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"Robot Rooms": How Guests Use and Perceive Hotel Robots

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Abstract
Robot-assisted hotel services get generally high marks in a study of guests at 88 hotels in China. Guests reported making fairly frequent use of the robots, primarily for such relatively simple functions as turning on the lights and turning off the TV. Chief problems occur when the robot cannot recognize operation commands, when guests must repeat their request, and when the robot isn't actually programmed for a particular operation. Asked what services they expect from a hotel robot, guests cited food distribution, delivering goods, handling check-in and checkout, and providing travel information and consumption recommendations. Two-thirds of customers considered that "robot rooms" present a good value, and a similar proportion were willing to make a return visit to rooms equipped with robots. Keys to the acceptance of hotel robots are that they must provide worthwhile services and be easy to use. An economic analysis of ten properties found favorable return on hotels' investment in robot rooms, particularly those in family suites.

Keywords
Simulated robot, Service industry, Hotel, Acceptance, Economics

Disciplines
Hospitality Administration and Management

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EXECUTIVE SUMMARY

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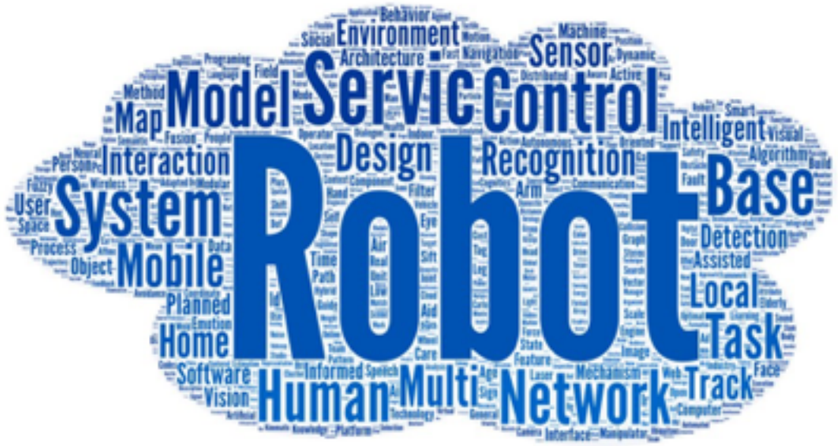
Machines that apply artificial intelligence have become sufficiently sophisticated that hospitality and service industry operators can use them for an increasing number of customer-service applications. While self-driving cars may still be on the horizon, robots can take and fill restaurant orders, handle routine hotel functions, and provide travel information.

Exhibit 1

Artificial intelligence study keywords



The study presented in this report examines the attitudes toward room robots of guests in 88 hotels in China. The nation has launched a strategic effort to accelerate robot industry development, and China has particularly targeted deployment of service robots. This includes such efforts as "Made in China 2025" and the "Robot Industry Development Plan" (2016–2020). Behind these phrases are national policies aimed at promoting rapid development of information technology and artificial intelligence.

According to the Indian survey company MRFR, the global service robot market will double to US$20 billion by 2022. To do this, developers will need to address such issues as technical maturity of security and reliability. Service robots also face potential issues surrounding information security and ethics—and governments will need to impose sound laws and regulations. Automation has spread to many service-related jobs, including translators, journalists, security guards, drivers, sales and service, traders, accountants, and even babysitters and elder care.[1]

[1] For example, see: Graaf M M A D, Allouch S B, Klamer T. Sharing a life with Harvey: Exploring the acceptance of and relationship-building with a social robot[J]. Computers in Human Behavior, 2015,43:1-14; and Compagna D, Kohlbacher F. The limits of participatory technology development: The case of service robots in care facilities for older people[J]. Technological Forecasting & Social Change, 2015, 93:19-31.

Given that the literature on robots has grown substantially, we developed a cloud map of keywords relating to robot research. As shown in Exhibit 1, researchers' chief keywords include robot, service, control, model, system, and human. Most interesting is the relationship between robot and human, which we see as becoming tighter over time. As we discuss in this paper, the hotel industry provides an excellent framework for analyzing that interaction between robots and humans.

Our examination of existing studies has found the following four "hot topics" regarding robot functioning: quality, effectiveness, peoples' expectations and acceptance of robots, and the interaction between people and robots. The research findings on these four topics are as follows.

Quality. Scholars have applied numerous frameworks to evaluate the quality of service robots, including speech recognition rate, appearance sophistication, remote control, featured smart scenario settings, and support for smart home devices. These lines of study have identified such defects as slow response, failure to provide a screen or an expression, and the robot's overall image.

