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Airport terminal flow simulation: impact analysis of self-service check-in technologies usage past and during the Covid-19 pandemic

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Abstract

Check-in is the process that passengers wait for the most before their flight. Waiting times of passengers will vary depending on the number of counters at the airport, the number of self-service facilities, and whether passengers benefit from online/mobile check-in technologies. As a result of the measures taken at airports with the Covid-19 pandemic, check-in processing times have been prolonged. In this study, Esenboğa airport domestic departure check-in operations are simulated with the ARENA-TRIAL simulation program. The developed scenarios were simulated at peak hours. Initially, it was determined that the number of employees and facilities should be increased to keep the service level at standards during the Covid-19 pandemic thanks to the optimum number of facilities obtained. Secondly, it was determined that the time spent by passengers for check-in processes increased significantly during the Covid-19 pandemic. In addition, it has been observed that the placement of the optimum number of self-bag drop facilities at the airport reduced the average waiting time required for the check-in processes of passengers in the period before and during Covid 19. Finally, during the Covid-19 pandemic, the airport queue density has increased dramatically.

1. Introduction

Airports are very complex systems and there are two types of passenger flow, departure passenger flow and arrival passenger flow. According to the model developed by Novrisal et al. (2013), the time passengers spend in the check-in queue during the departure process constitutes 61% of the total departure travel time. The less time passengers spend in the system, the higher their satisfaction will be (Guizzi, Murino, and Romano 2009). Today, some applications such as online check-in, self-service kiosks used at the airport and baggage bag drop areas have been developed to reduce the check-in time of passengers. In a 2018 study, 27% of check-in transactions are done online and 16% through kiosks. 33% of baggage tagging processes and 20.5% of baggage delivery took place via kiosks (SITA 2019). However, the perceived ease of use and perceived usefulness of self-service kiosks shape the kiosk usage preferences of passengers and that causes self-service kiosks that are difficult to use and time-consuming not to be preferred (Taufik and Hanafiah 2019). Recent studies show that many factors affect the acceptance of self-service kiosks, such as the age of the passenger, education level, nationality, previous experience, flight destination, type of journey; therefore, a significant portion of demand will continue to do traditional check-in (Castillo-Manzano and López-Valpuesta 2013; Chang and Yang 2008; Lu, Chou, and Ling 2009; Wittmer 2011). In the global survey conducted by IATA (International Air Transport Association) (2019), it was seen that 78% of passengers were satisfied with their current check-in process and 80% did not want to wait more than three minutes for baggage delivery.

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At the beginning of 2020, as a result of the social distance and hygiene rules implemented within the scope of the fight against the Covid-19 epidemic that emerged, airport passenger flow processes have been reshaped. In this context, many airports in the world have adopted different practices and the time spent by the passengers in the airport has been extended. Check-in processes, on the other hand, were more hygienic and could be done by increasing the social distance between people. In the future, applications and technologies will be developed that will enable passengers who check-in in airport systems to contact each other less, create less queues and wait less. Serrano and Kazda (2020) emphasized that more self-service kiosks will be used for check-in processes in the future, the use of biometric technological solutions will increase, and processes can develop to check the immunity of passengers or their vaccination status.

Thanks to the self-service kiosks, online check-in and baggage drop-off units at the airports, the waiting times in traditional check-in processes are tried to be reduced. In addition, since the use of these technologies during the emerging pandemic process reduces interpersonal contact, it is recommended to be used by the authorities. The effects of these technologies developed for check-in operations on pre-Covid-19 and amid-Covid-19 check-in processing times have been tried to be demonstrated by simulation, assuming that the airport operates in IATA optimum service level standards.

Motivation of the research is to measure the trend towards dehumanization in the aviation industry. The COVID-19 outbreak has had an unprecedented impact on industry. The incentives of the authorities and the increasing trend in the sector lead to the use of unmanned technologies that can use self-service more. When the literature is examined, no studies have been encountered that investigate how airport processes were affected during the Covid-19 period and to what extent the increase in the use of self-service technologies would affect the processes. The fact that this study explores these issues shows its originality.

While creating the content design of the article, a literature review was made first. Then, simulation assumptions were given in the methodology part and scenarios were simulated. The hypotheses were tested based on the simulation results. Depending on the data obtained, the results are given in the last section.

