SOLUTION THE AIRPORT CHECK-IN COUNTER ASSIGNMENTS PROBLEM

Tay-Lin Hwang, Associate Professor, Ph. D., Department of Aviation and Maritime Transportation Management, Chang Jung Christian University, Tainan 71101, Taiwan, R.O.C.

Chi-Ruey Jeng, Assistant Professor, Ph. D., Department of Leisure, Recreation and Tourism Management, Shu-Te University, Kaohsiung 82425, Taiwan, R.O.C.

Sin-Siang Wang, Ph. D. Student, Department of Civil Engineering, National Central University, Chungli 32054, Taiwan, R.O.C.

ABSTRACT

The recent global economic recession and adverse environmental impact have seriously shocked the airline industry. An important task for many airlines is to increase competitiveness. An extremely time-consuming check-in process, especially during peak hours, can significantly degrade passenger perceptions of service quality. Thus, improving the efficiency of check-in counters at airport passenger terminals is a major concern of airport operators and airlines. For example, improving the efficiency of counter assignments by airline reservation systems would reduce manpower needs and enhance operational efficiency. The objective of this study was to establish the operating pattern for airport check-in counter assignments by minimizing the operational cost from incurred by the airline and maximizing passenger service level with considering the use of KIOSK machine and regular/part-time duty counter personnel. According to the experimental results and sensitivity analyses of actual airline operations data, employing part-time counter personnel and using KIOSK machines would significantly reduce counter operation cost and improve passenger service quality.

Keywords: Check-in counter, KIOSK, service level, airport.

1. INTRODUCTION

Air travel is currently the most common mode of international transportation for business, leisure, and tourism. The current global economic depression, combined with surging oil prices, has degraded airline profitability. Airport infrastructure is the first and the last point of tourist contact at a destination. Thus, airport infrastructure significantly affects tourist perception of service quality (Rendeiro Martin-Cejas, 2006). The typical airline check-in process is extremely time-consuming, especially during peak hours.

According to Yan et al. (2005), airport check-in counters can be classified as airline-specific or common-use check-in counters (CUCC). Typically, the former requires a long-term lease while the latter is available for short-term lease. Kiosks (automated self-service check-in machines), are designed as one form of airport infrastructure, and act as a more recent addition to airport infrastructure, provide (i) time saver for passengers, (ii) cost saver for airlines, and (iii) space saver for airports (IATA, 2006).

1.1 Research Motivation

The airline industry is extremely customer-oriented, and sensitive to changes in related industries and changes in the external economic environment. Their operations are subjected to these external changes. Recent events that severely affected the domestic and international civil aviation industry include sudden changes in the external operating environment such as the 911 terrorist attacks in 2001, the SARS outbreak in 2003, oil price fluctuations, the recent global financial turmoil, and the H1N1 flu outbreak. In terms of revenue and cost, the global aviation industry is facing unprecedented challenges, particularly labor costs. The operations issues faced by all airlines in the current economic climate include reducing personnel costs and increasing passengers' satisfaction. Solutions are needed to reduce operating costs, particularly personnel-related items.

The purpose of this study was to formulate a viable strategy for reducing operating costs and increasing operational efficiency in airlines operating in the second terminal of the Taoyuan International Airport. Airport counter assignment is an important airline operating cost in terms of manpower allocation and counter rental expenses. A proper counter assignment system is needed to reduce time-consuming and labor-intensive manual assignment; it can also enhance counter utilization efficiency and therefore overall operating efficiency. This study also considered several elements of the counter assignment model, including operation methods adopted by western airports, such as the common-use counter model as well as the self-service check-in kiosks used in the Taoyuan airport, which are expected to facilitate passenger check-in and effectively reduce the airline operating costs. Employing part-time counter staff also reduces the personnel costs of counter services and therefore overall operating costs of common use counters. Therefore, it can be said that the assignment system used by common-use counters affect overall airport operational efficiency of airlines. To optimize counter resource utilization and to improve counter operating efficiency, airlines may consider implementing common-use counters, in addition to lowering operating costs, common-use counters would also enhance operations integration.

