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How passenger decides a check-in option in an airport: Self-Service Technology Adoption model in passenger process

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***Abstract*—This study intends to propose "Self-Service Technology Adoption Model" by utilizing the knowledge and experiences of front line experts. The Agent-Based Model has a fuzzy inference system to let passengers choose a check-in option: a conventional style check-in position or a self-service kiosk. The experiments are conducted with observed data, which are collected from the airline's Departure Control System (DCS). We tried approximating the experimental space to "the real world" and evaluating the proposed model by measuring how it reproduces the observed self-service usage rate in "the real world". This study also suggests the efficient practice of air–travel passenger handling with self-service kiosks in an international passenger terminal by the simulation of the proposed agent-based model. Through conducting the experiments, the scenario and the key factor are indicated, which may possibly accelerate the self-service usage rate with cost effective way and less impact for customer services.**

I. Introduction

THIS study pursues to clarify how consumers make decision when they face to choose self-service technology to help firms understand how they can best promote cost efficient service alternative. We look over the current circumstances of airline industry in this chapter, and describe the objectives of this study.

A. Background

Currently Full Service Carriers (FSCs) are facing severe competition with new players such as Low Cost Carriers (LCCs) and other foreign carriers, in which the current deregulation policy brings aircraft landing slots in the short-range view of the aviation industry in Japan. The recent statistic clearly shows our society is aging due to better health care and with fewer children; these facts consequently leads airlines to the necessity to enhance their presence in the international service sector rather than the domestic service sector.

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The competition in global airline industry will be even more severe for them because emerging countries can provide workforce with a lower wage cost than labor markets of developed countries. Current FSCs need to provide high quality service with lower price in order to keep attracting the loyal frequent flyers.

Huge investments are required to upgrade services as well as renew the aging air fleets and equipment. The automated process has been recognized as one of solutions for cost saving and self-service technologies (SST) have been implemented in various processes. However, though self-service process in the domestic airports is spreading, there is a lot of room for improvement in the international sector.

B. Objective of this study

This paper pursues two objectives. One of them is constructing the SST adoption model to examine the mechanism of how passengers choose their check-in option in the departure lobby of an international airport. We study how recognized waiting time and the degree of self-service options' perceivability affect usage rate of self-service kiosks by modeling the process of cognition and decision-making of passengers, which the queuing theory does not deal with [3]. We conduct series of experiments to ascertain the validity of the proposed agent-based model through calibration and expanding the prototype model. It has a fuzzy inference system, which utilizes the empirical knowledge of front line experts and observed data from airline's DCS.

The other objective of this study is to discuss the best practice of passenger service with self-service kiosks among the prepared scenarios. We also discuss how the frequent self-service users' existence helps increase the usage rate of self-service kiosks.

Knowing how the passengers makes decisions and what contributes to increase self-service usage rate will help firms to plan how they can best promote SST usage improvement.

II. RELATED WORK

According to Levitt [6], the product of an airline is not only transporting passenger from point A to point B, but "service" itself. As service has characteristic of "intangibility", "inseparability", "heterogeneity", "perishability", air-travel passenger evaluate those services from their travel experience including check-in process in the departure lobby. We reviewed previous studies of self-service technology and diffusion of innovation from three areas.

Convenience has been examined and discussed from mainly two perspectives, one side of them is "waiting time and its management" and other is "what people find their convenience from the consumer point of view" [1]. There are studies for finding factors which influence the usage of SSTs through various surveys by interviews and questionnaires on service site and/or in website etc.

Meuter[7] described that service convenience brought consumers' satisfaction of using SST and the most major reason of using SST when it is "better than alternatives" and they appreciate "time saving" the most. Bitner[2] proposed that "Consumer Readiness" influences the usage of SSTs in "The Model of SST Adoption". Meuter[8] extended their study and found "Technical Anxiety" explained influence of SST adoption even better than the demographics of users.

Rogers[9] described that the designated variables defined the speed of diffusion. More "Relative Advantage", higher "Compatibility", less "Complexity", higher "Trialability" and "Observability" speed up the diffusion of innovation. And how "change-agent" promotes the innovation is one of important variables to fasten the diffusion.

Check-in is mandatory process for air-travel passenger before boarding the aircraft. There are more conventional ways of checking in, however, if passengers discover and accept these new ways of checking in, they are introducing new ideas to increase their convenience. In this regard, how innovation diffuses has implication for self-service usage. Rogers indicated the 5 processes on how people adopt innovation.

Agent-based model is based on the technical instrument, which enables each agent to behave autonomously. Agent-based simulation developed its study field by expanding players in experimental space and approximating the experimental space to facsimile the real world. The social multi-agent system aims to explicate the phenomena in the complex social system [5]. Kawai [4] attempted to build abstract model to explain diffusion of services by the agent-based model.

Those studies are indicating the important factors and/or concepts of diffusion of SST adoption or innovation. However, they did not reproduce the mechanism of consumers' decision making when they face opting the conventional ways or SSTs by utilizing the agent-based model. As Kawai's attempt didn't utilize the observed data, it is difficult to explicate the phenomenon of diffusion and what makes consumers to select an alternative.

