliferation. Potential customers will gradually adopt the proliferation of new products over time, and these groups will influence the remaining potential customers through verbal communication. The number of non-adopters among potential customers will continue to decrease until the diffusion of the new technology is over [3].

Bass model was first proposed by Bass [4], who designed a sales growth model for general categories of consumer durables at the early stage of the product life cycle. Bass accurately described the purchase patterns of a large number of new products through this model. In his theory, repeated purchases are not a major consideration. The literature review shows that a bell curve can represent people's purchasing trend for new products, similar to figure 1. Sales of new products will grow rapidly and reach a peak in the early stage, and then gradually slow down. This also means that initial purchases by early adopters can be considered the most important factor in the diffusion of new products. The prediction of the Bass model can be well-matched with the market buying rules.
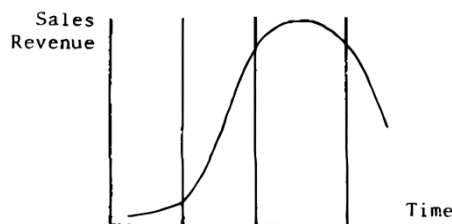

Figure 1 Consumer buying trend curve

Three variables mainly predict the model, innovation coefficient (P), imitation coefficient (Q), and market potential (M). Innovation coefficient refers to the external influence coefficient, which mainly depends on advertising and marketing mode. The imitation coefficient represents the internal influence coefficient, mainly on consumers' word-of-mouth communication of product reliability and durability.

The basic equation of Bass model is as follows:

$$L(t) = P + q/m\, N(t) \qquad (1)$$

Among them:

L (t) - the probability that potential consumers will purchase a new product before time T

N (t) - The cumulative number of consumers who have purchased the product before time T

P- Innovation Coefficient (Mass media)

Q- Coefficient of imitation (human-to-human transmission)

M- Number of potential consumers in the target market

Then, the sales volume in period T is (assuming that the purchase volume of each customer is 1) :

$$\mathbf{S(t) = [m - n(t)]L(t)}$$
$$= [m - n(t)]\{p + (q/m)\,N(t)\}$$
$$= \{p[m - n(t)] + (q/m)N(t)[m - n(t)]\} \qquad (2)$$

Because S of t is dN of t dt, so

$$DN(t)/dt = \{p[m - n(t)] + (q/m)N(t)[m - n(t)]\} \qquad (3)$$

By calculation:

$$N(t) = m\{[1 - e^{\wedge}(t) - (p+q)]/[1 + e^{\wedge}(q/p)(t) - (p+q)]\} * x(t)$$
$$S(t) = m\{[(p(p+q)^2)e^{\wedge}(-(p+q)t)]/[p + qe^{\wedge}(-(p+q)t)]^2\} * x(t)$$

3. RESULTS

3.1. Data acquisition

Unlike the international market, where cleaning robots gradually spread around 2000, cleaning robots did not emerge in the Chinese market until around 2010 and entered a period of rapid development since 2013. In this study, we chose not to use the sales data of Cleaning robots in China from 2010 to 2012, mainly because the product sales growth rate was too slow in the initial stage of diffusion, and the production was not proportional to the sales volume. According to the data released by the State Grid of China, we can obtain the market sales volume of cleaning robots in China from 2013 to 2020 [6]：

Table 1 Market sales volume of cleaning robots in China from 2013 to 2020

Year	2013	2014	2015	2016	2017	2018	2019	2020
Sale（million）	5.7	10.5	20.7	30.7	40.6	57.7	54.3	65.4

3.2. Estimation of related parameters

3.2.1. Estimation of maximum market potential M

By the end of 2018, the overall sales volume of cleaning robots in China was 11.49 million. Based on China's population of 14.1, there are 470 million households in China, with an average of three people per family unit. That means the penetration rate of cleaning robots in China is only 3 percent. This is mainly because, as a new technological product, a cleaning robot is not necessary for many low-income families. Secondly, in the early stage of product development, many functions are not perfect, leading to poor user experience. According to data from China's National Bureau of Statistics, China's per capita GNI has grown rapidly in the past 35 years, rising from $190 in 1978 to $5,680 in 2012. According to the classification standard of the World Bank, low-income countries have been upgraded to middle-income countries [7]. The rise in per capita disposable income means that people pay more attention to improving their quality of life. The demand for a high-quality living environment will be stronger. Secondly, with the development of technology, more and more new functions have been added to the cleaning robot. The

cleaning robot has gradually realized a better cleaning effect and brought a better user experience.