1.2 Objective

This study first analyzed the common-use counter assignment system used for Taipei-Tokyo flights in terminal 2 of Taiwan Taoyuan International Airport and then examined the self-service kiosk integrated counter operation mode as well as the effect on counter operation by combining full- and part-time staff at the counter. A common-use counter model was then constructed based on the analytical results. The purposes of this study can be summarized as follows:

1. To analyze the counter operating methods employed at Taoyuan International Airport. Manpower allocation of the counter is currently performed manually at this airport.
2. A programming model to optimize common-use counter assignment (a pattern for minimize operation costs) and the solution method are constructed in this study by using mathematical programming. The proposed model can help airlines to optimize their counter assignment operations and improve overall performance of common-use counter.
3. The use of kiosks, which are currently used in European and United States airports, employment of both part-time and full-time counter staffs, and service quality (i.e., passengers waiting time) were considered when constructing the common-use counter assignment model to minimize the cost of counter rental for Taipei - Tokyo flights departing from Terminal 2 of Taoyuan International Airport.

1.3 Research Scope

The scope of this study included to the counter operation methods of airlines running Taipei-Tokyo flights in Terminal 2 of Taoyuan International Airport. The proposed common-use counter assignment model was used to analyze actual operating data, including, Taipei-Tokyo flight frequency and schedule, number of passengers per flight, number of staff per counter, and time required to serve a passenger. Airline personnel were also interviewed to determine counter rental costs, personnel costs, and kiosk rental costs.

The model constructed in this study was based on the common-use counter operation pattern and assumed no holidays, Monday through Friday working hours, and non incidental assignment. The incidental counter reassignment refers to the counter assignment adjusted for events or certain dates such as weekends, specific holidays, flights cancelled or delayed for various reasons or unforeseen circumstances; these data were excluded from the analysis since the model was based on regular counter operation patterns.

2. MODEL

This chapter presents the proposed counter assignment model and collects parameters and data required for the modelling process. After describing the counter operations at Terminal 2 of the Taoyuan International Airport, the proposed counter assignment model is presented.

2.1 Common-use counter operations

The common-use counter assignment model in this study was constructed according to current operating practices at Terminal 2 of Taoyuan International Airport as well as the scheduling systems used by airline personnel. Counter personnel have a four-shift work schedule. Each counter is staffed by regular or part-time personnel. At least one full-time employee must be present during each shift whereas part-time personnel can serve at other counters as needed. The study assumes that each counter offers comprehensive service, including check-in for all airlines flying from Taipei to Tokyo in Terminal 2 of Taoyuan International Airport. The model considers the operating data of all the airlines with this route, such as flight schedule, number of counters, number of counter personnel, number of passengers, and passenger waiting time.

This proposed common-use counter assignment model can be applied in common-use counters as well as self-service kiosks, which are increasingly used in the airline industry to reduce personnel and operating costs and to boost operation efficiency. The model also includes data for part-time counter personnel as well as average passenger waiting time, which is an important service quality indicator, to address both costs and service quality.

2.2 Model description

This study aims to construct a common-use counter assignment model with Terminal 2 of Taoyuan International Airport as the subject from the airline's stand point. Because factors affecting counter assignment operation are numerous and their importance and perplexity differs, this study will try to simply the complexity of the model and make certain assumptions about following parameters:

1. Only counter assignments made Monday to Friday (twelve hours a day) are considered.
2. Special operating conditions such as holidays and typhoons are excluded.
3. Common-use counters and kiosks are provided by the airport for rental. This study only considers rent during the term of the lease.
4. Passenger numbers for each flight are known.
5. Regular counter personnel can process passengers faster than or as fast as part-time counter personnel.
6. Each self-service kiosk can process passengers at the same speed.
7. Each counter is served by a regular or part-time employee on duty. No other reserve personnel are available.

8. Each shift must include at least one full-time employee. For extra manpower needs, part-time personnel can be considered.

9. The common-use counters and the kiosks are homogeneous. The regular and part-time personnel are homogeneous. The passengers on Taipei -Tokyo flights are homogeneous.