Effectiveness. Numerous studies have examined the use of robots in a variety of service frameworks. Rudolph Triebel, for example, mainly examined service robots in airports, where the robots can track individuals or groups, recognize passengers' relationships and their activities, learn or model human behaviors, and guide passengers through the airport.[2] Graaf *et al*. found that home-based robots have gained increasing acceptance as they become more useful.[3] Increasing efficiency has also been recorded in the rapidly expanding areas of robots that assist in production systems[4] and social assistance robots (known as SAR, these robots can assist in dementia care or walking assistance).[5]

Expectations and acceptance. As in the studies cited above, usefulness is the key requisite for acceptance of robot services.[6] Using the technology acceptance model (TAM) proposed by Davis in 1989,[7] researchers have documented the process whereby customers come to accept and use service robots, together with the factors that influence their decision about how and when they will use them. Expectations form a large portion of this process. For instance, when R.M. Stock and M.A. Merkle compared customers' expectations toward a human frontline employee with those regarding robot-based self-service, they found that users held numerous expectations—notably regarding effectiveness and ease of use—which in turn led them to accept the service robots.[8] Wen-Hwa Lee and colleagues interviewed management staff at more than 100 restaurants in Taiwan and used TAM to analyze the managers' perception of service robots. They added quality of output—that is, being able to trust the robot—as a key element perceived usefulness.[9]

Interaction. To enhance favorable customer experience, service robots are often designed to have a humanoid appearance, with the goal of narrowing the mental and emotional distance between humans and robots. Scholars have focused strongly on aspects of humanoid robots to narrow any perceived interactional gap.[10] A study of robot types by Kang and Kwak compared an autonomous robot with a product-like robot, focusing in part on touch-related aspects. This study found that participants felt a greater social presence toward a telepresence robot or a human-like robot than a more machine-like device. However, they also reported more shyness toward a humanlike tactile-type robot.[11]

Graaf and colleagues analyzed the vital challenges regarding robot acceptance by installing a social robot in an elderly person's home for ten days. They found that as long as people were familiar with the robot, they would evaluate it as useful, intelligent, and sociable.[12] In this vein, Marcus Mast analyzed a usage concept of semi-autonomous robot control and designed the user interfaces through which elderly people can easily and efficiently control the robot with a handheld device and contact relatives or call-center professionals for an emergency.[13] These studies documenting favorable interactions between human and robot do not negate the possibility that people will feel anxious around a robot. Using two psychological scales to investigate how emotions affect the interaction, T. Nomura and colleagues focused on this matter, finding both negative attitudes and communication avoidance.[14]

[2] Triebel R, Kai A, Alami R, *et al*. Spencer: A Socially Aware Service Robot for Passenger Guidance and Help in Busy Airports[M]. Springer International Publishing, 2016

[3] Graaf M M A D, Allouch S B, Dijk J A G M. Why Would I Use This in My Home? A Model of Domestic Social Robot Acceptance[J]. Human-Computer Interaction, 2017(4)

[4] Bröhl C, Nelles J, Brandl C, *et al*. TAM Reloaded: A Technology Acceptance Model for Human-Robot Cooperation in Production Systems[J]. 4OR, 2016,10(3):287-311

[5] Jiang S Y, Lin C Y, Huang K T, et al. Shared Control Design of a Walking-Assistant Robot[J]. IEEE Transactions on Control Systems Technology, 2017,PP(99):1-8; and Nestorov N, Stone E, Lehane P, *et al*. Aspects of Socially Assistive Robots Design for Dementia Care: IEEE International Symposium on Computer-Based Medical Systems, 2014[C].

[6] Graaf *et al., op.cit*.

[7] Davis F D, Bagozzi R P, Warshaw P R. User Acceptance of Computer Technology: A Comparison of Two Theoretical Models[J]. Management Science, 1989,35(8):982-1003

[8] Stock R M, Merkle M. A service Robot Acceptance Model: User acceptance of humanoid robots during service encounters: IEEE International Conference on Pervasive Computing and Communications Workshops, 2017[C]

[9] Kuang H S, Lin C W, Wen H L. A Technology Acceptance Model for the Perception of Restaurant Service Robots for Trust, Interactivity, and Output Quality[J]. International Journal of Mobile Communications, 2018,16(1):1

[10] Kaneko K, Kanehiro F, Kajita S, *et al*. Humanoid robot HRP-2: IEEE International Conference on Robotics and Automation, 2004. Proceedings. ICRA, 2004[C]

[11] Kang D, Kwak S S. Feel Me If You Can: The Effect of Robot Types and Robot's Tactility Types on Users' Perception toward a Robot: Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction, 2017[C]

[12] Graaf *et al., op.cit*.

