Apply Importance Performance Analysis to Explore Innovation Resistance of Home Robot

Kuei-Chien Chiu
Department of Business Administration, Chaoyang University of Technology, Taichung, Taiwan
Email: cgc@cyut.edu.tw

Chih-Sung Lai and Hsing-Hui Chu
Department of International Business, National Taichung University of Education, Taichung, Taiwan
Chaoyang University of Technology, General Education Center, Taichung, Taiwan
Email: cslai@mail.ntcu.edu.tw, stacy8chu@gmail.com

***Abstract*—Owing to the rapid technological development of artificial intelligence, internet of things, precise sensor, and cloud computing and storage, diverse robots with distinctive intelligent function emerged in the market. However, the household robot market is still in the beginning phase because of little advance of technical development. The perception of consumers on home robot will be the influential factors for the development of home robot. The gap between expected and observed quality of service will determine the popularity of product. Moreover, the gap will be derived from the innovation resistance. This research employed IPA method to analyze the gap of importance and performance of consumers' perception of home robot due to innovation resistance. A survey method with a questionnaire includes variables of tradition barriers, value barriers, risk barriers, usage barriers, and image barriers were used. The IPA analysis showed that the improvement priority is image barrier followed by value barrier. That is to say, the home robot industry has to allocate more resources to promote the image of home robot to persuade the customers the products are worthy to purchase. As for the result of IPA on barrier items, the largest score differences of importance and performance fall into quadrant IV and the top nine priorities deserve to be improved. All items of value barrier except "cheaper price" belong to quadrant IV. It suggests that the home robot industry should pay more effort to overcome the perceived value barrier of consumers.**

***Index* Terms—importance performance analysis, innovation resistance, home robot**

I. Introduction

The household robots market is about USD 3.3 billion in 2019. It is expected to increase to USD 9.1 billion in 2024. That is to say, the compound annual growth rate of household robots market will be as high as 22.4% in the next five years. Among the factors inducing the growth of household robots market, the rising demand for automation of household routine tasks is most important. Besides, household robots became more practically and usable because of autonomous operation progress is another motivating factor for the market [1].

Because of the speedy technical development of artificial intelligence (AI), internet of things (IoT), precise sensor, and cloud computing and storage, various robots with different intelligent function launched the market. In this circumstance, the home robots are anticipated to include integrated function to become the hub of the smart home [2]. It is expected that the home robot can play the role of a conversation partner, a sympathetic object, and a house chore or daily life helper. Besides, by incorporating different field knowledge and technology, the robot can also offer entertainment functions and safeguard the residence by detecting fire, noises, steeling etc.[3][4].

Reference [2] summarized the functions of home robot as basic function and additional function. The former includes communication, entertainment, lifestyle, remote control, emotional expression, voice; and the latter includes pet care, baby care, silver care, home management, shopping, and security.

Because the household robots market has been keeping growing in the past years, the market became fairly competitive owing to the emergence of regional and global key players, for example, Aldebaran Robotics Nao, Asus Zenbo, Blue Frog Robotics Buddy, Emotech Olly, Intuition Robotics Elli.Q, Jibo Jibo, LG Hub Robot, Mayfield Robotics, Kuri, NTT Sota, Sharp Robohon, Softbank Pepper, Ubtech Robotics Alpha 2, and Ubtech Robotics Lynx, etc. [5].

General speaking, the household robot market is still in the beginning phase because of little advance of technical development. Therefore, the companies, even the whole industry, have to make continuous development to promote the popularization of the home robots [2].

That is to say, the perception of consumers (or even potential customers) on home robot will be the influential factors for the development of home robot. It is well known that the gap between expected and observed quality of service will determine the popularity of product [6]. Moreover, the gap will be derived from the innovation resistance [7]. The concept of innovation resistance indicates that consumers would not be easy to accept innovation because of perception barriers

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including tradition barriers, value barriers, risk barriers, usage barriers, and image barriers [8]. Diverse researches on different products or services present different results of the effects of these barriers. The results of reference [9] shows that all barriers significantly affect the mobile commerce adoption of generation X in Malaysia. On the contrary, the major barriers including value, risk, and tradition inhibit older adults toward online shopping while usage barriers and image do not [10]. Furthermore, image barrier is not a statistically significant innovation resistance of hydrogen-electric motorcycles [11]. That means the reasons of innovation resistance would vary from case to case.