2. Literature review

Many studies with simulation, optimization and hybrid approaches have been carried out on airport check-in activities. The most cited and most up-to-date literature on simulating check-in activities at airports has been scanned. Joustra and Dijk (2001) presented a toolbox to demonstrate why simulation is necessary in evaluating check-in operations and to simulate check-in counters. They conducted two case studies at the Shippol Airport. The first of the case studies sought to evaluate operational check-in rules and the other to determine the existing check-in facilities and growth capacity at Shippol.

Takakuwa and Oyama (2003) simulated airport international departure passenger flow. 25% of the time that the passengers spend at the airports is for waiting, and 80% of this waiting time is at the check-in counters. They created a data generator for simulation. Thanks to the data produced, they tried to test different crowd levels. As a result of the study, they emphasized that the number of passengers who missed their flight could be reduced as the employees who look after the first/business class passengers counters serve economy and group passengers will support the regular staff.

Chun and Mak (1999) developed an intelligent resource simulation system (IRSS) to predict the resource requirements of an international airport. They obtained data by entering the statistical check-in information they obtained into this system, and then they developed the check-in counter assignment system (CCAS), which facilitated the decision of the most appropriate number of counters and when to open. They observed that up to 40% of resources were saved thanks to the systems used.

Bruno et al. (2019) proposed a linear mathematical model for the efficient use of resources in traditional check-in services. They built the model with the aim of minimizing the waiting time depending on the capacity of incoming flights and aircraft. As a result of the implementation of the model, the service levels of the check-in counters were prevented from being idle and the most appropriate personnel programming was ensured.

Galanda et al. (2019) developed a simulation model to determine the number of check-in desks at the airport. In order to simulate the airport check-in process, they evaluated the software and made their applications on the ARENA software. The time data spent by the passengers during the check-in was obtained from a manufacturer that they created by programming.

Rolim et al. (2020) studied operating procedures and how demand growth affects check-in service level. They developed 273 scenarios on São Paulo–Guarulhos airport international departure check-in desks. As a result of

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the study, they found that the most important factors are the counter processing time, the number of counters per airline, the use of self-service technologies and the opening time of the check-in desks.

When the literature is examined, no studies have been found that simulate airport check-in processes and investigate delays during the Covid-19 process. With this study, it has been tried to show that the optimum number of facilities can be determined by simulation tools when delay may occur and examine the Covid-19 detention effect on check-in queue.

3. Methodology

In this study, an airline's domestic check-in transactions were simulated at Esenboğa airport. Self-service check-in services are used at Esenboğa airport and passengers can check-in online. However, when passengers use self-service, they cannot leave their luggage. In this study, the following hypotheses were investigated.

H1: The measures taken amid the Covid-19 outbreak extended the duration of check-in services.
H2: Before Covid-19, self-service baggage bag drop shortens the check-in process.
H3: During the Covid-19, self-service baggage bag drop shortens the check-in process.

The winter schedule of the airline that makes the most domestic flights at Esenboğa airport has been examined. The months of December 2020, January 2021 and February 2021 are taken into account. In the research, data that will form an input to the simulation were obtained by using the departure times of the flights. 00:01-23:59 hours on Monday are determined as the solstice. In this context, 9-night flights fat 23:55 hours are concentrated, were chosen as the application. It is worked with an intersection covering 4 hours before 23:55, which is the busiest hour in the simulation.

The aforementioned airline starts the check-in procedures 24 hours in advance and the check-in procedures end 60 minutes before the flight.

Airport service level is a concept that includes standards developed for the design and expansion of facilities and monitoring of existing facilities (IATA 2014). Service level standards are used to set requirements for efficiency in airport design. Optimum space requirements and waiting times for passengers for check-in facilities are given in Table 1.

Check-in processes are given in Figure 1. Only the third of the processes given is not implemented at Esenboğa airport. Esenboğa airport has been simulated by the scenario of putting 2 bag drop facility into service at the selected airline counter.

