Simulation method for dispatching national border security manpower to mitigate manpower shortage

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ABSTRACT

Recently, a record number of passengers have entered and exited Taiwan from Taiwan Taoyuan International Airport (TTIA). The number of passengers from Taiwan to mainland China has increased largely because of the improvement of cross-strait cultural interaction and other policies, as well as the opening of direct flights. Not only located in the transport hub of the East Asia Taoyuan International Airport is becoming more important and can provide 24 h Airport service, but also airport immigration officers must take 24 h shift to carry out the passenger document inspection requirement, Immigration officers can be fatigued by long shifts, thus negatively affecting border security clearance efficiency and work performance. Consequently, innovative management practices regarding immigration officers are necessary to strengthen international cooperation against terrorism. This study used system simulation Delphi interviews and a heuristic algorithm to determine the required number of airport immigration officers during a fixed passenger waiting time, for improving the efficiency and stability of airport immigration officers who work to consolidate the border security of the country. The results showed that the utilization of airport immigration officers at Taiwan Taoyuan International Airport is higher than 97.99%, and their work hours have been reduced by more than 54.68%. These results proved that using a system simulation can reduce long work shifts and negligence, which can lead improved border security and airport service quality. Additionally, the simulation results that when the National Immigration Agency and Taiwan Taoyuan International Airport implement the biometrics verification system for noncitizens, significant manpower shortages are expected. These shortages can cause complaints from customers and result in a negative image of the quality of airport service. Assigning priority to setting the E-GATE system to compensate for the lack of immigration officers would result in more efficient and effective border security.

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1. Introduction

Under the international trend of globalization, international travel is frequent, and the number of people traveling for business and sightseeing is increasing rapidly (Yu and Huang, 2014). By 2027, the number of tourists in the Asia-Pacific region will increase by 45%, and this region will become the world's largest air transport market (Boeing Company, 2007). This will lead to the development of global trade (Allroggen and Malina, 2014) for which the Taiwan Taoyuan International Airport (TTIA) will be a key hub, connecting northern Japan, South Korea, Beijing, and Southeast Asia's Hong Kong and ASEAN members, all of which are roughly 2.5 h from TTIA in flight time. TTIA is located on one of the major east–west routes between the United States and China. This prime location is a potential advantage for TTIA (Wang et al., 2011).

Taiwan opened regular direct flights to mainland China in 2008, promoting cross-strait economic exchanges and social interaction (Lin and Fu, 2014), which caused a record number of air passengers to travel between Taiwan and mainland China. According to Taiwan's Civil Aeronautics Administration (CAA) flight statistics (CAA, 2015), the number of flights at TTIA in April 2012 was 1.15 times higher than in September 2009. Therefore, the number of flights increased to 4,500 flights per month (Lu and Liu, 2014). Because the flow of international passengers has increased rapidly, immigration officers are essential for border security. The influx of passengers at TTIA has increased the workload for security officers, and the

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government did not timely increase the number of immigration officers to compensate for the shortage of manpower. The lack of immigration officers affects the stability of border operations and the management of immigration services. Therefore, airport immigration officials require proper human configuration to achieve stable border security operations.

Currently, most staffing research has focused on hospital nurses (Wong et al., 2014) and customer service staffing (Valls et al., 2009) as well as airport patrol and aircraft flight staffs (Farhadi et al., 2014; Soukour et al., 2013). No research has been conducted regarding airport immigration-related staffs. TTIA is the primary airport and provides services 24 h a day in Taiwan (Lin and Fu, 2014). Consequently, the airport immigration officers must rotate shifts. However, the long work shifts make immigration officers prone to fatigue. When fatigue increases, reaction times also increases, and attention and judgment decrease (Samaha et al., 2007; Takeyama et al., 2005; Winwood et al., 2006). Fatigue also affects the efficiency and stability of immigration officers (Milne and Kelly, 2014). Therefore, the proper configuration of immigration border security officers is worth exploring.

2. Literature review

2.1. Border security management

Border enforcement is a crucial part of border management. The primary objective is to prevent the illegal flow of goods and people from entering. Furthermore, the management of country borders at the time of the population across the border results in a gate of security (Patrick, 2006). Therefore, the government has the authority to determine who can cross the border, which enables protecting border security (Timothy, 2001). The government can establish a safety system based on risk management to conduct an evaluation. The results of a previous analysis that used risk management to assess travelers suggested that screening by immigration officers is the most crucial task of maintaining border security (Nie et al., 2009).