10. The operating time of each common-use counter and self-service kiosk is three hours to thirty minutes before the departure time of the flight (Taipei -Tokyo).

11. Average passenger waiting time between flights is used as a service quality indicator.

2.3 Modeling

Based on the above model description, the common-use counters assignment can be considered a mathematical programming problem. A linear model of average passenger waiting time can be constructed to minimize airport counter operating costs.
Modelling parameters:

1. The number of passengers that use the general counters and the kiosks during each shift (in a four-shift system) in week w .

2. The time limit of each shift (in a four-shift system) in week w .

3. The schedule time of each shift (in a four-shift system) in week w .

4. The allowable passenger waiting time during each shift (in a four-shift system) in week w .

5. Per minute cost of the general counters and the kiosks.

6. Per minute cost of the regular and part-time counter personnel.

7. The average processing time required for a passenger by the counter personnel and the kiosks.

Expected output:

1. The number of regular and part-time counter personnel needed for each shift (in a four-shift system) in week w .

2. The number of kiosks counters needed for each shift (in a f four-shift system) in week w .

3. The mathematical formulas:

Objective function

$$\text{Min.Z = Min.Z} = \sum_{w=1}^{5}\left\{\left[c_s\left(\sum_{i=1}^{4} t_{wi} d_{wi}^{sr}\right)\right]+\left[c_p\left(\sum_{i=1}^{4} t_{wi} d_{wi}^{pu}\right)\right]+\left[c_n\left(\sum_{i=1}^{4} a_{wi} d_{wi}^{nf}\right)\right]+\left[c_k\left(\sum_{i=1}^{4} m_{wi} d_{wi}^{ky}\right)\right]\right\} \quad (2\text{-}1)$$

s.t

$$\left(\sum_{j\in B} p_{wij}^{r} e_{wij}^{s} + \sum_{j\in B} p_{wij}^{u} e_{wij}^{p}\right) \Big/ \sum_{f\in F} d_{wi}^{nf} \le t_o \qquad \forall i\in I, \forall w\in W \quad (2\text{-}2)$$

$$\sum_{j\in B} p_{wij}^{k} e_{wij}^{k} \Big/ \sum_{y\in Y} d_{wi}^{ky} \le t_o \qquad \forall i\in I, \forall w\in W \quad (2\text{-}3)$$

$$\left[\left(h_{wi1}-g\right)-u_{wi1}\right]\left(\sum_{r\in R} d_{wi}^{sr} / e_{wi1}^{s} + \sum_{u\in U} d_{wi}^{pu} / e_{wi1}^{p} + \sum_{y\in Y} d_{wi}^{ky} / e_{wi1}^{k}\right) \ge p_{wi1} \qquad \forall i\in I, \forall w\in W \quad (2\text{-}4)$$

$$\left\{\left[\left(h_{wi1}-g\right)-u_{wi1}\right]+\sum_{j=2}^{j}\left[\left(h_{wij}-g\right)-\left(h_{wi1}-g\right)\right]\right\}\left(\sum_{r\in R} d_{wi}^{sr} / e_{wij}^{s} + \sum_{u\in U} d_{wi}^{pu} / e_{wij}^{p}\right) \ge \sum_{j} p_{wij}^{n} \qquad \forall i\in I, \forall w\in W \quad (2\text{-}5)$$

$$\left\{\left[\left(h_{wi1}-g\right)-u_{wi1}\right]+\sum_{j=2}^{j}\left[\left(h_{wij}-g\right)-\left(h_{wi1}-g\right)\right]\right\}\sum_{y\in Y} d_{wi}^{ky} / e_{wij}^{k} \ge \sum_{j} p_{wij}^{k} \qquad \forall i\in I, \forall w\in W, \forall j\in B \quad (2\text{-}6)$$

$$\sum^{P}\left\{e_{wi1}^{s}-\left\{\left[\left(h_{wi1}-g\right)-u_{i1}^{nf}\right] / p_{wi1}^{r}\right\}\right\} \;/\; p_{wi1}^{r} \le v_s \sum_{r\in R} d_{wi}^{sr} \qquad \forall i\in I, \forall w\in W \quad (2\text{-}7)$$