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Table 1. Airport check-in service levels (IATA 2004, 2014)

	Space Standards for Waiting Areas (m2/pax)					Waiting Time Standards for Processing Facilities (Minutes)				
						Economy Class				
ADRM[1] 9. Edition	A	B	C	D	E	A	B	C	D	E
ADRM 10. Edition	Over Design		Optimum	Suboptimum		Over Design		Optimum	Suboptimum	
Self Service Boarding Pass	>1.8		1.3-1.8	<1.3		0		0-2	>2	
Bag Drop Desk (queue width 1.4-1.6 m)	>1.8		1.3-1.8	<1.3		0		0-5	>5	
Check-in Desk (queue width 1.4-1.6 m)	>1.8		1.3-1.8	<1.3		<10		10-20	>20	

3.1 Assumptions and Limitations of Simulation

It is assumed that all passengers included in the simulation are flying in economy class. It is assumed that none of the passengers arrive on international or connecting flights. It is assumed that all nine aircraft that will take off at 23:55 are B737-8 model aircraft and have a capacity of 189 passengers. It is accepted that passengers other than the flights at the specified time do not check-in.

Measures to be taken against pandemics at Turkish Airports are determined in accordance with the "Airport Pandemic Precautions and Certification Circular" published by the Directorate General of Civil Aviation (DGCA). In addition, Esenboğa has also ensured compliance with the measures determined by European Union Aviation Safety Agency (EASA). Within the scope of these measures, it has been determined to take the following precautions during check-in procedures.

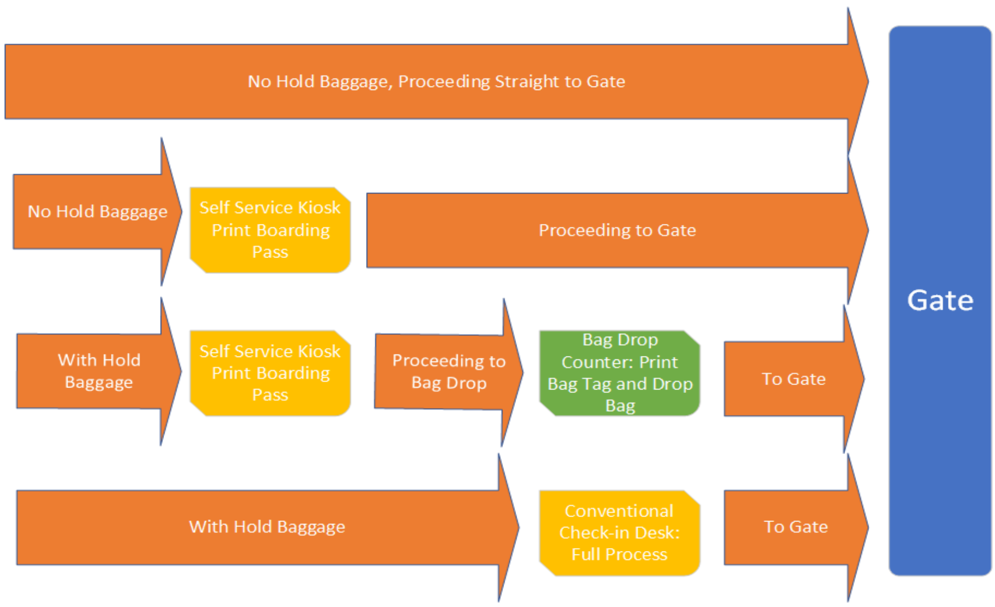

Figure 1. Check-in processes

[1] Airport Development Reference Manual

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1. Measures are taken to maintain social distance at least 1 meter in all airport facilities and terminal building.
2. Cabin baggage is not accepted on flights, the items to be accepted are limited to laptop computers, handbags, briefcases, and baby items; all other items are provided to the luggage during the check-in process.
3. It is encouraged to switch to SMS/QR Code and Electronic check-in applications, instead of the printed boarding pass, if possible. If it is not possible, the use of machines is provided for the passengers to receive the boarding pass in a way that minimizes their contact with the employee.
4. It is encouraged to implement technologies for remote contactless reading of the Republic of Turkey ID card at the check-in counters in a way that prevents the officer from contacting the passenger at the check-in counters.

During the Covid-19 pandemic, mobile or online check-in is not allowed in some lines of air transportation, depending on the center to be visited. It has been accepted that there is no obstacle in making mobile or online check-in for all of the flights taken as a basis in this study. Considering the above-mentioned measures for Covid 19, the following assumptions were made for the simulation.