III. FEATURES OF SST IN AN AIRPORT

Currently LCCs keep and gain passengers by providing

TABLE 1.
FEATURE OF SELF-SERVICE KIOSK FOR DOMESTIC/INTERNATIONAL AIRPORT

Items	Domestic	International
Feature of domestic/international service context in an airport		
Flight volume per day	Many flights per airline	Less flights per airline
Facility	Does not need any government formality (CIQ) Dedicate (24/7) usage	Needs government formalities Common use
Self-service kiosk (SSK)	Already spreading Long history in market	New product Implemented after 2005
Feature of domestic/international Self-service kiosk		
Ownership	Respective airlines	Airport or AOC
User(s)	Dedicate use	Common use
Features	Same: Color, Shape etc.	Various
Deployment	Consistent	Inconsistent
SSK operations	Simple	Complicated

competitive prices and adopting clear-cut attitude on customer services. Passengers fly with LCCs on the premises of self-service usage through their experience from reservation to boarding and cabin experiences. They opt additional service such as interpersonal check-in, as additional charges are applied.

LCC passengers have a clear intension to save money, so that when they fly with a LCC they take it granted using a self-service kiosk for check-in.

In this section we briefly review the history of self-service deployment in Japanese market and the current context of self-service devices in airports.

A. *Brief history of self-service kiosk in the airport*

We focus on the FSC passenger using international flights because these passengers' self-service kiosk usage is not as popular as for domestic services.

One of two major reasons why implementation of self-service kiosk for international flights had to wait until the late 2000s was due to ticket media. In Japanese domestic market, Automated Ticket and Boarding pass (ATB) have been deployed since the 1980's and those tickets with magnet stripes are compatible with self-service, as kiosk needs to read encoded information on the tickets. Since there is fewer interline connection passengers in the domestic market, most of the domestic ATB are controlled by the Japanese airlines and issued as machine-readable.

On the other hand, there were many international flight coupons (tickets) with red carbon because various foreign carriers and travel agencies overseas, whom Japanese airlines could not influence, issued those tickets. Even though the ticket had a magnet stripe, the encoding quality was not very consistent. Therefore substantial volumes of flight coupons were not machine-readable. It was an obvious challenge for airlines to introduce self-service kiosks under such circumstances: there were many passengers who could not use self-service kiosk due to their ticket type.

This difficult context was dramatically changed by International Airline Transportation Association (IATA) e-ticket policy announcement in 2004. In 2008 100% e-ticketing policy almost removed the inconsistency of ticket media, and airlines could verify the ticket validity with ticket database by ticket number.

Another aspect of delaying the implementation of self-service in international sector is the complexity of check-in procedure of international flights. The airline check-in agents need to verify the travel document to clarify if it satisfies passengers' disembarking requirement at their destinations. We needed to wait until new technology take place of this skill required procedure.

However, those two major issues have been solved. We see more self-service kiosks in international passenger terminals.

B. *Observed passenger behaviors in an airport*

Through interviewing the passenger service experts, we focus on a few simple rules, which is mentioned later (IV.B). The more than 16 days of on-site-observation were conducted. It includes 7 days that the airline provides their DCS data. We have learned some interesting passenger behavior in the departure lobby as follows:

- Passengers using self-service kiosk without hesitation
- Passengers using self-service kiosk on a case by case basis after observing the local context
- Passengers paying no attention towards self-service kiosk

We also observed how airline-handling agents (CSR: Customer Service Representative) interact with passengers in front of a self-service kiosk, who promote self-service kiosk usage to passengers. And three types of reaction were observed as listed:

- Passenger accepting the suggestion
- Passenger rejecting the suggestion
- Passenger accepting the suggestion with some conditions (with operational support, ensuring the self-service option is a quicker/easier process than alternatives)

We also observed that CSR's active and positive approach to passengers contributed to increasing self-service usage.

C. *Self-service kiosk for domestic/international flights*

The implementation of self-service kiosks for international service is fairly new since there are different in context from domestic services as described in the preceding paragraph. And it is rather difficult for international passengers to find a self-service kiosk under current circumstances as Table 1 describes.

IV. SELF-SERVICE ADOPTION MODEL IN AN AIRPORT

This study proposes to reproduce the dynamic decision-making mechanism of passengers in airport departure lobby in experimental space. We mapped a partial departure lobby ("the real world") to experimental space and ran the simulation with observed data which was collected by the airline DCS. In this section we describe the overview of the proposed model.

A. *Model Concept*

There are experienced airline handling staffs in passenger service, who know the tips to motivate and encourage passenger to use self-service kiosks and optimize their staff and self-service kiosks in the lobby. They know how to streamline the process of their passenger handling, they