According to the data of the latest population census released by Xinhua News Agency in 2021, the number of Chinese families has exceeded 490 million [8]. We take the penetration rate of vacuum cleaners in China as a reference. By the end of 2020, the penetration rate of household vacuum cleaners in China had reached 19%. Assuming that the cleaning robot industry can also reach 19% penetration in the next ten years, the maximum market potential m for cleaning robots is 95 million people.

3.2.2. Estimation of external influence coefficient P and internal influence coefficient Q

For P and Q, we used nonlinear regression and SPSS to complete the estimation based on the 2013-2020 sales data of the Cleaning robot market in China obtained in 3.1 and the maximum market potential m=9500 estimated in 3.2.1. The obtained data is as follows:

$$S(t) = \{0.09*[9500-N(t)]+(0.331/9500)N(t)/9500-N(t)\} \quad (3)$$

Through calculation, we can get the estimated value S (t) of the new sales of cleaning robots at time T, so we can get the predicted value of the new sales of cleaning

Table 2 Estimated value by SPSS

p	q	m	R^2
0.009	0.331	9500	0.94

After calculation, the estimated values of P and q are 0.009 and 0.33, respectively. R^2=0.94, which means that the result fits very well. The innovation coefficient is far less than the imitation coefficient, which is consistent with the general diffusion of new products, indicating that the diffusion of cleaning robots is relatively slow in the early stage. When the innovative adopters reach a certain base, the diffusion speed among potential consumers will be faster and faster under the influence of the imitation coefficient, showing an S-shaped curve trend.

3.3. Data fitting analysis

Substitute in the values of the parameters, and the Bass diffusion model is shown as follows:

robots in China every year from 2013 to 2020.The predicted value is compared with the actual value, and the result is shown in the figure below (Figure 2):
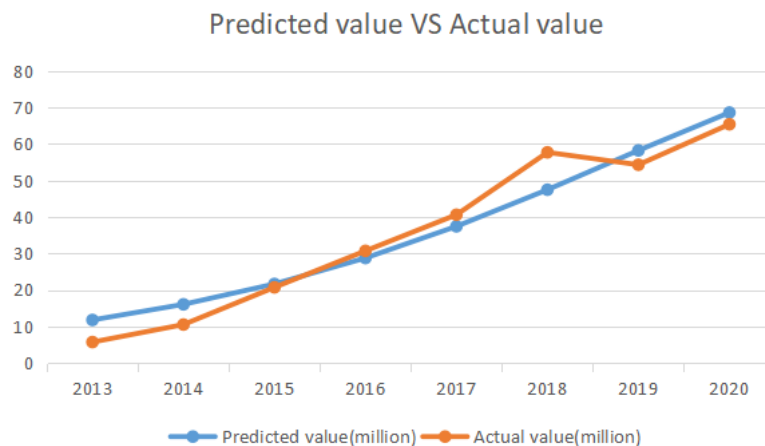

Figure 2 Comparison between estimated and actual sales of Cleaning robots from 2013 to 2020 in China

As can be seen from the line chart, the overall prediction result is relatively ideal and presents a gradually rising trend. The relatively large predicted data from 2013 to 2014 means that the actual diffusion speed of the cleaning robot in the initial stage is slower than predicted by the model. According to the above analysis，The reasons are low-income level of residents and imperfect product functions. The analysis shows that the overall fitting degree of the data is very

high, which means that the existing P, Q and M can be used to reasonably predict the future sales of cleaning robots in The Chinese market.

3.4. Future market prospects

According to the formula 3, we can predict the sales volume of China's cleaning robot market in the next ten years, and the results are shown as follows (Figure 3):
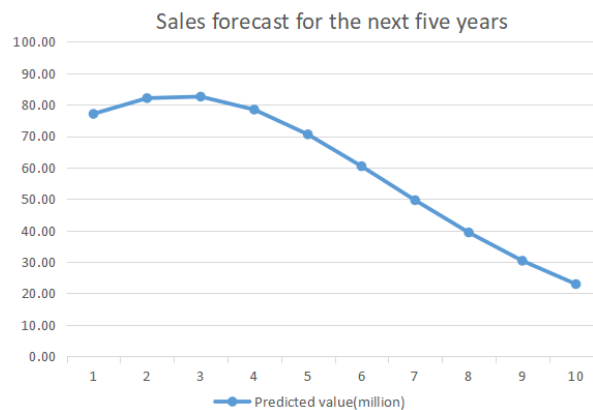
Figure 3 The forecast curve for the sales of cleaning robots over the next decade