- It is assumed that passenger arrivals start 5 hours before the flight time and end 1 hour before It has been observed that the time between the arrivals of passengers close while the departure time has come, and parallel results have been obtained in studies on passenger arrivals (Appelt et al. 2007; Park and Ahn 2010). Therefore, passenger arrivals are assumed to be exponentially distributed.
- It has been accepted that passengers can obtain their boarding passes from online, mobile, self-service kiosks and check-in counters. SITA survey data was used to determine the check-in probabilities of arriving passengers (SITA 2019). The developed probability network is given in Figure 3. It is assumed that 24% of arriving passengers get their boarding passes online and via mobile phone, 35% print them from self-service kiosks, and 41% of the remaining passengers get their boarding passes from the traditional check-in counter.
- It is assumed that 75% of the passengers who purchased their boarding passes online do not have baggage. Because, according to the survey data, 18% of the passengers perform their boarding operations with their phones (0.75x0.24=0.18). It is assumed that half of the remaining 25% deliver their luggage at the check-in counter and the other half at the self-service bag drop unit. In the scenario where there is no bag drop unit, the baggage delivery option is only at the check-in counters.

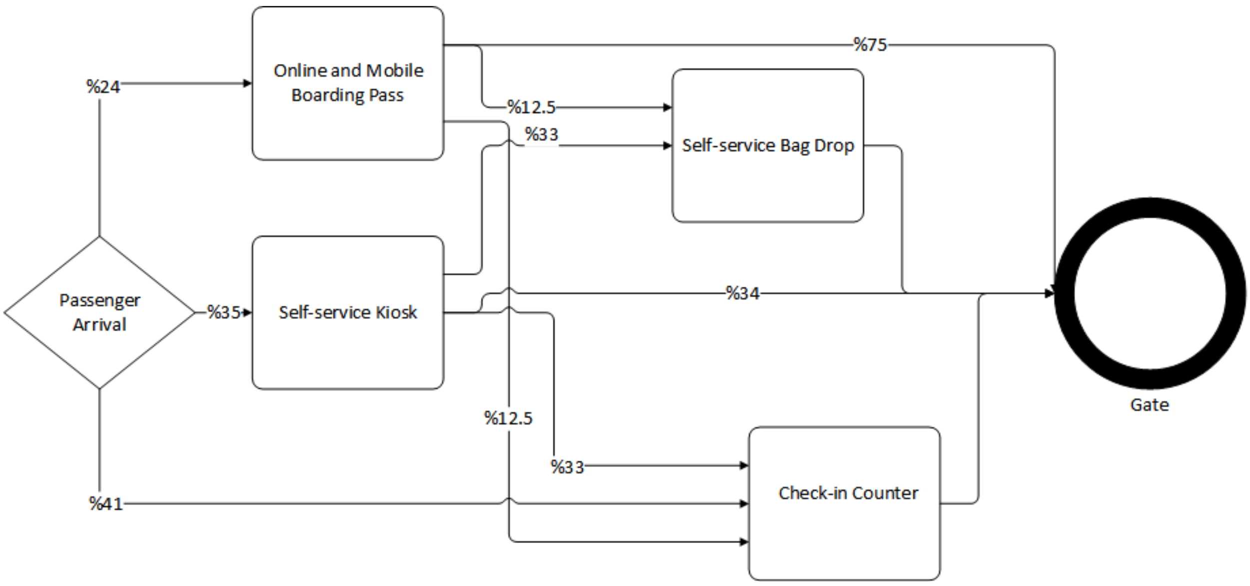

Figure 2. Check-in probability map

3.1.1 Simulation 1 Assumptions

In Scenario 1, the following assumptions were made, taking into account the existing infrastructure of Esenboğa airport:

- The time spent by the passengers in self-service kiosk transactions is assumed to be triangular (0.5, 1, 2) minutes, taking into account the IATA service standards in Table 1.

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- Considering the IATA standards of the passengers, the duration of the service provided at the check-in counter is assumed to be (1, 3, 4) minutes.
- After the self-service kiosk, the probability of the passengers to leave their baggage, to go to the gate and check-in counters is taken as equal.

3.1.2 Simulation 2 Assumptions

In the second scenario, it takes into account the measures taken within the scope of Covid-19 measures. The assumptions determined accordingly are given below:

- Passengers were encouraged to use self-service check-in during the Covid-19 process. Since some passengers are using these technologies for the first time, it is assumed that there will be an average delay of 30 seconds in transactions. The determined distribution was taken as (1, 1.5, 2.5).
- Due to the changes in the cabin baggage handling rules with the measures specified in the 2nd, 3rd and 4th articles of the DGCA circular check-in procedures; It is accepted that the processing time of the passengers at the check-in counter will increase by 1.5 minutes on average. It is assumed that the service time at the check-in counter is distributed in a triangle, and the processing times are taken as (2.5, 4.5, 6.5) minutes.