[13] Mast M, Burmester M, Graf B, *et al*. Design of the Human-Robot Interaction for a Semi-Autonomous Service Robot to Assist Elderly People[M]. Springer International Publishing, 2015: 15-29

[14] Nomura T, Kanda T, Suzuki T. Experimental investigation into influence of negative attitudes toward robots on human–robot interaction[J]. Ai & Society, 2006, 20(2): 138-150.

Exhibit 2

Individual action frequency analysis (all robots)

Command	Command meaning	Frequency
LOP	Turn all night on	120,235
TOP	Turn off TV	100,573
LCL	Turn all off	95,037
CL01	Open the curtain	79,388
CL01CL	Sleep, close the curtain	66,411
CS01CL	Sleep, close the window screen	38,024
MPP	Play the music/Play a song	32,066
AOP	Air conditioner on	25,721
QJ3	Sleep, turn off all lights	20,493
DOP2	Please open the door	9,786
QJ2	Dark, turn on all lights	8,864
TTV	Watch TV	8,119
CT1_1	Wake up, open the curtain	7,402
DOP	Unlock the door	6,445
ACL	Turn off air conditioner	6,074
CT1_0	Too bright, close the curtain	5,322
TV1_1	Turn on TV	4,231
OPEN_ALL_DENG	Turn on all lights	2,556
TV1_0	Turn off TV	2,320
TVOICEADD	Turn up TV volume	2,299

In sum, it seems clear that the hospitality and service industries should pay more attention to adopting robots for customer service. Social robot functions have steadily advanced, although challenges remain.[15] The advantages derived from using robots constitute a two-way street. Not only can robots add more fun and convenience into guests' life experience, but they also can helpfully collect valuable customer data. With these considerations in mind, we conducted the study described below, which examines hotel guests' use of and responses to robot service.

How Hotel Guests Use and Respond to "Robot Rooms"

In the study presented here, we examine the applications used by guests staying in "robot rooms," including the operating commands made by guests, their satisfaction with the automated functions, and their desires for how robots should assist in hotel rooms. On balance, we found that robot rooms have received reasonable acceptance and have provided a favorable return on investment for many properties.

Operating Commands Analysis

To see how guests used the robots, we collected data during all of calendar year 2017 from 88 hotels in 23 cities across China.[16] The study comprised 789 robot rooms from which we obtained 745,528 effective robot operating instructions. We classified these commands into twenty categories of operation instructions, as shown in Exhibit 2. The most prominent commands involved turning on the lights, turning off the TV, turning off the room power, opening the curtains, and closing the curtains while sleeping.

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[15] Ivanov S, Webster C, Berezina K. Adoption of robots and service automation by tourism and hospitality companies: Invtur, 2017[C]

[16] That is, data collection ran from January 1, 2017, to December 31 of that year.

Exhibit 3

Overall hour-based action frequency (all robots from 1 January to 31 December 2017)

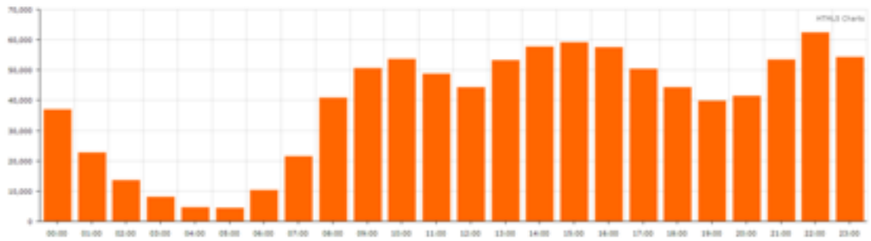
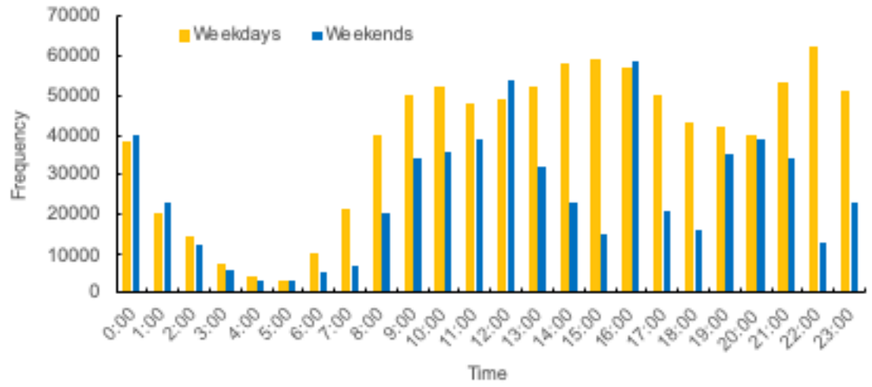