Research shows that China's cleaning robot market will further expand in the next five years and reach the highest point around 2023, after which the growth trend will slow down year by year, and the whole market will gradually become saturated. It is worth noting that the predicted data and the diffusion trend of the Chinese vacuum cleaner market in the past are consistent. Vacuum cleaners have entered the Chinese market for 30 years, but the market penetration rate of traditional household vacuum cleaners in China has never exceeded 30%. According to data released by Euromonitor International in 2018, the market penetration rate of traditional vacuum cleaners in Hong Kong and Japan has reached 88% and 96%, respectively, which is far behind that in mainland China. This shows that household cleaning equipment plays a role of life necessity in developed countries. The current forecast of China's cleaning robot market sales in the next ten years is based on the premise that China is a developing country. However, there is no doubt that with the further improvement of people's living standards after ten years, the maximum potential customer number needs to be re-estimated. That means the market for cleaning robots is much bigger than the chart suggests. In addition, the current market penetration rate of cleaning robots in the US is only 11%, largely because the user experience of cleaning robots is not much better than that of household vacuum cleaners. In the future, with the further development of science and technology, when cleaning robots are irreplaceable and have a more important impact on people's lives, the product market will further expand.

4. ANALYSIS OF CLEANING ROBOT INDUSTRY IN CHINA - ECOVACS AND ROBOROCK AS EXAMPLES

4.1. Object Selection

Since 2010, China's cleaning robot industry has mushroomed, and several successful enterprises have emerged. Among them, Ecovacs occupies the leading position in the industry. Online sales of Ecovacs robots account for 41 percent of the market, while offline sales account for 80 percent. According to Oviyun.com.And, Roborock's recent period of sales growth was the industry's first. In the past, Roborock has been a partner of Xiaomi OEM products. It was not until 2016 that the sales of independent brands were gradually realized, and the growth rate ranked first in the industry. We hope to find the most reasonable path for Future cleaning robots in China through the analysis of these two enterprises.

4.2. Comparison of sales data

Since Roborock did not sell its brand until 2016, the company had been a contract manufacturer until then. Therefore, the author obtained the sales data of the two companies from 2017 to 2020 through expert interviews. The comparison results are as follows:

Table 3 Sales volume of Roborock and Ecovacs from 2017 to 2020

Year	2017	2018	2019	2020
Sale（ROBOROCK）/Million	0.06	0.89	1.51	2.38
Sale（ECOVACS）/Million	3.2	4.14	3.34	3.17

The data showed that the sales volume of Ecovacs, as an industry giant, reached the highest value in 2018 and then entered a trend of slow decline, which is different from the overall market trend predicted by the Bass model in 4.2. Sales of Roborock increased rapidly in this time frame, in line with the market trends previously estimated. In order to study the reasons for this difference, the author analyzes the business strategies of the two companies in the next part.

4.3. Analysis of the development strategies of the two companies

In the context of fierce competition in the Chinese market, all companies need to increase advertising investment to obtain C-end user groups continuously.

Ecovacs' annual report for 2020 shows that the current year's sales expenses reached 1.56 billion yuan. The marketing promotion and advertising expenses reached 836 million yuan in the huge sales expenses, accounting for 54% of the sales expenses, with a year-on-year increase of 42%. However, only 338 million yuan was invested in R&D, accounting for 4.67% of the total revenue [9]. This means that Ecovacs has always been a technology company focused on marketing rather than r&d. The huge investment in advertising is one of the reasons why Ecovacs was able to quickly gain a large market share in the early stages of product proliferation.

Given the significant increase in sales expenses, Ecovacs pointed out in the annual report. In order to further expand the domestic and international business and increase market investment, huge advertising investment is indispensable. This strategy has enabled the Ecovacs brand to demonstrate strong competitiveness and drive overall revenue growth. This means that high advertising costs will be a long-term strategy for Ecovacs.

The annual report of Roborock in 2020 shows that the sales expenses this year also reached 620 million yuan. The expenses for marketing promotion and advertising amounted to 318 million yuan, accounting for 51% of the sales expenses. The r&d expense was 263 million yuan, accounting for 5.8% of the total revenue [10]. This means that in addition to spending much money on advertising to reach new customers, Roborock is also interested in improving the customer experience by spending more on research and development than Ecovacs.

Map this analysis data to the internal parameters of the Bass model. The input of advertising expense is the external influence factor (P), which means attracting customers through mass media. In contrast, the input of R&D expense is the internal influence factor (Q), which means attracting customers by improving the user experience of a single user. In 4.2.2, the estimated value of P is much smaller than the estimated value of Q, which also indicates that the influence of the imitation coefficient (Q) is greater than that of the innovation coefficient (P) in the long-term process of product diffusion.