3.1.3 Simulation 3 Assumptions

In Scenario 3, the assumptions made as a result of adding a self-service bag drop unit to regular check-in facilities, regardless of Covid-19 measures, are stated:

- It is assumed that the service time of the self-service baggage release unit is distributed in a triangle and the processing times are accepted as (1, 2.5, 4) minutes based on Table 1.

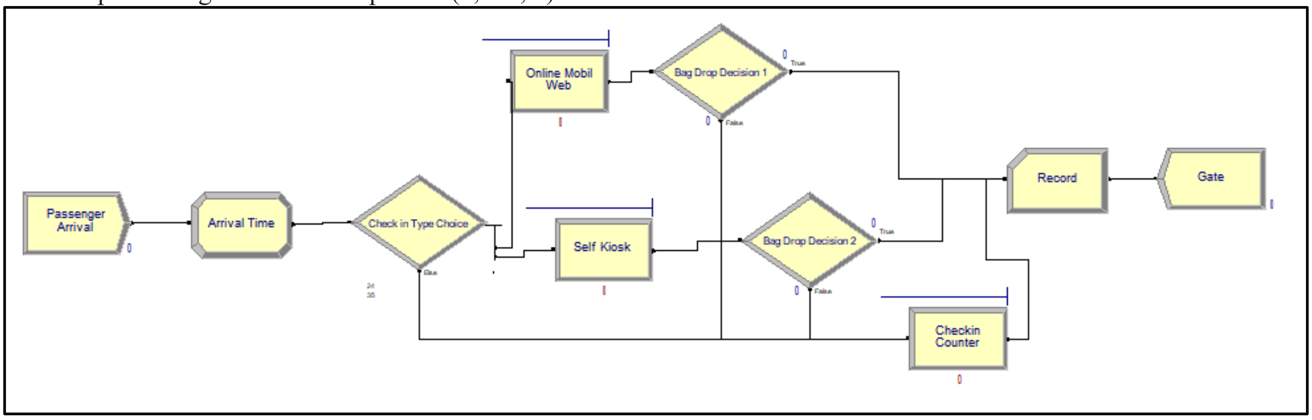

Figure 3. Check-in processes simulation model

Figure 3 shows the model of scenario 3 developed to simulate check-in processes in Arena software. The model here was created taking into account the scenario in which the self-service bag drop unit is included in the process. Other scenarios are modeled similarly.

3.1.4 Simulation 4 assumptions

In this scenario, it is assumed that Covid-19 measures are implemented and self-service baggage drop units are added to the check-in system.

- It is assumed that the service time of the self-service baggage release unit is triangular as in other scenarios. As a result of the covid-19 measures, it is assumed to be longer the usage time of the facility is 30 seconds then the distribution is (1.5 3 4.5) minutes.

4. Analysis and findings

Within the framework of the determined assumptions, 4 main scenarios were run in the Arena software. The optimum number of check-in counters, self-service kiosks and self-service bag drop facilities were determined for each scenario. The optimum number of check-in counters and self-kiosks for the scenarios is determined based on the general check-in process times of the passengers in Table 2. The process analysis (PAN analyzer)

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of the Arena software was used. The main scenarios developed were tested with different sub-scenarios. Each scenario was simulated 10 times, and the average time for passengers to complete their check-in procedures after entering the terminal and arrive at the airside security checkpoint was determined.

Table 2. Optimum check-in facility numbers

	Self-Kiosk	Check-in Desk	Self Service Bag Drop Unit	Passengers Waiting Times (min)
Scenario 1 (Before Covid-19)	4	12	-	11,45
Scenario 2 (Amid Covid-19)	5	19	-	10,94
Scenario 3 (Before Covid-19 + Self Bag Drop)	4	10	3	9,45
Scenario 4 (Amid Covid-19 + Self Bag Drop)	5	16	5	10,73

For example, in order to determine the optimum number of check-in counters in scenario 2, the number of self-service kiosks was kept constant and the most suitable values that provide the closest waiting standards in Table 1 were accepted as optimum. As seen in scenario 2, it was necessary to increase the number of self-kiosks by 1 and the number of open check-in counters by 7, compared to the pre-Covid-19 situation, in order to ensure an average wait of 11 minutes during the Covid-19 process.