Exhibit 4

Overall hour-based action frequency, weekdays versus weekends (all robots from 1 January to 31 December 2017)



Time-of-day analysis. Taking a look at the robot commands given by guests, we found two overall patterns. First, as shown in Exhibit 3, upon checking into the room, the customer is curious about the robot and takes a stab at communicating with it through a burst of commands. On the basis of that testing and verification of the robot's functions, the guest gradually accepts and recognizes the robot's presence. The other pattern we noted was that (after a break) the frequency of using the robot is relatively high before going to sleep and after getting up.

This time-of-day analysis can be helpful to hotel managers and automation developers, as we discuss further below. Having the robot available can initially attract the customer's attention, and we anticipate that interaction with the robot will encourage the customer to stay in a room with a robot on subsequent visits.

Weekdays versus Weekends

We noted slightly different patterns in robot use when we compared commands on weekdays to those recorded on weekends (see Exhibit 4). For one thing, the overall frequency of robot use is higher on weekdays. That said, certain weekend times obtained higher use than on work days (namely, 0000, 0100, 1200, and 1600 hours). The possible reason is that customers sleep late on most rest days, while they head to bed earlier on workdays. That pattern would explain why they use robots more frequently on rest day mornings than on workdays. However, this usage pattern may also be an artifact of hotel operations, with check-in typically occurring at 1200 (noon) and check-out at 1600 (4:00 p.m.). Robot use drops substantially after 1600 on weekends, but not so much on weekdays.

Exhibit 5

Robot operation data at different times on November 28, 2017

Time	Command	Pattern Found
2:20	Play the music/Play a song	
2:21	Sleep, close the curtain	Repeated Command
2:21	Sleep, close the window screen	
2:21	Turn off TV	
2:23	Air conditioner on	Repeated Command
2:23	Air conditioner on	
2:23	Turn off TV	On/Off Commands (play with robot/ testing, not serious command)
2:23	Watch TV	
2:24	Turn off TV	
10:06	Turn off air conditioner	
13:32	Turn all off	On/Off Commands (play with robot/ testing, not serious command)
13:32	Turn all on	
17:14	Turn off air conditioner	
21:46	Play the music/Play a song	Repeated Command
21:46	Play the music/Play a song	
21:46	Play the music/Play a song	
21:52	Air conditioner on	Repeated Command
21:52	Air conditioner on	
21:56	Turn all off	
21:56	Turn all on	Repeated Command
21:56	Turn all on	
21:56	Turn all on	
21:56	Turn all on	
21:56	Turn off TV	Repeated Command
21:58	Turn off TV	
21:58	Turn all off	
22:03	Temperate set to 26 degree	Repeated Command
22:03	Temperate set to 26 degree	
22:08	Stop the music	
22:09	Turn on the room light	
22:09	Turn all on	On/Off Commands (play with robot/ testing, not serious command)
22:11	Turn all off	
22:11	Turn all on	
22:26	Turn off TV	Repeated Command
22:26	Turn off TV	
22:27	Turn off TV	
22:27	Turn off TV	

Generally speaking, there are two possibilities for guests staying at the hotel on weekdays. One is business needs, and the other is leisure needs. Whichever of those makes it possible to have more time to stay at the hotel increases the possibility of using robots. Most of the guests who check in on a rest day have less time to stay at the hotel. When it comes to the period that they should be in residence at the hotel, such as 0:00 (midnight) to 0500 (a.m.), the frequency of using the robot is similar.

Analysis of Robot Operation throughout the Day

Returning to the time-of-day analysis found in Exhibit 3, we analyzed specific commands for a single day, as shown in Exhibit 5. Here, we note the following three lessons.

(1) *The robot's ability to interact with guests needs to be improved*. When we see the same command repeated several times in succession, we can infer that the robot has certain problems in accepting customer orders. That is, the guest felt the need to repeat numerous commands, presumably because the robot didn't respond immediately. Part of this may be the variability in how people speak. For instance, the robot may not be able to recognize the accent of a customer speaking Mandarin, or the customer's voice may be too small for the robot to hear. Or there may just be too much ambient noise or external environmental interference. Regardless of the possible reasons, developers are expected to continue to improve the performance of robots in a human-computer interaction.