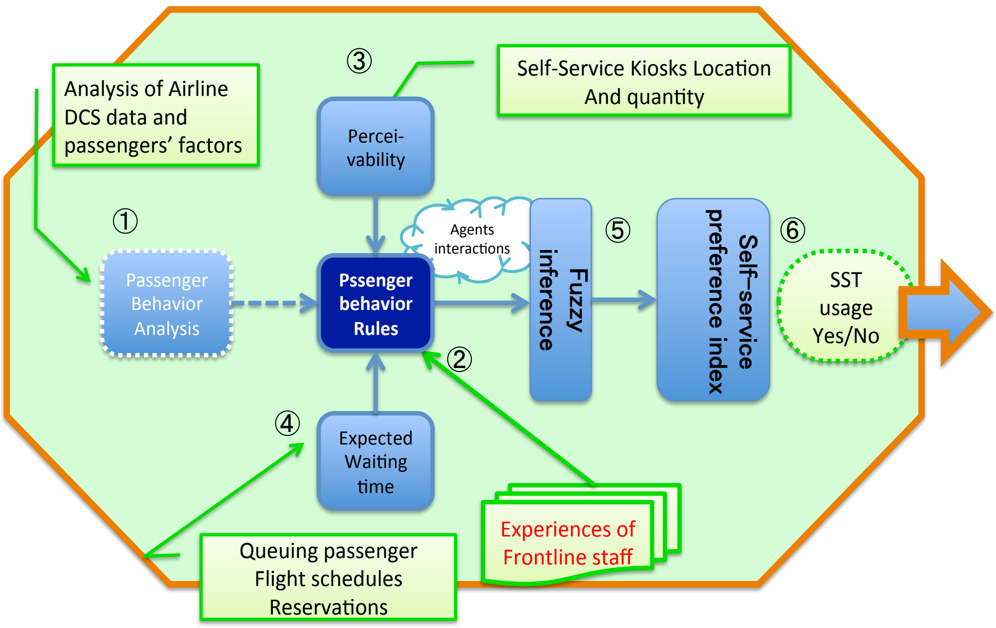

Fig 1. SPI model

know how passenger behave according to their surrounding situation.

We have come up with the self-service adoption model by utilizing the front line experts in passenger services, and that it has a fuzzy inferences system in order to take into consideration of human decisions, as passengers deal with vague information (Fig.1).

The fuzzy rules for inferences are defined through empirical knowledge of passenger service experts. The inputs for calculating membership scores are generated in the agent-based model, which introduce the observed data provided by the airline. By compiling the results of each rule, this model outputs the "Self-service Preference Index (SPI)", which means passenger decision to use or not to use a self-service kiosk for the check-in option.

B. SPI quantification (Defuzzification)

It applies two simple rules as listed in Table 2. The estimate waiting time of queuing in front of the conventional check-in position (Fuzzy membership score "W") and the perceivablity of Self-Service Kiosk (Fuzzy membership score "V") are the key indexes to decide his/her option for check-in.

TABLE 2: FUZZY RULES

Rule-1	IF "W" is short and "V" is low, THEN Self-service Preference is rather negative.
Rule-2	IF "W" is long and "V" is high, THEN Self-service Preference is rather positive.

The respective rules calculate their results by the max-mini inference method and using the simplified centroid method for defuzzification combines these results.

The input value to calculate the membership score "W" is defined as equation (eq.1).

EQT is the waiting-time in a queue at conventional check-in position predicted by the passenger, compared with the waiting time of using the self-service kiosk.

NCCQ stands for the Number of passenger waiting in Conventional Check-in Queue. And CCPs stands for the number of Conventional Check-in Positions. NSSQ stands for the Number passenger waiting in Self-Service Queue. And SSU stands for the number of Self-Service Units.

"*p1*" and "*p2*" are weighting-parameters of each members of equation. How we arrange the weighting parameters will be mentioned later. How we arrange the weighting parameters will be mentioned later.

$$EQT = \frac{NCCP}{CCPs} xp1 - \frac{NSSQ}{SSUs} xp2 \qquad (1)$$

Another input value to calculate is the membership score "V" which is the passenger head count in front of self-service kiosks. The membership score "V" is low when no passenger uses self-service kiosk. The more passenger use self-service kiosk, the higher it scores. However once number of passenger exceeds the number of self-service kiosks, it scores lower and lower.

C. Process of experiments and evaluation

In this study, firstly we build a prototype model (Fig.2) and verify the behavior of agents, secondly map existing

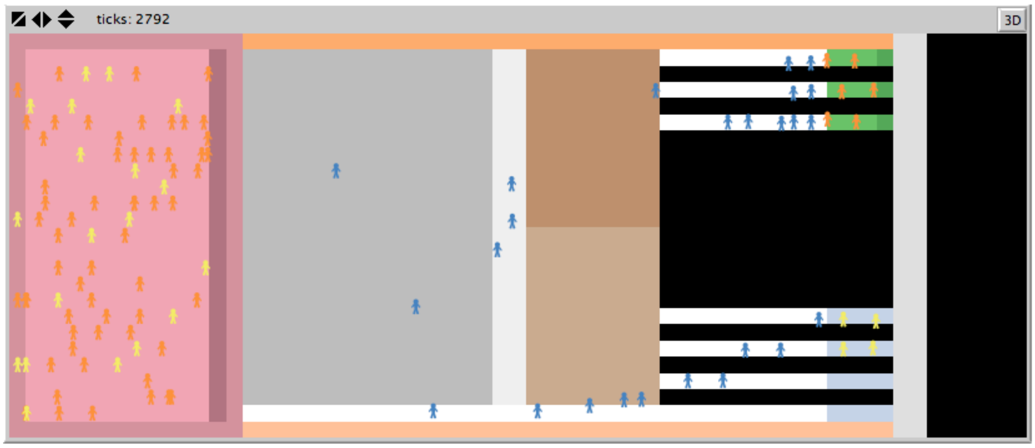

Fig 2. mini-model (Prototype)

observable data of the real world to this model. And after examining the gaps and found subjects, we apply them and expand the model to approximate to the real world.

To evaluate the probability of this model, we focus on the "self-service usage rate" which is the ratio of passengers using self-service kiosk for all check-in passenger. We estimate the best parameter value with the training data, and run the simulation with other experiment data, using the fitted parameter value. We look at the "self-service usage rate" that is the result of the experiment and the observed "self-service usage rate" in the real world to evaluate the probability of the proposed model.

We collect the proxy data of passengers' 60 minutes show-up timing (check-in complete timing) from the airline's DCS for the simulations. Using this data, we generate passenger agents in the experimental space and see reproducibility of this agent-based model.