When Scenario 1 and Scenario 3 are compared, the inclusion of 3 self-service bag drop units in the system caused the number of self kiosks to remain constant and the number of check-in counters to decrease by 2. Scenarios 2 and 4 were compared in order to compare the number of facilities in the case of adding a self-service bag drop unit to the system during the Covid-19 process. In scenario 4, 5 self-service bag drop unit were included in the system and the number of open check-in counters was reduced by 3.

Table 3. Accepted number of check-in facilities in testing hypotheses

	Check-in Desk	Self-Kiosk	Self Service Bag Drop Unit
Scenario 1 (Before Covid-19)	4	12	-
Scenario 2 (Amid Covid-19)	4	12	-
Scenario 3 (Before Covid-19+ Self Bag Drop)	4	12	3
Scenario 4 (Amid Covid-19 + Self Bag Drop)	4	12	3

The scenarios were simulated 15 times over the number of facilities given in Table 4, and the hypotheses H1, H2 and H3 were investigated. Based on the number of facilities in Table 3, it was simulated 15 times.

Table 4. Simulations output summary

	Scenario 1 (Before Covid-19)		Scenario 2 (Amid Covid-19)		Scenario 3 (Before Covid-19 + Self Bag Drop)			Scenario 4 (Amid Covid-19 + Self Bag Drop)		
	contour	self-kiosk	contour	self-kiosk	contour	self-kiosk	self bag drop	contour	self-kiosk	self bag drop
number of waiting passengers	40,95	1,5	219,4	25,2	4	1,5	2,6	141,7	21,3	6,1
passenger waiting time (min)	8,47	0,58	47,2	9,7	1	0,6	2,5	36,2	8,4	6
utilization	0,98	0,74	0,99	0,98	0,86	0,73	0,85	0,99	0,97	0,94

As can be seen in Table 4, the queue in front of the check-in counter during the epidemic periods extended and the waiting times of the passengers extended. With the introduction of the self-service baggage release unit, the

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utilization rates of the facilities have decreased even more. However, during the Covid-19 epidemic periods, the utilization of the counter continued at the level of 99%.

The t-test was used to test the hypotheses. The simulated scenario data was analyzed using the SPSS package program. The following assumptions must be provided for the t-test used to test the difference between unrelated groups (Anderson et al. 2010).

- There must be no relationship between the observations in each group or between the groups themselves.
- Each sample group must be approximately normally distributed.
- Variances are homogeneous.

First of all we tested the homogeneity of groups with applying Levene's test. In Table 5, scenario 1 and scenario 2 groups are tested. The test statistic is 4,747 and the corresponding p-value is .038. Since this p-value is less than .05, we reject the null hypothesis. This means two groups have different variances.

Table 5. Homogeneity test of scenario 1 and scenario 2 variances

		Levene Statistic	df1	df2	Sig.
scenario1_2	Based on Mean	4,747	1	28	,038
	Based on Median	4,651	1	28	,040
	Based on Median and with adjusted df	4,651	1	24,853	,041
	Based on trimmed mean	4,735	1	28	,038

In Table 6, scenario 1 and scenario 3 groups Levene statistics is given. The test statistic is 15,445 and the corresponding p-value is .001. Since this p-value is less than .05, we reject the null hypothesis. This means two groups have different variances.

Table 6. Homogeneity test of scenario 1 and scenario 3 variances

		Levene Statistic	df1	df2	Sig.
scenario1_3	Based on Mean	15,445	1	28	,001
	Based on Median	14,613	1	28	,001
	Based on Median and with adjusted df	14,613	1	14,663	,002
	Based on trimmed mean	15,178	1	28	,001

In Table 7, scenario 2 and scenario 4 groups are tested with Levene's test. The test statistic is ,195 and the corresponding p-value is .662. Since this p-value is not less than .05, we do not reject the null hypothesis. This means two groups have equal variances.