(2) *Customers may just be testing the robot due to curiosity*, as indicated by the sudden burst of commands upon checking into the room. In this situation, the customer would give several (possibly conflicting) operating commands in a short period, and the robot may be challenged to keep up. The guest may be trying to verify what the robot can actually do, or may be interested in trying new things. Either way, the fact that guests want to try out the robots is conducive to expanding their implementation.

Exhibit 6

Expectation statistics for robot hotel services

Expectation	1	2	3	4	5
In general, I expect hotel robot to offer better living experiences.	2	0	7	20	68
I expect hotel robot to offer more convenient services.	2	0	7	17	71
I expect hotel robot to offer more interesting experiences.	2	0	5	16	74
I expect hotel robot to offer more customized services.	2	0	5	20	70
I expect it will be a cost-effective choice to stay in robot hotel.	2	1	4	18	72

Note: Ratings are on a Likert-type scale, with 5 being highest.

Having tried out the robot, the customer will make an evaluation of its performance. A favorable assessment is crucial for the follow-up customer's willingness to continue using robots or staying in a robot-equipped hotel room. Return visits to the hotel can be promoted as a result of good feelings regarding an experience with a robot, based on the guest's conclusion that the robot has offered convenience and comfort. On the other hand, guests might develop a negative attitude following a poor experience that might result from attempting complex or infinite operations for which the robot is not designed.

(3) *Operating functions may be too limited*. The instructions listed in Exhibit 4 are fairly elementary, and they can only meet the customer's regular, basic needs. Since robots cannot yet handle complex tasks, it may be difficult to make a deep impression on the customer and prompt the customer to return.

Consequently, designers of robot rooms might well go to the hotel to experience first-hand the on-site experience of their products, think about guests' potential needs (from the customers' perspective), and develop some operating functions that can impress customers. We believe, for example, that guests would appreciate such functions as automatic indoor temperature monitoring and regulation, automatic monitoring of their personal comfort, automatic danger alarms, input and implementation of special needs, and customer health care. Only by developing more "heart-to-heart" orders can robots grasp the hearts of customers and promote greater robot use.

Guests' Expectations for and Satisfaction with Robot Rooms

To develop a snapshot of guest satisfaction with robots, we surveyed 97 customers at fifteen hotels in five cities, again during calendar year 2017. Forty-seven of the 97 customers were women, and most respondents were between eighteen and forty years old.[17] In short, our study found that customers wanted more and better robot services.

Expectations for robot hotel service. Using five-point Likert-type scales, we surveyed customers' expectations for five possible robot functions, as shown in Exhibit 6. We found the expectations to be relatively high for all five. Overall, we conclude that guests are seeking both a greater number and a wider diversity of services from robots. In addition to the everyday functions now performed, guests are hoping for robot services with distinctive features, outstanding performance, and private customization. We believe that personalized services will truly support the meaning and value of robots' existence. The goal for designers is to make service robots irreplaceable by expanding the scope of existing robot services.

[17] The respondents' age breakdown was as follows: 18-25: 38.1%; 26-30, 27.8%; 31-40, 19.6%; elderly and children, 14.5%.

Exhibit 7

Satisfaction statistics for robot hotel services

Satisfaction	1	2	3	4	5
Robot's response to my demand.	2	1	10	24	60
The convenience of the robot room.	2	0	8	23	64
The interestingness of the robot room.	2	0	8	21	66
Robot room protects my privacy.	2	0	16	19	60
Robot room offers more customized services.	2	0	7	26	62
Robot is able to chat with me.	2	0	8	25	62
The overall experience in the robot room.	2	0	7	23	65

Note: Ratings are on a Likert-type scale, with 5 being highest.

Exhibit 8

Expectation statistics for specific hotel robot functions

Service	N	Expectation Percentage
Food delivery	57	58.76%
Goods delivery	44	45.36%
Check-in	44	45.36%
Check-out	43	44.33%
Travel information	42	43.30%
Travel consumption recommendation	32	32.99%
Others	14	14.43%

Note: Expectations are presented in descending order.

Satisfaction with robot service. Interestingly, even though customers wished for upgraded robot service, their overall satisfaction ratings for the robots also were relatively high, as shown in Exhibit 7. About two-thirds of the customers gave high ratings to the overall experience of the hotel robot, indicating that they were pleased by the convenience and comfort offered by the robot's functions, and they held a favorable overall perception of the robot.