V. Model Experiments and Discussions

A. Experimental space and parameters

Through the experiments, we verified that the model behaved how we intended to and observed expected output by calibration. However, We find following issues to make it approximate to the real world:

- We need to adjust the productive properties of the proposed model to the same quantity as the observed environment. Passengers using self-service kiosk with baggage consequently stop by "Bag Drop position" to check their baggage. And these positions are utilized like conventional check-in positions when there is no waiting passenger for checking the baggage.
- We need to set the observable parameters to the values observed in the real world.
- We need to estimate the values of unobservable parameters in the real world.
- We need to implement the mechanism of CSR's interaction with passengers. They approach passengers to urge them to try the SST.

B. Summary of imported data and parameters

In consideration of the preceding clause, we correspond raised issues as following:

- We add "Bag Drop position" in addition to the conventional check-in position and self-service kiosk as a check-in option. Those quantities are adjusted to the same amount of the operation date. (See Appended Table 1.)
- We map the observed parameter values to the model, such as "baggage holder ratio", "frequent self-service user ratio", etc. (See Appended Table 2.)
- We estimate the values of unobservable parameters: "*speed-limit*" and "*p1*", the weighting parameter of interpersonal service preference.
- CSR's interaction to passenger will be described later in V.*C*.1) The Concept of "Hesitation model".

C. The expanded model-1: Bag Drop Utilizing (BDU) model

1) Corresponding the raised issues by prototype

We have corresponded the raised issues in "V.*A*. *Experimental space and parameters*" by setting productive properties just the same as the operation date. Then parameters both observable and unobservable are set and estimated.

Bag Drop is not only the position to check bags but also that CSR can perform check-in similar to the conventional check-in position when there are no passenger queue for checking their baggage.

We select the data (date412) as a training data for this experiment, because we see there is almost no positive approach from CSR to passenger. We calibrate "self-service usage rate" by changing the values of two parameters (firstly "*speed-limit*" and then "*p1*") and finally select the values of those parameters, which bring it almost approximately to the real world.

For fitting the parameter, we changed "*speed-limit*" value from 0.10 to 0.30 by 0.01 and ran 20 simulations and calibrated the self-usage rate for each time. It was observed that RMSE from the real world is smallest when "*speed-limit*" was 0.25 in the experiment.

Next parameter fitting with "*p1*" was done after setting "*speed-limit*" 0.25. We ran 20 simulations and calibrated the self-service usage rate by changing "p1" from 3.0 to 6.0 in every 0.1 value. Through the calibration, it was observed that the experiment results approached closest to the real world with "*speed-limit* = 0.25" and "*p1* = 5.1".

Table 3: Simulation Results with Speed-limit=0.25, *p1*=5.1

Speed-limit *p1*	*0.25* *5.1*	date406	date408	date409	date410	date411	date412	Ave.
Productive	*quantity*	*CC3BD3*	*CC2BD3*	*CC2BD2*	*CC2BD2*	*CC2BD2*	*CC3BD2*	
Usage rate	real data (a)	0.351	0.375	0.364	0.446	0.496	0.272	
	sim ave. (b)	0.303	0.369	0.303	0.377	0.369	0.245	
difference	(c) = (b)-(a)	-0.048	-0.006	-0.061	-0.069	-0.127	-0.027	
RMSE	SQRT(c^2)	0.048	0.006	0.061	0.069	0.127	0.027	0.056
								RMSE Varaiance
SSU : Self-Service User , Usage rate : SSU usage rate								0.0017

Table 3 and Fig.3 show the simulation results (6 days) of the expanded model, Bag Drop utilizing model. The productive properties are fitted to the observed context. Therefore active check-in positions, Bag Drop positions and self-service kiosk are same in experimental space as the situation of which data was collected. In Table 3, the simulation results are shown below the observed "self-service usage rate" of the real world.

In Fig.3, the bar graph displays the RMSE of simulation results average and observed "self service usage rate", the line graph shows the observed "self-service-rate"(real-data) and simulation result average (CSR=0 means that this model does not include CSR's interaction).

The data "date412" was collected on the day CSR did not positively approach the passengers. Our experiment shows RMSE between the real world and the experimental space becomes 0.027.

This result is within the expectation and feasibility because it means that 100 passengers showed up in departure lobby during the busiest business hour and consequently there were 3 more/less passengers using self-service kiosks than the observed result. Therefore we evaluated this result is approximating to the real world. However other experiment results except using data412 are lower than observed values and the errors from the observed values vary inconsistently.

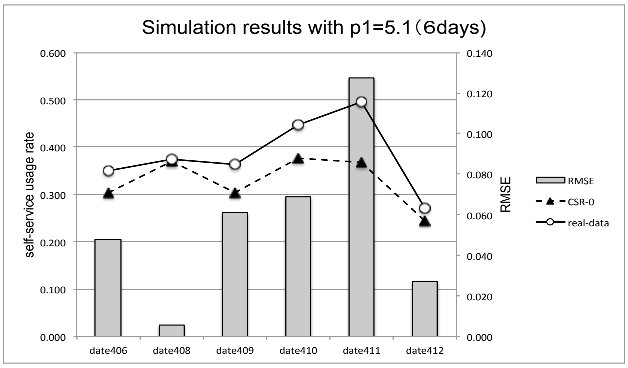

Fig.3: Simulation results with *Speed-limit* =0.25,*p1*=5.1

2) Bag Drop utilizing model experiments and discussion

We analyze that the reason why the experiment results vary and produce the error from the observed data in the real world. Though we recognize that CSRs are approaching passengers to urge them using self-service kiosk in the real world and it appears to work effectively, the "BDU model" doesn't include interactions between CSRs and passengers.