$$\sum^{P}\left\{e_{wi1}^{p}-\left\{\left[\left(h_{wi1}-g\right)-u_{i1}^{nf}\right] / p_{wi1}^{u}\right\}\right\} \;/\; p_{wi1}^{u} \le v_p \sum_{u\in U} d_{wi}^{pu} \qquad \forall i\in I, \forall w\in W, \forall p\in P, \forall u\in U \quad (2\text{-}8)$$

$$\sum^{P}\left\{e_{wi1}^{k}-\left\{\left[\left(h_{wi1}-g\right)-u_{i1}^{kv}\right] / p_{wi1}^{k}\right\}\right\} \;/\; p_{wi1}^{k} \le v_k \sum_{y\in Y} d_{wi}^{ky} \qquad \forall i\in I, \forall w\in W, \forall y\in Y \quad (2\text{-}9)$$

$$\sum^{p}\sum_{j=2}^{j}\left\{e_{wij}^{s}-\left\{\left[\left(h_{wij}-g\right)-\left(h_{wi(j-1)}-g\right)\right] / p_{wij}^{r}\right\}\right\} \;/\; p_{wij}^{r} \le v_s \sum_{r\in R} d_{wi}^{sr} \qquad \forall i\in I, \forall w\in W \quad (2\text{-}10)$$

$$\sum_{j=2}^{p}\sum^{j}\left\{e_{wij}^{p}-\left\{\left[\left(h_{wij}-g\right)-\left(h_{wi(j-1)}-g\right)\right]\Big/p_{wij}^{u}\right\}\right\}\Big/p_{wij}^{u}\le v_s\sum_{u\in U}d_{wi}^{pu}\quad \forall i\in I,\forall w\in W,\forall p\in P,\forall u\in U \tag{2-11}$$

$$\sum_{j=2}^{p}\sum^{j}\left\{e_{wij}^{k}-\left\{\left[\left(h_{wij}-g\right)-\left(h_{wi(j-1)}-g\right)\right]\Big/p_{wij}^{k}\right\}\right\}\Big/p_{wij}^{k}\le v_k\sum_{y\in Y}d_{wi}^{ky}\quad \forall i\in I,\forall w\in W,\forall j\in B \tag{2-12}$$

$$d_{wi}^{nf}\ge d_{wi}^{nf+1}\quad \forall i\in I,\forall w\in W,\forall f\in F \tag{2-13}$$

$$d_{wi}^{ky}\ge d_{wi}^{ky+1}\quad \forall i\in I,\forall w\in W,\forall y\in Y \tag{2-14}$$

$$\sum_{f\in F}d_{wi}^{nf}=\sum_{r\in R}d_{wi}^{sr}+\sum_{u\in U}d_{wi}^{pu}\quad \forall i\in I,\forall w\in W,\forall f\in F \tag{2-15}$$

$$d_{wi}^{nf}\ge d_{wi}^{sr}\ge 1\quad \forall i\in I,\forall w\in W,\forall f\in F \tag{2-16}$$

$$d_{wi}^{nf},\, d_{wi}^{ky}=0\ or\ 1\quad \forall i\in I,\forall w\in W,\forall f\in F,\forall y\in Y \tag{2-17}$$

Decision variables:

d_{wi}^{nf} Number of counters rented f during shift i (in a four shifts system) in week w

d_{wi}^{ky} Number of kiosks rented y during shift i (in a four shifts system) in week w

d_{wi}^{sr} Number of regular personnel during shift i in week w

d_{wi}^{pu} Number of regular personnel during shift i in week w

Parameters:

c_s Per minute cost of the regular counter personnel

c_p Per minute cost of the part-time counter personnel

c_n Per minute cost of one counter area

c_k Per minute cost of one kiosk

t_{wi} Service time of the ground crew during shift i in week w

a_{wi} Counter area used during shift i in week w

m_{wi} Kiosks used during shift i in week w

p_{wi1} Total number of passengers of the first flight during shift i in week w

p_{wij} Total number of passengers of flight j during shift i in week w

p^n_{wij} Number of passengers on flight j that used the counters during shift i in week w