However, respondents' satisfaction with either the response of the robot to their needs or the robot's role in privacy protection was somewhat lower than other aspects. We believe that the lower rating for a robot's responsiveness may be a result of the customers' repeatedly having to request a particular function.

The issues surrounding privacy protection need additional attention. The concern here is that when the customer communicates with the robot, it will automatically collect the customer's image and fingerprint (if so equipped). The use of such personal identification methods may worry customers. To address this issue we recommend that robot developers develop a routine in which the robot destroys any personal information once it has completed its service to a particular guest. With this approach the robot would start fresh with new guests. To dispel the customers' privacy concerns, hotels would clearly indicate that all personal data are removed from the robot. Another approach would be to store guest preferences in a database that contains coded or encrypted information that identifies a (returning) guest only by number.

Robot function expectations. Asked about their expectations for specific functions in robot service, our respondents suggested functions relating to room service, front-desk service, and concierge service. As shown in Exhibit 8, substantial percentages of respondents expected that robots would handle food distribution, delivery of goods, check-in and check-out, and travel information and recommendations. What we see here is that guests would like the hotel's service

Exhibit 9

Robot function performance satisfaction

Performance function	*N*	Percentage satisfied
Turn all the lights on	66	68.04%
Turn all the lights off	48	49.48%
Turn on TV	46	47.42%
Play music	44	45.36%
Withdraw the curtain	39	40.21%
Turn off TV	37	38.14%
Drew back the curtain	35	36.08%
Turn lights up	27	27.84%
Turn lights down	26	26.80%
Open the door	24	24.74%
Close the door	24	24.74%
Stop music	21	21.65%
Change TV channels	21	21.65%
Next music	17	17.53%
Others	7	7.22%

Note: Satisfaction ratings are presented in descending order.

to be smooth for both primary and secondary functions and to proceed on the guests' preferred schedule (rather than when hotel staff members are available to handle a request). Moreover, customers hope that service processes can be completed without any interference from the hotel. The expectations regarding check-in and check-out functions reflect the cumbersome processes, complicated procedures, and time-consuming and labor-intensive problems involved in most hotels' check-in and check-out procedures. Customers are eager to automate more tasks, and this affords the industry with a huge potential to greatly improve the quality of service, for example, by speeding up check-in. Customers' expectations for access to travel information send a clear signal to the hotel and related service industries that guests seek timely information on attractions, shopping recommendations, and travel information, as well as tourist guides for the hotel's vicinity.

Satisfaction with robot performance. We asked our respondents about their satisfaction with specific robot functions, with the results shown in Exhibit 9. It appears that guests are most satisfied with functions

Exhibit 10

Robot room value perception analysis

Questions	1	2	3	4	5
I am satisfied with the services in terms of the price.	2	0	7	24	64
I am satisfied with the price in terms of the services.	2	0	8	24	63

Note: Ratings are on a Likert-type scale, with 5 being highest.

that are relatively simple to complete, such as turning the lights on and off, turning on the TV or music, and opening the curtains. The two chief reasons for this situation are: **(1)** These kinds of service are common due to habitual use, so the impression of these types of service on customers is relatively deep; and **(2)** Compared with other services, the operation of these types of service is relatively simple, so that the probability of the robot being wrong is small and the customer enjoys a pleasant experience. Further down Exhibit 9, we can see areas for improvement, notably in functions that are a bit more complicated, including switching to the next song on a playlist, changing the TV program, opening or closing the door, and adjusting light levels. So, we suggest that robot designers could address these more complicated tasks, many of which require different functions to be coordinated.[18]

Customer Perception Analysis

Perhaps the most critical questions arising from customers' perceptions of robot rooms are whether the robots deliver value, encourage return visits, and create economic value for the hotel (by offering value to the guest). We address these issues in the following section.

Robot room value. We addressed the question of whether the robot room delivered value by asking about price-value from both directions (services for price, and price for services). As shown in Exhibit 10, regardless of which way we asked the question, guests indicated that they felt that robots added value. Just under two-thirds of the customers thought that the

[18] As a side note, as a potential indication of their satisfaction with hotel robots, a substantial percentage of respondents indicated that they would consider purchasing a robot for tasks at home.