In this sense, output results from this simulation model are predictable as expected, because they come out below the observed result without CSR's interaction, so the effectiveness of CSR's approach depends upon their skills and actual effort of them.

In the next step, we propose to implement the interacting sub-model between CSRs and passengers in order to refine and develop the Bag Drop utilizing model.

D. The expanded model-2: Reducing Hesitation model ("Hesitation model)

1) The Concept of "Hesitation model"

Corresponding the subject in the previous clause, and focusing the influential factor, we introduce "state of mind" into passenger agent to expand the BDU model.

When the experimental space generates passenger agents, it gives each agent a new variable valued randomly, which is equivalent to hesitation of adopting the new way of doing. And the expanded model locates CSR agents in the lobby who approach and urge passenger agents to use the self-service kiosk. (See Fig.4)

CSR agent can reduce the "hesitation" of using self-service for passenger agents when they come into contact. The reducing value depends upon the status of CSR agents. If they contact passenger agent twice in a short period, the first contact will reduce more value of the "hesitation" variable than the second time. If duration after first contact is long enough, the reducing value of second contact will be of the same amount.

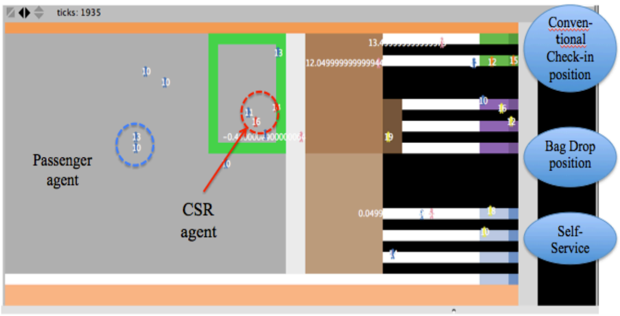

Fig.4: Reducing Hesitation model ("Hesitation model")

2) Result of "Hesitation model" experiments and discussion

We conducted 50 simulations for respective datasets and calibrate the self-service usage rate. The experiment shows that the results approximate to the real world most closely with 2 or 3 CSR agents. The average of RMSE between the experimental result and the observed self-service usage rate is 2.5% (See Table 4).

Table 4: Simulation Results with CSRs

Speed–limit p1	0.25 5.1	date406	date408	date409	date410	date411	date412	Ave.
Productive CSR	quantity quantity	CC3BD3 2	CC2BD3 2	CC2BD2 2	CC2BD2 3	CC2BD2 3	CC3BD2 0	
Usage rate	real data (a)	0.351	0.375	0.364	0.446	0.496	0.272	
	sim ave. (b)	0.361	0.422	0.364	0.452	0.434	0.245	
difference	(c) = (b)–(a)	0.010	0.047	0.000	0.005	−0.062	−0.027	
RMSE	SQRT(c^2)	0.010	0.047	0.000	0.005	0.062	0.027	0.025
								RMSE Varaiance 0.0006

SSU : Self–Service User, CSR : Customer Service Representative
Usage rate : SSU usage rate

It is considered that this model has a fair probability to approximate to the real world as follows:

- The number of CSR located in the real context is equivalent to the number of CSR agents in "Hesitation model".
- The errors between the real data and simulation result average decrease from the "BDU model" experiment. And RMSE of "Hesitation model" becomes about half amount of "BDU model".
- The RMSE variance reduces as 1/3 in comparison with that of "BDU model".
- Fig.5 shows that the experimental result of the proposed model is getting closer to the observed data.

VI. Scenario Analysis

In this chapter we examine two sets of scenario analysis. Firstly we discuss the effective passenger handling by utilizing self-service kiosk through the simulations with the proposed model. Secondly we focus on the passenger who most likely use self-service kiosk to discuss how "frequent self-service user" gives positive influence in terms of increasing self-service kiosk users.

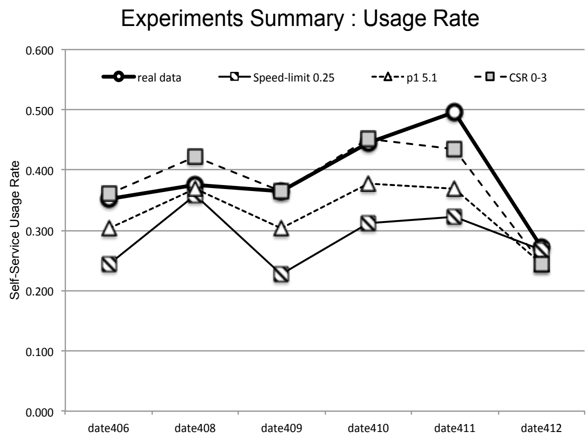

Fig.5: Experiments Summary of "Hesitation Model"

A. Scenario analysis: examining an efficient passenger handling to increase self-service usage rate with cost-effectiveness and low-impact for customer service

1) Experiment scenarios and focus of scenario analysis

There are two perspectives how we set the scenarios. Firstly, we are looking at the impact which staff reduction makes. Secondly, we examine differences staff relocation makes. We set the reference scenario using the dataset "date406", which we have 3 conventional check-in positions (CC3), three Bag Drop positions (BD3) without CSRs (CSR0): CC3BD3CSR0 (hereafter the combination of productive properties are stated CCnBDnCSRn). Examined scenarios are listed in Table 5.