p^k_{wi1} Number of passengers on the first flight that used the kiosks during shift i in week w

p^k_{wij} Number of passengers on flight j that used the kiosks during shift i in week w

p^r_{wi1} Number of passengers on the first flight served by regular counter personnel during shift i in week w

p^r_{wij} Number of passengers on flight j served by regular counter personnel during shift i in week w

p^u_{wi1} Number of passengers on the first flight served by part-time counter personnel during shift i in week w

p^u_{wij} Number of passengers on flight j served by part-time counter personnel during shift i in week w

e^n_{wij} Passenger processing time on flight j at the counter during shift i in week w

e^k_{wi1} Passenger processing time on the first flight at the kiosk during shift i in week w

e^k_{wij} Passenger processing time on flight j at the kiosk during shift i in week w

e^s_{wi1} Time required for regular personnel to serve a passenger on the first flight during shift i in week w

e^s_{wij} Time required for regular personnel to serve a passenger on flight j during shift i in week w

e^p_{wi1} Time required for part-time personnel to serve a passenger on the first flight during shift i in week w

e^p_{wij} Time required for part-time personnel to serve a passenger on flight j during shift i in week w

h_{wi1} Departure time of the first flight of shift i in week w

h_{wij} Departure time of flight j of shift i in week w

$h_{wi(j-1)}$ Departure time of flight $j-1$ of shift i in week w

u_{wi1} Starting check-in time of the first flight of shift i in week w (three hour before departure)

t_0 Time limit of four shifts system

v_s Average waiting time for the passengers served by regular counter personnel (in minutes)

v_p Average waiting time for the passengers served by part-time counter personnel (in minutes)

v_k Average waiting time for the passengers using the kiosks (in minutes)

g End of check-in time for any flight is g minutes before departure (assumed to be 30 minutes)

B Set of all shifts

F Set of all counters

Y Set of all kiosks

I Set of all shifts in a day (four shifts system)

W Set of all weeks

R Set of regular staff counters

U Set of part-time staff counters

3. EXPERIMENTAL SETTING

3.1 Purpose

The experiment was designed to perform simulations to test and analyze the effectiveness of the mathematical model for optimizing costs under different conditions, including number of passengers, distribution of passengers using counters versus those using kiosks, time needed to serve a passenger, and average passenger waiting time.

This experiment used the object-oriented supply-chain optimization software, OPL Studio, as a model input interface to compute different experimental factors on personal computers.

3.2 Experimental factors of simulation

The counter rental costs, personnel costs, and passenger numbers used in the simulation were modelled using actual operating data for airlines flying from Taipei to Tokyo. The cross-experiment analysis considered variations in passenger number, passenger distribution between counters and kiosks, passenger service time, and passenger waiting time. The passenger number was based on the flight capacities of the airlines flying from Taipei to Tokyo in the second terminal of Taoyuan International Airport. Passenger service time and average waiting time were determined by field research in Taoyuan International Airport; the average times plus or minus a certain percentage were applied in the model. Applying different sets of experimental factors in the simulations revealed how different combinations of experimental factors affect the operating costs of counters.

3.3 Results

The results of this study can be summarized as follows:

1. Regarding average waiting time under varying load factors, the operating costs of common-use counters and the number of counters available can be minimized by limiting passenger processing time at both counters and kiosks to 3 minutes and limiting average waiting time to 5 minutes.

2. Regarding average waiting time under different load factors, the operating cost of common-use counter is highest when passenger processing times are four minutes at counters and three minutes at kiosks and average waiting time is four minutes. This indicates that more counters are needed when the passenger waiting time is shorter.

3. Regarding process time, the combination of four minutes at counters and three minutes at kiosks has higher operating cost than three minutes at counter and four minutes at kiosks under various load factors and waiting times. This indicates that since counters process more passengers than kiosks do, they have a larger effect on operating cost.

4. Without considering passenger waiting time, the cost of common-use counters and the number of counters required depend on the passenger processing time and the number of passengers under various load factors. Costs are lower when processing time is faster and the number of passengers is smaller, and vice versa.