Exhibit 11

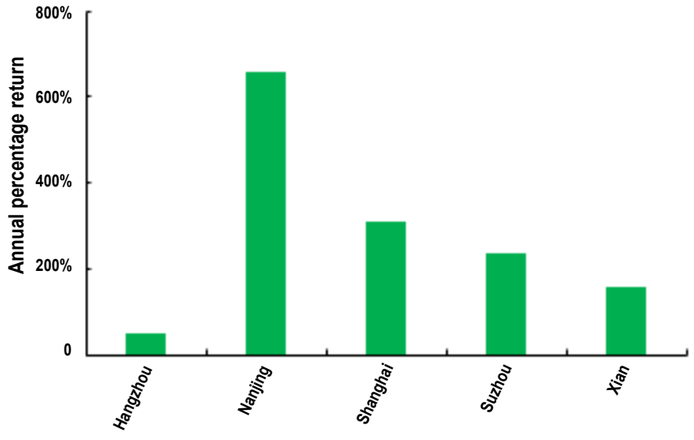
Analysis of rebooking intentions

	Score				
	1	2	3	4	5
Will you stay in robot room again?	2	0	3	31	61
Will you stay in robot room again if the room rate rises by 10%?	3	1	17	27	49
Will you recommend your friends to stay in robot room?	2	0	5	29	61

Note: Ratings are on a Likert-type scale, with 5 being highest.

Exhibit 12

Annual percentage return over additional cost of implemenation, by region



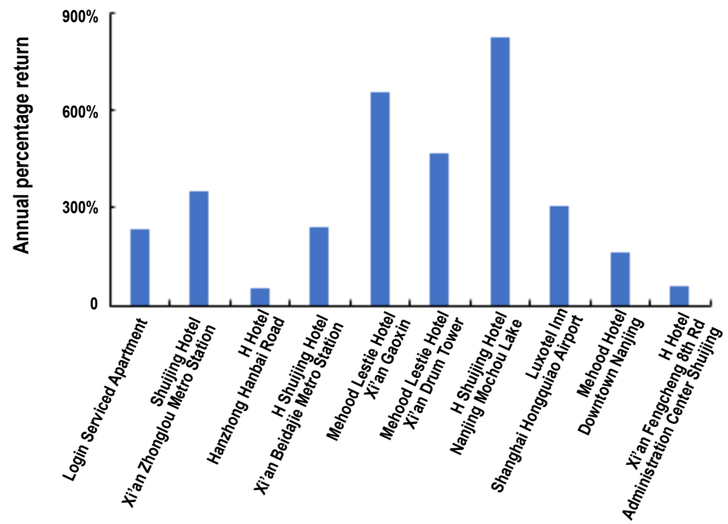
service of the robot room was highly worthwhile (five out of five on a Likert-type scale), while only 2 percent of respondents reported that the services of the robot room are worthless. Those respondents explained that the service provided by the robot was simply not what they sought in a hotel room.

Rebooking intentions. We found that guests seemed willing to return to the robot room, and many would return even if they had to pay more for that room, as shown in Exhibit 11. Regarding the simple question of a return visit, all but five respondents said they would visit the rooms with robot service again, and all but seven were willing to recommend them to friends. A potential 10-percent price increase slowed down the rebooking enthusiasm, but half of the respondents still said they were willing to visit the hotel again. We take this result as a caution for hoteliers not to unreasonably raise the rates for robot rooms.

Economic analysis of robot applications. To examine the economic value of hotel robots, we calculated the annual return on the additional cost of installing the robots for hotels in the following five representative cities: Hangzhou, Nanjing, Shanghai, Suzhou, and Xi'an. As can be seen in Exhibit 12, the return on the additional cost for robot installation approached or exceeded 200 percent for hotels in four of the five regions. Only in Hangzhou was the annual return on the added cost of installation quite low (51.1%), whereas Nanjing hotels reported a remarkable percentage return over the additional implementation costs exceeding 655 percent. Although this analysis is limited by a small sample size, we believe that the low percentage return for hotels in Hangzhou is mainly related to the timing of robots being put into use, since the property had installed its robots only recently, as well as the number of robots implemented and the error rate in the robot application process. By contrast, Nanjing has a large tourism market, and the hotels there have a relatively large occupancy, both of which facilitate promotion of robot use. We also believe that hotels in Nanjing have a greater number of robots that were installed on a timely basis in relation to our study. Again, the specific constraints need further investigation and analysis due to the limitation of sample size.

Exhibit 13

Annual percentage return over additional cost of implemenation for selected hotels



Economic Analysis of Individual Hotels

To the extent possible, we examined the return on the cost of robot installation for the individual hotels in our sample. Of the fifteen hotels studied, ten provided economic data that allowed us to analyze their percentage return relative to the additional cost of implementation, which demonstrated a favorable return on the robot investment. As shown in Exhibit 13, the average percentage return in relation to implementation cost for the ten properties was just over 334 percent. With two exceptions, these hotels have an annual return on the cost of implementation of 150 percent or more, with a range of 51.1 percent to 823.4 percent.