Martilla and James [12] developed Importance-Performance Analysis (IPA) to help to understand customer satisfaction and determine priority of automobile dealers' services. IPA is now an extremely popular managerial tool in various fields for performance evaluation and development for products and services. Being a graphic method, IPA uses a two-dimensional coordinate system with performance as horizontal axis and importance as vertical axis. The attribute scores of products and services on importance and performance form point coordinates to be placed on this importance-performance grid. The horizontal axis and vertical axis are divided into two parts, the low and the high, to form four quadrants. The demarcation can be the middle of the scale of *x* and *y* axis or the average value of importance-performance. The former is called Scale centered quadrant model (SCQM) and the latter is called Data centered quadrant model (DCQM) as Fig. 1 [13].

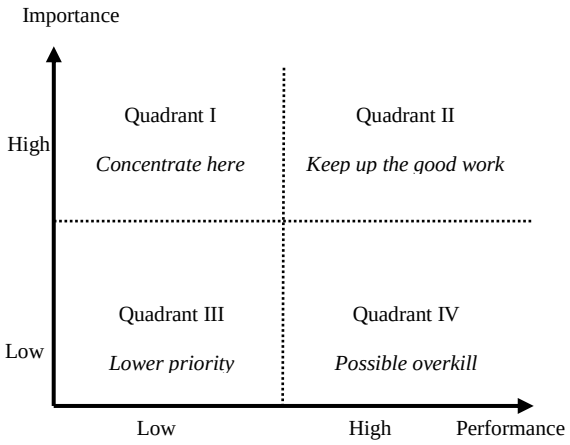

Figure 1. The original importance-performance analysis graph
Source: Martilla and James (1977)

This study aims to investigate the underlying reason why home robot is still in its early developing stage by exploring the phenomenon of innovation resistance. As mentioned in the previous paragraphs, the gap between expected and observed function should be discovered. IPA is a well established method to solve these kinds of problems. Therefore, this research employed IPA method to analyze the gap of importance and performance of consumers' perception of home robot due to innovation resistance.

II. Research Methodology

A. Research Method

This research employed innovation resistance theory to explore the perception of using home robot. The variables used in this study include tradition barriers, value barriers, risk barriers, usage barriers, and image barriers. Although home robot has been launched the market for decade, it is still not a universal home appliance. That means all the five barriers might have significant effect on the perception of the performance of home robot. This study utilized survey method to collect the perception data of using home robot. A questionnaire containing twenty five questions based upon the above-mentioned five variables were designed to conduct pair-wise comparison of importance and performance. Hence, there were five questions designed for each variable. These 25 questions were appraised by five-point Likert scales with the subsequent categories: strongly disagree", "disagree", "neutral", "agree" and "strongly agree" with "1" corresponding "strongly disagree" to 5 as "strongly agree".

B. Research Materials

The questionnaires were delivered to 195 subjects participated in this research, including freshmen, sophomores, juniors and seniors from college of Management, humanities and social sciences, informatics, design and engineering of Chaoyang University of Technology who took the courses of general education in first semester of year 2019. 183 copies of questionnaire respondents were collected with 93.85% response rate. After screening invalid response, a total of 177 respondents were valid with 90.77% valid response.

C. Research Instrument

This study included two stages of analysis by using the same graphic method – IPA. Because the quadrant of original graph is not consistent with ordinary mathematic expression, most researchers revised it to the mathematical quadrant system [14-15]. In the first stage, the average scores of importance and performance of all respondents for each variable were calculated firstly. Secondly, the average score of five variables of importance was calculated and designated as the cutting line of quadrants on *x*-axis and the average score of five variables of performance *as* that of *y*-axis. These two average scores formed the pair of coordinates (*x, y*) to be the reference point. Thirdly, each pair of importance-performance for five variables was compared with the reference point and arranged to the four quadrants. Finally, the priority of these five variables was ranked according to the differences of importance and performance. As for the second stage, the above four steps were repeated for twenty five items to obtain the quadrant distribution.