Table 7. Homogeneity test of scenario 2 and scenario 4 variances

		Levene Statistic	df1	df2	Sig.
scenario2_4	Based on Mean	,195	1	28	,662
	Based on Median	,052	1	28	,821
	Based on Median and with adjusted df	,052	1	25,322	,821
	Based on trimmed mean	,151	1	28	,700

Another assumption that we need to provide in order to apply the t-test is that the groups are normally distributed. This assumption is demonstrated by the Shapiro-Wilk test, because of our sample is less than 30.

Table 8. Normality tests scenario 1

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Simulation_1	,123	15	,200*	,955	15	,599

*. This is a lower bound of the true significance.

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a. Lilliefors Significance Correction

In Table 8, p value of Shapiro-Wilk is not less than .05. We do not reject the null hypothesis which means scenario 1 data is normally distributed.

Table 9. Normality tests scenario 2

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Simulation_2	,145	15	,200*	,978	15	,955

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

In Table 9, p value of Shapiro-Wilk is not less than .05. We do not reject the null hypothesis which means scenario 2 data is normally distributed.

Table 10. Normality tests scenario 3

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Simulation_3	,144	15	,200*	,959	15	,669

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

According to the normality test in Table 10., the Shapiro-Wilk p value is greater than .05. Therefore, the null hypothesis is not rejected, and this shows that the simulation 3 values are normally distributed.

Table 11. Normality tests scenario 4

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Simulation_4	,162	15	,200*	,942	15	,411

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

As in other normality tests, the Shapiro-Wilk p value in Table 11. is greater than .05. Therefore, the null hypothesis is not rejected and this shows that the simulation values are normally distributed.

Data analysis and independent t-test were performed with MS Excel and the data obtained are given in Table 4.

$H1_0: \mu_1 = \mu_2$ *There is no difference between check-in processing times before and during Covid-19.*
$H1_1: \mu_1 \neq \mu_2$ *There is a difference between check-in processing times before and during Covid-19.*

Table 12. Scenario 1 and scenario 2 simulation data t-test

	Total Check-in Processing Time Before Covid-19 (Scenario 1)	*Total Check-in Processing Time Before Covid-19 (Scenario 2)*
Mean	7,60748	29,89714
Variance	4,052104132	11,39061422
Observations	15	15
Hypothesized Mean Difference	0	
df	23	
t Stat	-21,96783197	
P(T<=t) one-tail	0,00000000000000003	
t Critical one-tail	1,713871528	
P(T<=t) two-tail	0,00000000000000006	
t Critical two-tail	2,06865761	

An independent t-test was performed assuming that the two samples had different variances for scenario 1 and scenario 2 simulation. According to the results of the test, a statistically significant difference was observed between the average of the check-in processing times before Covid-19 $\bar{x}_{scenario1} = 7{,}6$ and the average of the check-in processing times during the Covid-19 period $\bar{x}_{scenario2} = 29{,}9$ $t(23) = 3 * 10^{-17}; p < 0{,}05$. Depending on this result, it can be said that check-in processing times have increased during the Covid-19 process.The following basic and alternative hypotheses have been developed for the H2 hypothesis.

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$H2_0: \mu_1 = \mu_3$ *Check-in processing times will not be affected when a self-service bag drop unit is included in the system before Covid-19.*

$H2_1: \mu_1 \neq \mu_3$ *Check-in processing times will change when a self-service bag drop unit is included in the system before Covid-19.*

Table 13. Scenario 1 and scenario 3 simulation data t-test

	Total Check-in Processing Time Before Covid-19 (Scenario 1)	*Total Check-in Processing Time When Bag Drop Units are Included in the System Before Covid-19 (Scenario 3)*
Mean	7,60748	3,40026
Variance	4,052104132	0,124620935
Observations	15	15
Hypothesized Mean Difference	0	
df	15	
t Stat	7,973020991	
P(T<=t) one-tail	0,000000449	
t Critical one-tail	1,753050356	
P(T<=t) two-tail	0,000000898	
t Critical two-tail	2,131449546	

In Table 13, an independent t-test was performed assuming that the two samples had different variances for scenario 1 and scenario 3 simulation. According to the results of the test, there is a statistical difference between the average of check-in processing times before Covid-19 $\bar{x}_{scenario1} = 7{,}6$ and the average of check-in processing times $\bar{x}_{scenario3} = 3{,}4$ when bag drop units are included in the system before Covid-19 $t(15) = 449 * 10^{-9}; p < 0{,}05$. Based on this result, it can be said that check-in processing times are shortened when bag drop units are included in the system before Covid-19.