5. Given varying load factors and waiting times, a 7:3 distribution of passengers between counters and kiosks has a lower operating cost than an 8:2 distribution. This

indicates that decreasing counter usage and increasing kiosk usage can effectively reduce the operating cost of common-use counters.

6. Under various load factors, more counters are needed on Friday than on Monday to Thursday, because the number of travellers is usually highest on Fridays.

7. Under various load factors, fewer counters are needed on Wednesday than other weekdays, because the number of travellers is usually lowest on Wednesdays.

8. Additional counters have higher operating costs than additional kiosks do because the operating cost of counters includes the cost of counter rental and personnel cost, which are higher than those associated with kiosk rental.

4. EMPIRICAL RESEARCH

4.1 Parameters

This study performed an additional field survey at Taoyuan International Airport Terminal 2 to collect the empirical data that were entered into the research model. This study analyzed airlines with Taipei-Tokyo flights leaving from Terminal 2 of Taoyuan International Airport. Empirical data were gathered from Civil Aeronautics Administration records and by field research in Terminal 2 of Taoyuan International Airport.
Model data for empirical research:

1. Flight schedule, Passenger numbers for flights.

2. Counter rental cost, kiosk rental cost, Regular and part-time personnel cost.

3. Passenger distribution between using counters and kiosks.

4. Average processing times for a passenger by counters and kiosks.

5. The average waiting time for passengers.

4.2 Results

Findings:

1. Passenger processing time correlates with the number of counters needed and operating costs.

2. Cost is lowest when waiting time is ignored. When passenger waiting time is considered, cost increases, but quality of service also increases.

3. Every counter requires counter personnel. Personnel cost has a substantial effect on target cost value. Operating costs can be reduced by decreasing the number of counters and the number of full-time personnel and by increasing the number of kiosks and the number of part-time personnel.

In practice, airlines rarely consider passenger waiting time, which reduces passenger satisfaction with service quality. The number of counters and kiosks operated by an airline is determined by its current passenger volume. The empirical results of tests that did not consider waiting time compared favourably with actual operating costs, as shown in Table 1.To ensure that actual operating costs were consistent with the assumption of a five-day work week, the calculation was performed as follows:

[Counters rented in each shift ＊(Counter rental cost of each shift + counter personnel cost of each shift) + kiosks rented in each shift ＊ kiosk rental cost of each shift] ＊four shifts a day ＊five days a week.

Based on the above formula, the counter operating cost of Taipei - Tokyo flight in Terminal 2 of Taoyuan International Airport was calculated as NT$197,914. This figure is over one hundred thousand dollars higher than the figure obtained in the empirical analysis. Assuming that counters are operated 7 days a week and that all flights use this model, the resulting cost savings are significant.

***Table 1** –Cost Comparison*

Load factor	Processing time for a passenger	The cost from empirical results (Unit: dollars)	Real operating costs (Unit: dollars)
Calculate from actual flight load factor: counter user is 90%; kiosk user is 10%	Counter: 3 minutes	kiosk: 3 minutes 73,048	197,914
	Counter: 4 minutes	kiosk: 3 minutes 86,870	

4.3 Sensitivity analysis

The empirical case study was based on the data gathered as described above. In actual operation, factors such as model parameters or unit cost are subject to change, which may affect the end result. The sensitivity analysis in this study included the following factors: load factors, service quality (passenger waiting time), passenger processing time, counter rental cost, kiosk rental cost, personnel cost, and support personnel for kiosks. Although these factors are important to for airline operations, they are subject to change.

4.3.1 Data Entry

1. Passenger Number, and User Ratio between Counter and Kiosk

To assess the effect of passenger number on cost, actual passenger numbers were increased and decreased by 10%. The analysis assumed that the ratio of counter use to kiosk use was 9:1. This ratio includes counter personnel who are not required to support kiosks that enable passengers to check in luggage. To control for counter personnel who support kiosks, the ratio of counter check-ins to kiosk check-ins was changed to 8:2.