III. Analysis Results

A. Demographic Characteristics of Respondents

In this research, 177 valid respondents are analyzed. Demographic characteristics of these respondents are as

Table I. The majority of the respondents are female (64.4%), management college (78.5%), junior (37.3%), living in parent's house (41.2%), sometimes house worker (52.5%), and part time worker (50.3%).

TABLE I. DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Variable	Response	Frequency	Percent
Gender	Female	114	64.4
	Male	63	35.6
College	Management	139	78.5
	Engineering	5	2.8
	Design	5	2.8
	Humanities And Social Sciences	12	6.8
	Informatics	16	9.0
Grade	Freshman	30	16.9
	Sophomore	53	29.9
	Junior	66	37.3
	Senior	28	15.8
Living	Parent's house	73	41.2
	Rent	70	39.5
	Dorm	34	19.2
Housework	Never	5	2.8
	Sometimes	93	52.5
	Always	79	44.6
Work	No	19	10.7
	Part time	89	50.3
	Full time	69	39.0

B. Reliability Analysis

In this study, the Cronbach's Coefficient Alpha correlation coefficients were used to assess the reliability of each scale. The Cronbach's Alpha of all items of importance is 0.958 and performance is 0.950. Regarding to the reliability of five dimensions of innovation resistance, the Cronbach's Alphas of these sub-measures of importance range from 0.845 to 0.889, and 0.843 to 903 for performance. The results show that all dimensions and items in this survey are highly reliable, and none of them would be deleted (Table II and III).

TABLE II. ITEM-TOTAL STATISTICS OF IMPORTANCE

	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Importance	Cronbach's Alpha: 0.958	
Tradition	Cronbach's Alpha: 0.889	
Unnecessary	.691	.874
Ineffectual	.812	.848
Unprofessional	.759	.859
Unfulfillable	.751	.861
Substitutable	.649	.884
Value	Cronbach's Alpha: 0.878	
More convenient	.718	.849
Better function	.751	.842
Quality of life	.760	.839
Cheaper price	.582	.885
Saving time	.752	.842
Risk	Cronbach's Alpha: 0.877	
Usefulness	.647	.865
Malfunction	.674	.858
Error	.707	.852
Leaking information	.762	.837
Unsafe	.752	.840
Usage	Cronbach's Alpha: 0.862	
Pattern	.574	.859
Change habit	.676	.835
Unpleasant	.690	.832
Learning problem	.729	.821
Difficult operation	.742	.817
Image	Cronbach's Alpha: 0.845	
Consumer right	.628	.820
Unpractical	.657	.812
Unconfident	.580	.832
Hype	.658	.812
Real service	.741	.790

TABLE III. ITEM-TOTAL STATISTICS OF PERFORMANCE

	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Performance	Cronbach's Alpha: 0.950	
Tradition	Cronbach's Alpha: 0.881	
Unnecessary	.733	.852
Ineffectual	.755	.847
Unprofessional	.800	.836
Unfulfillable	.740	.851
Substitutable	.565	.892
Value	Cronbach's Alpha: 0.849	
More convenient	.746	.795
Better function	.795	.782
Quality of life	.754	.794
Cheaper price	.335	.909
Saving time	.749	.796
Risk	Cronbach's Alpha: 0.903	
Usefulness	.686	.896
Malfunction	.786	.876
Error	.764	.880
Leaking information	.773	.878
Unsafe	.783	.876
Usage	Cronbach's Alpha: 0.843	
Pattern	.602	.823
Change habit	.556	.835
Unpleasant	.672	.805
Learning problem	.714	.792
Difficult operation	.701	.796
Image	Cronbach's Alpha: 0.898	
Consumer right	.720	.882
Unpractical	.791	.866
Unconfident	.810	.862
Hype	.802	.864
Real service	.633	.903