Most travelers who pass through the borders of Taiwan use international airports into and out of Taiwan. To strengthen the management of border security, Taiwan implemented a preflight passenger information system or the Advance Passenger Information System (APIS) at the end of 2011, to ensure security for cross-border travelers and to strengthen international cooperation against terrorism (Yu and Huang, 2014). Transferring these data facilitates security and customs inspection. Reviewing prior traveler lists and auditing passenger documents help airport immigration officers, security departments, and customs inspectors (Sulmona et al., 2014). Therefore, the primary function of the APIS is to provide immigration officers with immigration-related information before flight departure or landing. This information allows for screening of suspicious information to assist in rapid processing incoming passengers and to warn officials of potentially dangerous passengers. Additionally, this information will facilitate extending the security audit mechanism outside the country and assist airport immigration officials through a computer early-warning function, seizing function, detection, prevention, and control of illegal immigrants function, and query function. The advance passenger information system (APIS) can effectively screen out suspicious personnel or potential terrorists from entering a country to engage in illegal activities. In addition, it saves passengers from the extra time that they have to spend to undergo more stringent security checks following a terrorist attack (Beck et al., 2016).

Passport and customs inspections monitor the cross-border flows of people and goods, and create a "bottleneck" in the international transportation system that can cause significant and costly waiting times for many passengers (Prager et al., 2015). How to ensure that high numbers of visitors clear immigration counters smoothly per measurement hour. (Manataki and Zografos, 2006; Odoni and de Neufville, 1992; TRB, 1987). Therefore, because effective staff scheduling is crucial, researchers have used a heuristic genetic algorithm to improve staff scheduling problems and verify the accuracy of simulation methods (Soukour et al., 2013).

2.2. System simulation

Recently, a generic system dynamics based airport performance tool has been developed (Manataki and Zografos, 2009a, 2009b). System simulation involves using a computer program that employs existing systems and consistent allocations of logic for simulations that entail using different algorithms for system simulation and optimization. To simulate an aerial flight situation, the system uses a clustering method and system architecture. For flight planning, added size as well as peak and off-peak flight data analysis and other modeling might be generated at various times points during flight traffic (Öttl et al., 2013). Under the original condition, only originally estimated data can be used. After construction of the system, the model can be obtained by using simulation correction data more accurately for airport improvement. The system simulation approach can be used to construct the airport model (i Casas et al., 2014).

Existing simulation models are either models of specific airports, or general simulation platforms that require substantial modeling effort and knowledge to represent a given airport terminal (Manataki and Zografos, 2009a). The simulation system can be used to make a prediction, and the algorithms can then be used for problem-solving (Yan et al., 2014). Therefore, the system simulation can be used to test decision-making, and can be verified in practical situations to ensure that the system and method are feasible and effective (Wu et al., 2014a, 2014b). Consequently, the system simulation can be used to obtain data that are otherwise difficult or expensive to obtain. These data can then be used for decision-making.

2.3. Human resources

Integrating the human resources and total quality management of a company is paramount, because it influences the development and competitiveness of the company (Izvercian et al., 2014). Under the current multiple-tasks arrangement, staff can easily be distracted. This can be improved by using automation to increase the efficiency of auxiliary personnel (Cullen et al., 2013). In addressing the multistandard combination of staffing problems, genetic algorithms and the decision-model approach can be used to achieve effective results (Lin and Gen, 2008). For the randomness of overtime work, the optimal redundant remaining-time system can be used for optimization and planning (Chen and Nakagawa, 2013).

When staff work continually in the same environment, the use of staff is diminished, thus increasing job turnover rates. However, an exchange environment can increase the use of staff (Blaga and Jozsef, 2014). An exchange environment can also use bonuses or equipment to improve the use of staff (Dai et al., 2014). Simulation algorithms and heuristic approaches can also be applied to solve the problem of staff usage (Costa Filho et al., 2012).

3. Border immigration service counter simulation

In Taiwan, passenger auditing documents from airports are handled by the Department of Immigration's border affairs brigade. The number of tourists visiting Taiwan has been increasing every year and contact with each passenger is most frequent at the border