Table 5: Scenarios for experiments

Scenario	CCK	BD	CSR	SSU	Number of Operating Agents	code
Original plan	3	3	0	4	6	CC3BD3CSR0
Scenario(1)	3	2	0	4	5	CC3BD2CSR0
Scenario(2)	2	3	0	4	5	CC2BD3CSR0
Scenario(3)	2	2	0	4	4	CC2BD2CSR0
Scenario(4)	3	2	1	4	6	CC3BD2CSR1
Scenario(5)	2	3	1	4	6	CC2BD3CSR1
Scenario(6)	2	2	1	4	5	CC2BD2CSR1
Scenario(7)	2	2	2	4	6	CC2BD2CSR2

CCK: Conventional-Checkin , BD: BagDrop , CSR: Lobby Service Agent, SSU: Self-Service Unit

2) Experiments of scenario analysis

We ran the simulations to compare the effectiveness among them from following three perspectives;

a) How does the respective scenario work to increase self-service kiosk users?
b) Is it contributing to cost reduction?

c) Does it result in a significant impact on waiting time?

Each experiment consists of 50 simulations for each scenario. We look at the results with above measures to evaluate the scenario.

3) Experiment results and discussion

Fig.6 displays the results of 6 scenarios with the experiments result including the reference model on the far left (CC3BD3CSR0). The bar graph shows self-service usage rate and line graph shows the largest totals of agents' headcount in simulations, which are making queue in front of productive properties.

As each scenario has 50 simulations, number displayed on the graph is the average totals of the largest headcount of each simulation.

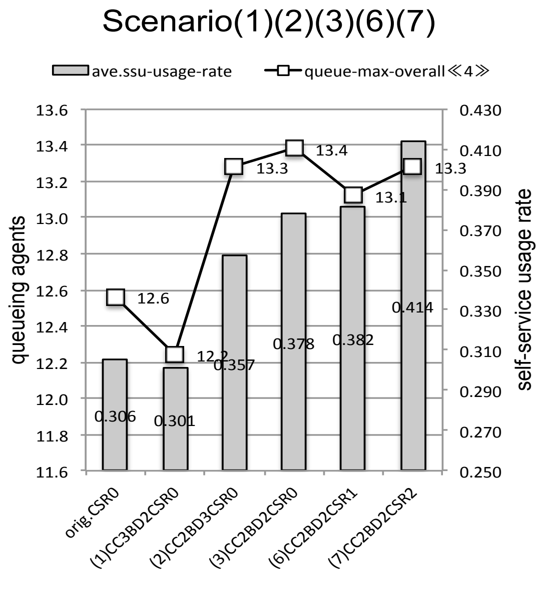

Fig.6: Simulation results

Table 6 displays ranked scenarios according to the respective perspectives. It shows that the most feasible scenario is the Scenario 6, which reduces a conventional check-in position and a Bag Drop position and relocates one operating staff in the lobby to assist and urge passengers to use self-service kiosks.

Focus point	Scenario 3	Scenario 6	Scenario 7
Perspective a)	3	2	1
Perspective b)	1	2	5
Perspective c)	3	1	2

TABLE 6: SCENARIO RANKING FOR EACH PERSPECTIVE

With regard to increasing self-service users, the scenario 7 is the top. However, it does not reduce cost. With regard to cost reduction, the scenario 3 defeat all but it produces the queuing passengers most. The scenario 6 is in second place with regards to increasing self-service users and cost effectiveness, however this scenario does not give a huge impact on waiting time, because it didn't make as long queue as those scenario which took the first and/or second place in perspective a) and b).

Through observing the passenger handling and simulation experiments, this study reaffirms the important principle of on-site management. Knowing the expected result through simulation, the management will be able to locate necessary man resource at the necessary position. It is also important for management to make the man resource function.

We see CSRs' approaching to passenger make difference to increase self-service users. It is important for the acting staff to recognize the role and expected outcome. The agent-based model may be able to give both of them the visible ideas and outcomes of their scenarios.

In the real world, the local managements take prudent steps to try new things, because they can't take a chance, don't like that the new way affect their current service level. We can say that as long as the agent-based model is approximating to the real world, and the local managements understand its limitation, agent-base model with high probability can be some of help for service industry to get a rough idea how new things work.

B. Scenario Analysis: In terms of increasing self-service product users for international air-traveler

1) Experiment scenarios and focus of scenario analysis

We conduct series of simulation in the previous section by changing the productive properties. In this section, we select three scenarios and calibrate the self-service usage rate by changing the ratio of "frequent self-service user".

2) Experiments of scenario analysis

It is observed that the existence of passengers who is using self-service kiosks gives positive influence to passengers who select check-in option in both the real world and the experimental space. In this section we calibrate and examine how the change of "frequent self-service user" will give impact to self-service usage rate.

The proposed agent-base model stochastically gives the property, which is to select self-service kiosk, to generated agents. We select following three scenarios and run 20 simulations for each scenario by changing the parameter of "frequent self-service user" rate into every 0.05 from 0.00 to 0.40. Each scenario has 6 service agents who are located in different ways. We use the same dataset as the previous scenario experiment in VI.*A*: "date406".