C. IPA on Barrier Dimensions

The results of Importance Performance Analysis on barrier dimensions show in Table IV and Fig. 2. Risk barrier belongs to quadrant I with the smallest difference (0.419) between importance and performance means that the resources assign to risk barrier are appropriate. The fact that there is not any barrier fall into quadrant II means there is no misallocation of the resource to the low important barrier. Furthermore, although quadrant III represents low importance score with low performance score and hence deserves low priority, there were still a lot of differences between the scores of importance and performance for tradition barrier (0.986) and usage barrier (0.737). That means it is necessary to further decrease the resources allocated to these two barriers. Finally, because quadrant IV represents high importance score with low performance score, it means insufficient resources were allocated to reduce value and image barriers. By comparing the score differences of importance and performance in quadrant IV, the improvement priority is image barrier (1.165) followed by value barrier (1.082).

TABLE IV. RESULT OF IPA ON BARRIER DIMENSION/ITEM

Dimension / Item	μ_I	μ_P	μ_I-μ_P	Quadrant	Priority
Tradition	***3.718***	***2.731***	***0.986***	***III***	
1.Unnecessary	3.466	2.824	0.642	III	
2.Ineffectual	3.852	2.540	1.313	IV	6
3.Unprofessional	3.773	2.619	1.153	III	
4.Unfulfillable	3.903	2.585	1.318	IV	5
5.Substitutable	3.602	3.074	0.528	II	10
Value	***3.888***	***2.806***	***1.082***	***IV***	***2***
6.More convenient	3.972	2.563	1.409	IV	2
7.Better function	3.960	2.670	1.290	IV	7
8.Quality of life	3.926	2.506	1.420	IV	1
9.Cheaper price	3.614	3.415	0.199	II	14
10.Saving time	3.966	2.625	1.341	IV	4
Risk	***3.942***	***3.523***	***0.419***	***I***	
11.Usefulness	3.716	3.347	0.369	II	11
12.Malfunction	3.932	3.523	0.409	I	
13.Error	3.994	3.614	0.381	I	
14.Leaking information	4.045	3.619	0.426	I	
15.Unsafe	4.045	3.528	0.517	I	
Usage	***3.536***	***2.799***	***0.737***	***III***	
16.Pattern	3.551	3.188	0.364	II	13
17.Change habit	3.449	3.080	0.369	II	12
18.Unpleasant	3.477	2.580	0.898	III	
19.Learning problem	3.585	2.523	1.063	III	
20.Difficult operation	3.619	2.614	1.006	III	
Image	***3.869***	***2.704***	***1.165***	***IV***	***1***
21.Consumer right	3.915	2.665	1.250	IV	8
22.Unpractical	4.057	2.648	1.409	IV	3
23.Unconfident	3.648	2.693	0.955	III	
24.Hype	3.750	2.750	1.000	III	
25.Real service	3.994	2.756	1.239	IV	9
Average	**3.793**	**2.902**	**0.891**	**-**	**-**

μ_I : Average score of Importance
μ_P : Average score of Performance

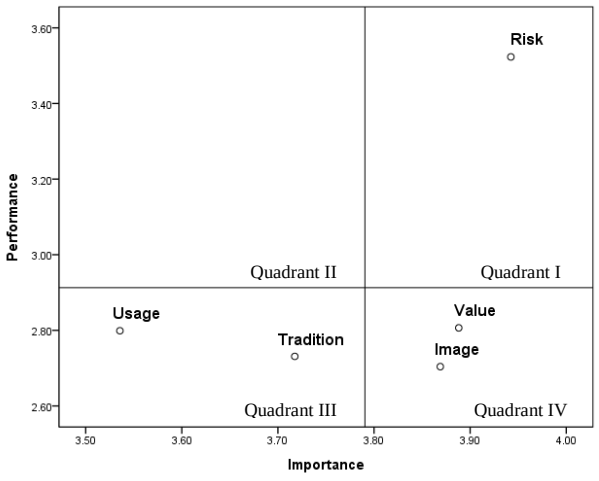

Figure 2. Quadrant distribution of IPA on barrier dimensions

D. IPA on Barrier Items

Subsequently, Importance Performance Analysis was applied to overall twenty-five barrier items. There were four, five, seven, and nine items falling into Quadrant I to IV respectively as below (Table III and Fig. 3).
Quadrant I: 12, 13, 14, 15
Quadrant II: 5, 9, 11, 16, 17
Quadrant III: 1, 3, 18, 19, 20, 23, 24
Quadrant IV: 2, 4, 6, 7, 8, 10, 21, 22, 25