2. Counter and Kiosk Rental Costs and Counter Personnel Cost

   Counter cost is an important airline operating cost and an important model parameter. The model classified costs as counter rental cost, regular and part-time personnel cost, and kiosk rental cost. Based on the empirical research results, counter rental costs, kiosk rental costs, and personnel costs were adjusted by ±15%, ±30% and 0%, respectively.

3. Average Passenger Processing Time of Counters and Kiosks

   Excluding the cases in which counter personnel are required to support kiosks with luggage check in, the average passenger processing times for counters and kiosks were four minutes and three minutes. For the cases in which counter personnel were required to support kiosks with luggage check in, the average processing times for counters and kiosks were four and a half minutes and three and a half minutes.

4. Average Passenger Waiting Time

   The average passenger waiting time or counters and kiosks was five minutes and six minutes, respectively. Again, the analysis did not consider waiting time.

4.3.2 Results

Base on above information, the cross-test results were as follows.

1. Given a similar magnitude of change in the ratio of counter users to kiosk users, the results for different passenger numbers change proportionately. This study revealed positive correlations between number of passengers, number of counters and kiosks needed, and operating costs.

2. Average passenger waiting time was compared given the following constants: ratio of counter users to kiosk users, counter cost, passenger number, passenger processing time, and passenger waiting time. The comparison of passenger processing times of the counters assumed the following constants: user distribution between counter and kiosk, counter cost, passenger number, passenger waiting time, passenger processing times of the kiosks, passenger processing times of the counters. This study revealed positive correlations between passenger processing time, number of counters needed, and operating cost.

3. Comparison of different user distribution ratios between counter and kiosk (9:1 and 8:2) revealed that operating cost was higher when the ratio was 9:1, mainly because the 9:1 ratio requires more counters and fewer kiosks. The cost of each extra opened counter includes increased counter rental and personnel costs and exceeds that of each additional kiosk rental. Thus, operating cost is higher when user distribution between counter kiosks is 9:1.

4. Load factor, processing time, and waiting time are positively correlate with target value. Therefore, the model target value increases or decreases along with cost in a similar trend.

5. CONCLUSIONS

The airport common-use counter operation model proposed in this study considers the growing use of self-service kiosks and considers both regular and part-time personnel. The model also differentiates number of counters rented and number of personnel according to four daily shifts. Thus, the number of counters and the number of regular and part-time personnel can be adjusted according to the expected number of flights and the number of passengers. This not only provides airlines with increased flexibility in terms of counter rental, kiosk rental and personnel set-up, it also reduces.

The common-use counter operation model in this study set an upper limit on passenger waiting time so that airlines consider service level when calculating counter operating cost. Thus, airlines can still provide good passenger service at reduced counter operations cost. This experimental study revealed that operating costs correlate with load factor, passenger processing times at counters and kiosks, and average passenger waiting time. Due to the need for counter personnel, counters have a larger impact on operating costs than kiosks do.

The empirical data indicated that combining kiosks with counters and combining full- and part-time personnel can reduce the number of counters and regular personnel needed, and reduce counter operating cost. Assuming constant load factors, constant passenger processing times for counters and kiosks, and constant average passenger waiting times, the sensitivity analysis in this study indicated that operating cost gradually changes from 30% higher to 30% lower. This indicates that the reduction in the target value is determined by operating cost. In the sensitivity analysis, comparison of the different user distribution ratio between counters and kiosks (9:1 and 8:2, respectively) indicated that the 9:1 ratio incurred relatively higher operating costs. The explanation is that the 9:1 ratio requires more counters and fewer kiosks compared to the 8:2 ratios. The cost of each additional counter includes counter rental cost and personnel cost. Thus, operating cost is higher for a 9:1 ratio of counter users to kiosk users.

To reduce counter personnel costs without reducing manpower, airlines can adopt the mixed shift of regular and part-time personnel analyzed in this study. Combined with the replacement of counters with kiosks, airlines can significantly reduce operating costs. The hypothesis in this study was validated by the empirical analysis. Follow-up research is needed to test the proposed model in other areas of the airline industry. The experiment and empirical analysis verify that this common-use counter operating model for evaluating counter operating cost and service quality can optimize the balance between cost and service quality. Future studies may apply the model to other service-related industries.

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