An examination of the robot installations at the hotels at these two extremes of percentage return leads to a suggestion that hotels target their robot installations to appropriate market segments, rather than deploy the robots widely throughout the property (at least initially). The hotel with the highest rate of return, H Shuijing Hotel (Nanjing Mochou Lake), first installed its robots in a suite with an average price of 500 yuan per night. Thus, the hotel focused on putting the robots in rooms occupied by high-end guests, where recognition and acceptance are better. In contrast, the hotel with the lowest percentage return, the H Hotel (Hanzhong Hanbai Road), installed robots extensively, placing them in standard rooms and big-bed rooms, as well as suites. The ADR for robot rooms in this hotel came out to 230 yuan, and guests in a variety of market segments are in robot rooms. It seems clear that these various market segments have a differential acceptance of robots, which in turn leads to variable room sales and a less desirable return on the cost of installation for the robots in the entire hotel.

Economic analysis of different room types. In the above analysis, we noted that guests purchasing different room types responded differently to the robots, with the resulting impact on the robot percentage return in relation to the additional cost of implementation. Looking more closely at this issue, we conclude that the economics of placing robots in family suites are significantly better than other types of room (see

Exhibit 14

Annual percentage return over additional cost of implemenation, by room type

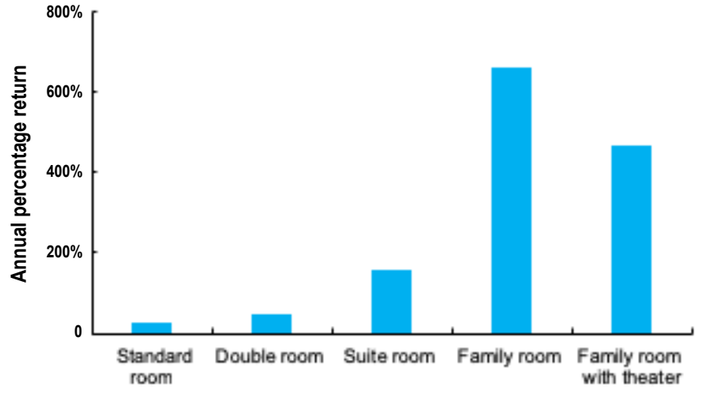


Exhibit 14). Among the five room types that we examined, family suites have the highest annual return on the cost of installation, at 657 percent, while the annual percentage return for standard rooms is only 26 percent. This phenomenon may occur because the family suite has a large difference in guests' age, occupation, and gender, as compared with other room types. The proportion of children in the family room is particularly high, and we propose that children must be much more attracted to a robot than are adults. As a result customers with children will choose the suite with robot service when choosing a family suite, even though the price is slightly higher than other room types. For the standard room, in contrast, most of the customers who book these rooms are people of similar age, gender, or occupation. They may communicate with each other more often and don't pay much attention to whether there are robots. Moreover, customers who choose the standard room may worry more about the cost of the hotel room than the quality of extra features (including robots).

A Robot in Your Future

Our analysis of robot installations in 88 Chinese hotels indicates that automation is relatively elementary at this juncture, with considerable opportunity for designers to improve the guests' experience. Our survey of robot usage shows that the most common machine operation commands for customers are turning the lights on and off, turning the TV on and off, turning off the power, and opening and closing the curtains. After an initial flurry, guests tend to use the robots late in the day to settle for room for sleeping. We noted that the frequency of using a robot on a working day is higher than on rest days. There's still development needed for hotel robots, as customers reported such problems as robots not recognizing operating commands so that guests have to repeat themelves, and the fact that robots currently have limited operating functions.

Nevertheless, respondents in our survey reported relatively high satisfaction with their robot room, and guests hope that future robots can provide interesting services and private customized services. Guests would expect that robots would deliver food and goods, assist with check-in and check-out, and provide travel information and recommendations. Guests reported that their robots were particularly handy for turning lights on and off and for turning on the TV (but not so much for changing channels).

A solid two-thirds of the respondents reported that the robot room was worth the money, and a similar proportion said they would return to the robot room. The main factors affecting the acceptance of hotel robots are their perceived usefulness and ease of use, as well as guests' social and individual differences. Economic analysis of robot applications in ten Chinese hotels shows that most of the hotels using robots have a favorable annual return on the additional cost of installing the robot (exceeding 200 percent), and the annual return on investment for family-type rooms is much higher than other room types. ■

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