Unquestionably, almost all the items (except 11.Usefulness) of risk barrier fall into quadrant I, which is accordance with the result of IPA on barrier dimensions. However, there are five items fall into quadrant II, which are substitutability of tradition, usefulness of risk, change habit and pattern of usage, and cheaper price for value. The priorities of these items rank as 10 to 14. Although these items have relatively low importance and high performance, their scores of importance are still higher than those of performance by 0.199~0.528. It means that the efforts paid to these items were not too much overkill.

Quadrant III includes seven items, sorted by difference, consisting of unprofessional (tradition), learning problem (usage), difficult operation (usage), hype (image), unconfident (image), unpleasant (usage), and unnecessary (tradition). Two of them come from tradition and three from usage. This is partially in consistent with the result of IPA on barrier dimensions except two items from image with high difference.

Undoubtedly, the largest score differences (from 1.420 to 1.239) of importance and performance fall into quadrant IV and the top nine priorities deserve to be improved. All items of value barrier except "cheaper price" belong to quadrant IV. It suggests that the home robot industry should pay more effort to overcome the perceived value barrier of consumers. Besides, it is worth noting that the second largest score differences fall into quadrant III represents there were still a lot of perception gap between the perception of importance and performance for these barrier items. However, because these barrier items are low priorities, it is not necessary to care about the resources allocation to these seven barrier items.

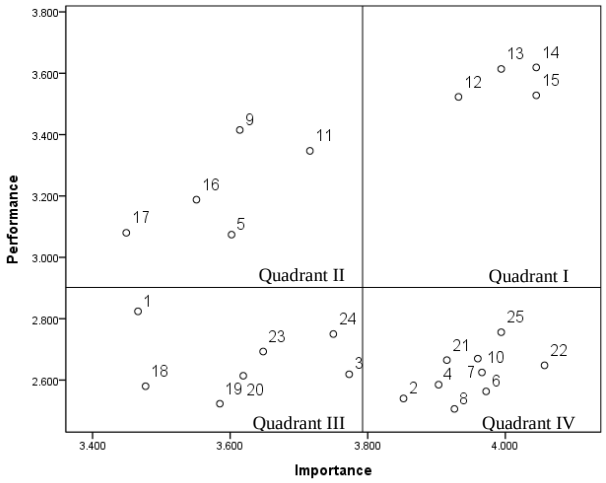

Figure 3. Quadrant distribution of IPA on barrier items

IV. CONCLUSION

Because of the speedy technical development of artificial intelligence, internet of things, precise sensor, and cloud computing and storage, various robots with different intelligent function launched the market.

However, the household robot market is still in the beginning phase because of little advance of technical development. The perception of consumers on home robot will be the influential factors for the development of home robot. The gap between expected and observed quality of service will determine the popularity of product. Moreover, the gap will be derived from the innovation resistance. This research employed IPA method to analyze the gap of importance and performance of consumers' perception of home robot due to innovation resistance. A survey method with a questionnaire includes variables of tradition barriers, value barriers, risk barriers, usage barriers, and image barriers were used. The IPA analysis showed that the improvement priority is image barrier followed by value barrier. The result does not meet the original expectation that all the five barriers have significant affect on the perception of the performance of home robot. That is to say, the home robot industry has to allocate more resources to promote the image of home robot to persuade the customers the products are worthy to purchase. As for barrier items, the largest score differences of importance and performance fall into quadrant IV and the top nine priorities deserve to be improved. All items of value barrier except "cheaper price" belong to quadrant IV. It suggests that the home robot industry should pay more effort to overcome the perceived value barrier of consumers.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Kuei-Chien Chiu initiated the research and handled questionnaire delivery, collection, and coding. Chih-Sung Lai organized research design and wrote paper. Hsing-Hui Chu analyzed data and explained results.