Combining the sales volume of the two companies in recent years, we can conclude. At the initial stage of product diffusion, increasing advertising investment is a necessary strategy, which can help the company seize a larger market share and cultivate a loyal customer base faster. In the long run, investing more in R&D to improve product quality is an irreplaceable solution to the trend of slowing market growth. Better product quality can help build word of mouth and attract more new users through word of mouth while consolidating the existing customer base. This is also very important for the long-term development of a company.

5. CONCLUSIONS

Based on the diffusion theory of innovation, this paper establishes the Bass model of the Cleaning robot market in China. It forecasts the sales volume of electric vehicles in China from 2021 to 2030. As the products in China to promote the deeper, and per capita, disposable income has increased, the number of potential consumers should be more and more. Based on the sales volume of the product in the Chinese market in the past eight years, the model parameters are estimated by using linear regression. It is found in this paper that the innovation coefficient of the model is not high. However, the imitation coefficient is high, ensuring that the cleaning robot can be rapidly propagated and spread among potential consumer groups after some innovators take the lead in using it. In the next 3-4 years, the sales of cleaning robots will reach their peak.

Secondly, based on the analysis of the business model of the leading enterprises in the current cleaning robot market, the author predicts the future market development trend and puts forward reasonable suggestions: the long-term development of the company is inseparable from the increase of R&D investment, to attract more customer groups by spreading among potential consumers.

The limitation of this study is that only the traditional Bass model is used to make a rough prediction of the future sales of sweeping robots. With the in-depth study by many scholars, more and more factors and variables have been added to the Bass model. In order to make more accurate prediction, the author needs to try more new research methods in future studies. Secondly, it has been less than ten years since the sweeping robot selected in this paper appeared in the Chinese market as a new cleaning tool. Longer time horizons and more raw data can further ensure the accuracy of the prediction results.

REFERENCES

[1] Zuo, J. (2003). From revolutionary comrades to gendered partners: Marital construction of breadwinning in post-Mao urban China. Journal of Family Issues, 24 (3), 314-337 .Retrieved from: https://journals-sagepub-com.ntunhs.80599.net/doi/abs/10.1177/0192513x02250888

[2] Gao, X., Li, K., Wang, Y., Men, G., Zhou, D., & Kikuchi, K. (2007, December). A floor cleaning robot using Swedish wheels. In 2007 IEEE International Conference on Robotics and Biomimetics (ROBIO) (pp. 2069-2073). IEEE.Retrieved from: https://ieeexplore-ieee-org.washington.80599.net/abstract/document/4522487

[3] Rogers, E. M. (2010). Diffusion of innovations . Simon and Schuster.Retrieved from: https://books.google.com/books?hl=zh-CN&lr=&id=v1ii4QsB7jIC&oi=fnd&pg=PR15&dq=Rogers+E+M%EF%BC%8E+Diffusion+of+Innovations+1962&ots=DMVuvPXl9Q&sig=BluKcgFppKjL6E7OHoDT6Py1NXM

[4] Bass, F. M. (1969). A new product growth for model consumer durables. Management science , 15 (5), 215-227..Retrieved from: https://pubsonline.informs.org/doi/abs/10.1287/mnsc.15.5.215

[5] Rink, D. R., & Swan, J. E. (1979). Product life cycle research: A literature review. Journal of Business Research, 7(3), 219–242.Retrieved from:Product life cycle research: A literature review - ScienceDirect

[6] Cheaa.com.(April ,2021).Market development of sweeping robot in 2021 .Retrieved from: http://upload.cheaa.com/2021/0412/1618193834666.pdf

[7] State Statistics Bureau.(Nov 06,2013). Great changes in China's economic and social development since 1978 . .Retrieved from: http://www.gov.cn/jrzg/2013-11/06/content_2522445.htm

[8] The Xinhua News Agency.(May 11,2021). Main data of the seventh National census .Retrieved from: http://www.gov.cn/xinwen/2021-05/11/content_5605871.htm

[9] Roborock 2020 annual report. (April 11,2021), Roborock. Retrieved from: http://static.cninfo.com.cn/finalpage/2021-04-30/1209877501.PDF

[10] .Ecovacs 2020 annual report. (April 29,2021). Ecovacs. Retrieved from http://static.cninfo.com.cn/finalpage/2021-04-24/1209790805.PDF