The following basic and alternative hypotheses have been developed for the H3 hypothesis.

$H3_0: \mu_1 = \mu_4$ *Check-in processing times will not be affected when a self-service bag drop unit is included in the system during the Covid-19.*

$H3_1: \mu_1 \neq \mu_4$ *Check-in processing times will change when a self-service bag drop unit is included in the system during the Covid-19.*

Table 14. Scenario 2 and scenario 4 simulation data t-test

	Total Check-in Processing Time During Covid-19 (Scenario 2)	*Total Check-in Processing Time When Bag Drop Units are Included in the System During Covid-19 (Scenario 4)*
Mean	29,89714	23,58166667
Variance	11,39061422	14,74225781
Observations	15	15
Pooled Variance	13,06643602	
Hypothesized Mean Difference	0	
df	28	
t Stat	4,784735823	
P(T<=t) one-tail	0,000024979	
t Critical one-tail	1,701130934	
P(T<=t) two-tail	0,000049958	
t Critical two-tail	2,048407142	

In Table 14, an independent t-test was performed assuming that the two samples had equal variances. According to the results of the test, there is a statistical difference between the average of the check-in times of the during Covid-19 $\bar{x}_{scenario2} = 11{,}4$ and the average of the check-in processing times $\bar{x}_{scenario4} = 14{,}7$ when bag drop units are included in the system during the Covid-19 $t(28) = 25 * 10^{-6}; p < 0{,}05$. Depending on this result, it can be said that the check-in process times are shortened when self-loading facilities are included in the system during the Covid-19 pandemic.

5. Conclusion

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Check-in is one of the reasons for the most common delay for air travel. Performing check-in procedures quickly and getting passengers on board is effective in determining the quality of the service provided. In order to prevent the spread of the Covid-19 epidemic, passengers and employees in many parts of the world have been obliged to comply with various precautions, especially for check-in procedures during air travel. In addition, the use of technologies such as self-service kiosks and self-loading units, which will enable passengers to have less contact with employees during check-in processes, has become widespread. In this study, it has been investigated how the passenger check-in times will be affected if the self-service bag drop unit to be used in check-in processes is used at Esenboğa Airport. On the other hand, the effect of the procedures to be followed during the Covid-19 pandemic on the check-in process has been studied.

In the study, it was first tried to determine the optimum number of facilities before and during the Covid-19 period under certain assumptions. A model of the check-in process was created to determine the optimum numbers. Check-in times under different facility number combinations were obtained by simulating and the optimum number of facilities was reached. In the Covid-19 process, the necessity of more counters has emerged to keep the processing times at the standards. It has been seen that the number of the self kiosk and self bag drop units used should be increased. It has been determined that the widespread use of self-service technologies used in check-in processes reduces the need for labor and has a positive effect on check-in process times.

In order to test the hypotheses put forward in the study, four different scenarios were developed and each scenario was simulated 15 times. An independent t-test was performed to show that the obtained data sets were different from each other. As a result of the tests, it was observed that the check-in processing times during the Covid-19 increased by differentiating from the situation before Covid-19. It has been determined that the self-service technologies used for check-in processes have a positive effect on passenger waiting times both before and during Covid-19. Thanks to these technologies used to reduce contact, the fight against the epidemic has been an effective solution.

With this study, it has been revealed that the use of self-service technologies should be increased in order for airports like Esenboğa, where the number of passengers is increasing and the passenger profile is diversifying, to experience safer and faster airport processes. It is possible to turn the timely service needed by all kinds of passengers into the most efficient processes with the knowledge provided by the times of crisis.

As the arrival distribution of passengers during the Covid period may change, for future studies it can be shown by observation or other data collection methods, how the crisis period affects distributions. By modeling the passenger arrival structures with the data obtained, capacity problems can be investigated for an uninterrupted and fast flow at the airport. By studying airports with the vision of Airport 4.0, completely unmanned passenger departure and arrival processes can be simulated.

Contribution of Researchers

Niyazi Cem Gürsoy developed the model, run the simulation, and checked data with statistical tests. Savaş Selahaddin Ateş reviewed the paper and contributed to the interpretation of model results.

Conflicts of Interest

The authors declared that there is no conflict of interest.

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