REFERENCES

[1] MarketsandMarkets (2019) iRobot (US) and Neato (US) are Leading Players in the Household Robots Market. Available: https://www.marketsandmarkets.com/ResearchInsight/household-robot-market.asp

[2] H. Y. Lee and S. H. Choi, "About digital home platform and service robot," *The Journal of Korea Robotics Society*, vol. 3, no. 1, 2006.

[3] Y. G. Kim and K. D. Lee, "Ubiquitous home security robot system based on sensor network," *Journal of Korea robotics society*, vol. 2, no. 1, 2007.

[4] W. Eom, Y. Kim, J. Lee, G. Choi, and E. Sim, "Development trend of intelligent robots," *Current Industrical and Technological Trends in Aerospace*, vol. 11, no. 1, 2013.

[5] J. H. Park, and H. Y. Ryoo, "User perception of the home robot price," International *Journal of Advanced Science and Technology*, vol. 115, pp.87-98, 2018.

[6] A. Parasuraman, V. A. Zeithaml, and L. L. Berry, "Servqual: A multiple-item scale for measuring customer perceptions of service quality," *Journal of retailing*, vol. 64, no. 1, pp. 12-40, 1988.

[7] S. Ram, "A model of innovation resistance," *Advances in Consumer Research*, vol. 14, pp. 121–125, 1987.

[8] S. Ram and J. N. Sheth, "Consumer resistance to innovations: The marketing problem and its solutions," *Journal of Consumer Marketing*, vol. 6, no.2, pp. 5-14, 1989.

[9] K. Moorthy, C. S. Ling, Y. W. Fatt., C, M. Yee, E. C. K. Yin, K. S. Yee, and L. K. Wei, "Barriers of mobile commerce adoption intention: Perceptions of generation X in Malaysia," *Journal of Theoretical and Applied Electronic Commerce Research*, vol. 12, no.. 2, pp. 37-53, 2017.

[10] H. Chen, B. Tsai, C. Hsieh, "The effects of perceived barriers on innovation resistance of hydrogen-electric motorcycles," *Sustainability*, vol. 10, no. 6, 2018.

[11] J. W. Lian, D. C. Yen, "Online shopping drivers and barriers for older adults: Age and gender differences," *Computers in Human Behavior*, vol. 37, pp. 133–143, 2014.

[12] J. A. Martilla, and J. C. James, "Importance-performance analysis," *The Journal of Marketing*, pp. 77-79, 1977.

[13] Š. Ormanović, A. Ćirić1, M. Talović, H. Alić, E. Jelešković, D. Čaušević, "Importance-performance analysis: Different approaches," *Acta Kinesiologica*, vol. 11, Supp. 2, pp. 58-66, 2017.

[14] R. Deepa, R. Baral, "Importance-performance analysis as a tool to guide employer branding strategies in the IT-BPM industry," *Journal of Organizational Effectiveness: People and Performance*, vol. 6, no. 1, pp.77-95, 2019.

[15] S. Sum, T. Champahom, S. Jomnonkwao, and V. Ratanavaraha, "An application of importance-performance analysis (IPA) for evaluating city bus service quality in Cambodia," *International Journal of Building, Urban, Interior and Landscape Technology*, vol. 13. 2019.

Kuei-Chien Chiu earned his MBA degree from Chaoyang University of Technology, Taiwan in 2009. He is now a lecturer in Department of Business Administration and General Education Center of Chaoyang University of Technology. His current research interests include news & communication, grey theory and innovation management

Chih-Sung Lai earned his ph. D. degree in Business and Management at National Chiao Tung University in 2001. He is now an Assistant Professor in the Department of International Business at National Taichung University of Education. His current research interests include technology management, electronic commerce, and decision science. Dr. Lai served as technical committees of 2018 and 2019 The 2nd and 3rd International Conference on E-Society, E-Education and E-Technology.

Hsing-Hui Chu received her M.S. degree from Institute of Medical Sciences, Taipei Medical College, Taiwan in 1999. She is now the secretary- general of Creative Taiwan Research Society and lecturer in General Education Center of Chaoyang University of Technology.. Her current research interests include creative design, innovation management, kansei engineering and grey system analysis.