- CC3BD3CSR0: "Original plan" which has 3 conventional check-in positions and 3 Bag Drop positions and no lobby service agent
- CC2BD3CSR1: "Scenario 5" which has 2 conventional check-in positions and 3 Bag Drop positions with 1 lobby service agent
- CC2BD2CSR2: "Scenario 7" which has 2 conventional check-in positions and 2 Bag Drop positions with 2 lobby service agent

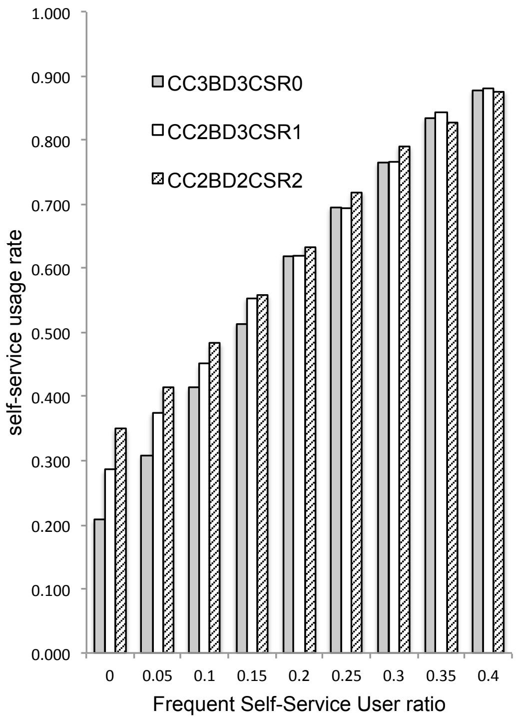

Fig.7: Influence of Frequent Self-service Users

3) Experiment results and discussion

The results of experiments are displayed in Fig.7. It shows that each case increases self-service usage rate in proportion to "frequent self-service user" rate. The experiments with zero "frequent self-service user" rate display that the existence of lobby service agents affects positively to self-service usage rate. More service agent who invites and advises passenger to use self-service kiosks brings higher self-service usage rate.

However, as the rate of "frequent self-service user" gets higher, the difference between three cases becomes closer. Once "frequent self-service user" rate reaches 0.2, the self-service usage rate of the original plan without lobby service agents becomes almost same as the cases with lobby service agents.

The Fig.7 shows that when "frequent self-service user" rate gets more than 0.25, the case without lobby service agent gains even or higher self-service usage rate than other cases with lobby service agents.

This series of experiments indicates that if there are "frequent self-service users" more than 20% of passenger in the departure lobby, who are most likely use self-service kiosk, there is less necessity to locate lobby service agents. In addition, Fig.8 shows the regression line of "frequent self-service user" ratio and self-service usage rate. As the liner equation displays, it is observed that if frequent self-service user rate increases by 0.1 point, self-service usage rate increases by 0.17 point. These results indicate that it is important for the diffusion of international self-service kiosk to increase the "frequent self-service users" rate up to 0.2 as soon as possible.

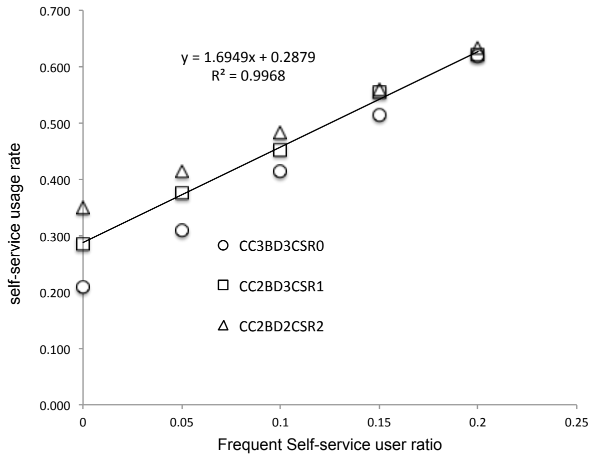

Fig.8: Influence of Frequent Self-service Users

C. Conclusion and subjects

It is common understanding that passenger's travel frequency of international flight is less than the one of domestic flights. Besides that, as mentioned in III.*C,* it is rather difficult for international passengers to find a self-service kiosk under current circumstances. Understanding such contexts, currently Full Service Carriers need to promote self-service product to survive in severer competitions to achieve cost effective operation.

It is necessary for attaining higher cognition of self-service product in airport to appeal the new option in each process of air-travel: travel-planning, booking flights, purchasing flight tickets etc. Because air-travel passengers need to identify themselves to the airline during the travel experience, B to C approach is possible in terms of promoting the self-service product in airport. Instructing the self-service kiosk is available for the international flight which the passenger flies with, and by advising the convenience of them, airlines could reduce "hesitation" of passengers to choose the new way of doing.

The experiments in this section describe that in early stage of international self-service kiosk's diffusion, it is important for local management to locate lobby service agents to urge passenger to use self-service kiosks. They need to clarify that their staff understands to approach passenger actively. The accumulation of continuous diligent effort would lead to higher self-service usage rate and increase the number of frequent self-service users.

VII. Summary

A. Conclusion

As this study stated in the related work, service has its natures such as “intangibility”, “perishability”, "simultaneity" and ”heterogeneity”. It is very difficult for service to be evaluated, because service quality depends upon the person who receives and the situation to which the service is provided. In this study, by utilizing ABM, we reproduced the context of "simultaneity" and ”heterogeneity” in the experimental space as follows, those are characteristic of service and are difficult to quantify.

- The external context which consumer perceive at the moment of choosing a service option (the congested situation of each service productive: the conventional check-in position and self-service kiosk)
- The consumers’ internal context when the service is provided to (the attribute of passenger attitude when they choosing the service from either the conventional way or new way)

Conducting series of experiments under various conditions with data extracted from data warehouse, it was verified that the model equipping the important factors of decision making approximated to the real world with reproduced passenger’s external/internal context.

In short, this work indicates that decision-making mechanism of consumer’s service selection could be reproducible with ABM.

1) Self-service adoption model

In this study we have conducted experiments and found that the results of the expanded model of self-service adoption in the airport approximated to the observed values. In consideration of this outcome, there are two indications:

- How passenger decides whether using self-service is explicable without their demographics
- Simple rules with combination of three factors can mostly explain how passengers select a check-in option.

Three factors are “estimate waiting time of queuing in front of the conventional check-in position”, “perceivablity of Self-Service Kiosk” and “passengers’ hesitation”.

Another perspective from the outcome of experiments is agent-based model simulation may be able to reproduce extracted context of the real world in which passengers select a check-in option with simple rules and observed values.

In related literatures, there are many useful indications. They explain the attributes, which influence consumer to use self-service products, advantage of time saving and the internal status of consumers. We introduce those efforts to the proposed model from the works of service marketing. And the active approach of change-agent, which is mentioned as an important explanatory variable for diffusion’s speed in Diffusion of innovation, is reflected in the proposed agent-based model as implementation of CSRs, which reduces hesitation of passengers through interaction.

However, though statistical analysis explains major reasoning of consumer who uses or not uses self-service products, but does not mention the mechanism, which could reproduce the observable outcome. This study displays that the proposed agent-based model is approximating to the real world and reproduces the almost close outcome to the observed result in the real world by using the existing data. The proposed “Self-service Adoption model” is validated and expanded through conducting a series of experiments with observed data collected from the airline’s DCS by using the agent-based model.

2) Scenario analysis

Through conducting the simulations of carefully prepared scenarios, we suggest the efficient way of passenger handling to increase self-service usage rate with less impact for service quality. As each firms and local management should define the perspective and its priorities to evaluate the experiments results, we describe our perspective in VI (2). The result of experiments indicates that reducing the number of conventional check-in position could increase self-service usage rate and active approach of lobby service agents are effective to urge passenger to choose self-service kiosks.

It also indicates that ratio of “frequent self-service user” needs to be increased up to 20% of check-in passenger as soon as possible. This is the threshold to determine whether the local manager needs to appoint lobby service agents or not.

B. Subject and discussions

This model mapped the limited space and environment of the real world. Even though our experiments display one of the possibilities of how passengers make a decision, our focus is limited and there should be other important influential factors of passenger behavior.

This is another fact that even though we have observed and learned their visible group behavior (i.e. herd behavior); we haven’t yet implemented it into the proposed model. It may be possible to find it in the airline’s database; however, we need to search those influential factors by analyzing the airline’s database in depth.

To enhance the validity of the model, it would be better to apply the estimated parameters to another dataset of same characteristics with the training data. However, since collected data was limited, we don't have the same characteristic dataset as training data. Collecting ample data could be contributory to enhance the validity of the model.

We display that how the agent-based model may work for managers to obtain the idea of alternative ways of handling passenger. It is very important how we design the simulation scenarios because scenarios should come from the business priority.

It is obvious that we need to continue to analyze the data details regarding how and why consumers choose self-service product. There are huge data and attributes in airline's database, in which we have not yet looked.

It is our hope that our study may give some feasible indications in case the airline industry will introduce totally new self-service products, or to other industries seeking the possibility of using self-service technology.

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Appended Table 1.
The Observed data of the data collected days

real data	date406	date408	date409	date410	date411	date412
Number of CC positions	3	2	2	2	2	3
Number of BD positions	3	3	2	2	2	2
Number of Self-Service Units	4	4	4	4	4	4
cck passenger	85	100	68	67	63	67
ssu passenger	46	60	39	54	62	25
total passenger	131	160	107	121	125	92
usage-rate	0.351	0.375	0.364	0.446	0.496	0.272
CSR	2	2	2	3	3	0

Appended table 2.
Summary of parameters

parameter	value	factor	explanation, remarks
speed-limit	0.25	Speed limit of passenger agents	The speed limit of passenger agents. The negative correlation was observed in the experiments.
p1	5.1	Weighting parameter of the conventional service preference	"*p*1" is one of coefficient value in equation. (1), which calculate the quantified value of "Estimated Queuing Time" of conventional check-in position.
classic-ckin-speed	0.02	Check-in speed of the conventional check-in positions	Check-in speed of the conventional check-in position in the experimental space: about 3 min. for 1 passenger 3 min. per 1 passenger for check-in is industry standard.
ssu-ckin-speed	0.03	Check-in speed of the self-service positions	Check-in speed of the self-service position in the experimental space: about 2 min. for 1 passenger.
bagdrop-ckin-speed	0.035	Check-in speed of the Bag Drop positions	Baggage Check-in speed of the Bag Drop position in the experimental space: about 1.7 min. for 1 passenger.
frequent-ssu-user	0.05	Ratio of "self-service users"	The ratio of " Passenger who most likely use self-service kiosk" among departing passengers; We collect the 13 month boarding history of FFP holders who departed in 7 days. FFP holders who travel more than 4 times within 13 months and chose self-service kiosk in all occasion for check-in
CSR-number	0〜3	Lobby service agents who urge passenger to use self-service products	The number of lobby service agent, which is generated in "Hesitation-model".