Waiting times in Copenhagen Airport

Comparison of two periods of data

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Waiting times in Copenhagen Airport

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By

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Content

Summary

In a previous report [1], we have analysed waiting times in the central security check in Copenhagen Airport using data for the period March 2015 to October 2015.

The purpose of the present project is to

- Undertake a descriptive analysis of waiting times in the central security check at Copenhagen Airport for data from November 2015 to July 2016.
- Analyse the changes in waiting times between this time period and the previous time period from March 2015 to October 2015.
- Analyse how the development in waiting times compare to changes in demand and capacity, i.e. the number of open lanes in the central security check.
- Discuss how the censoring of waiting times affect the results.

The overall conclusion is that the airport has improved capacity by increasing number of open lanes but that this has not led to reduced waiting times.

There are several potential explanations.

- Increasing demand.
- The processing time per passenger can have increased, for example due to changed security procedures or due to more passengers with carry-on bagage.
- In principle, it is possible that the airport has misallocated its increase in capacity to times when it turned out to be less useful.

We have verified that demand during the months March to July increased about 10% from 2015 to 2016. These are the periods for which we have comparable data. We have not verified the other two potential explanations. We emphasize that the third potential explanation, misallocation of capacity, is mentioned only for the sake of completeness. We have no specific reason to think that is the case.

Concerning the censoring, the nature of this will cause both average waiting times and variation in waiting times to be biased downward in both this as well as the previous period. To assess the effect of the bias on the results of phase 1 is difficult. But both of these observations mean that we would expect a reestimation on uncensored data (if that was somehow possible) to indicate higher benefits as compared to those found in the previous report.

1. Background and purpose

Waiting times in the central security check force travellers to arrive at the airport earlier than they would have in the absence of waiting time, as they have to allow sufficient time to make sure they reach their departure in time. As waiting times are variable and unpredictable from the point of view of travellers, they need to allow not only for the average waiting time but also for the variability of waiting times.

In a previous report [1], we have analysed the waiting times using data for the period March 2nd to October 31st, 2015.

This project analyses the development in waiting times in the central security check in Copenhagen Airport since then, using data for the period November 1st 2015 to July 31st 2016. It compares the waiting times in the second period to the waiting times in the first period and discusses how these can be explained by changes in demand and capacity.

The mean waiting time was 5.43 minutes in the first period. It increased to 5.63 minutes in the second period. It is of interest to identify causes for this increase.

The purpose of this project is to

- Undertake a descriptive analysis of waiting times in the central security check at Copenhagen Airport for data from November 2015 to July 2016.
- Analyse the changes in waiting times between this time period and the previous data time period from March 2015 to October 2015.
- Analyse how the development in waiting times compare to changes in demand and capacity, i.e. the number of open lanes in the security check.

Finally, we provide a comparison of waiting times for the period September-October 2016 with waiting times for the previous year. For this period we do not have information about demand. The issue is that it was discovered that the waiting time data until August 2016 were affected by a censoring mechanism that partly limited how long waiting times that could be measured [2].

The project is carried out by Mogens Fosgerau, Abhishek Ranjan and Stefan L. Mabit for the Ministry of Transport, Building and Housing.

1.1 Motivation for the analysis

Before we go into details with the data and the analysis, we present a simple graph that illustrates the relationship between waiting times and capacity.

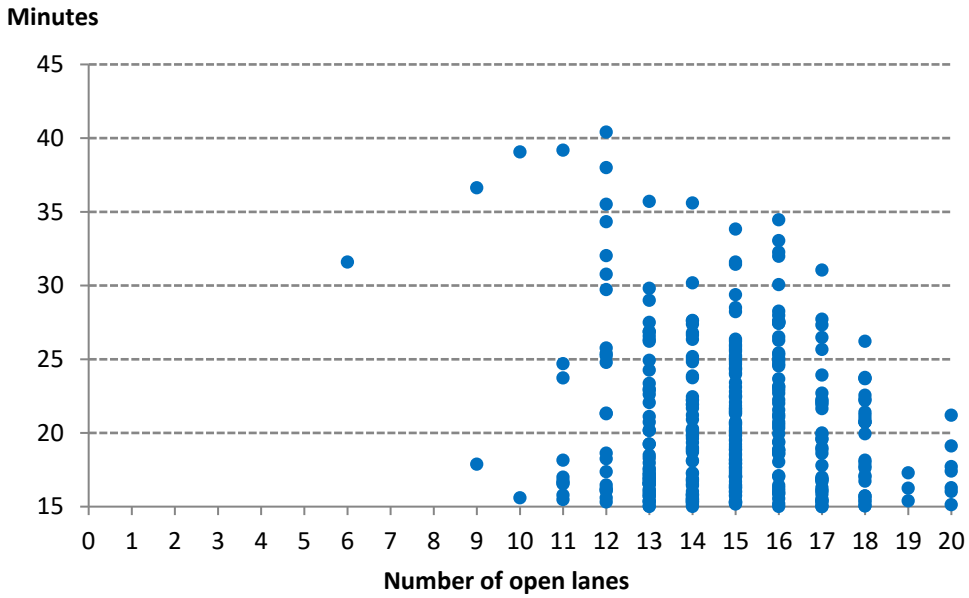

Figure 1 Extreme waiting times split on number of open lanes for the period August 29th ot September 25th, 2016.

Figure 1 shows that extreme waiting times happen most frequently when the number of open lanes is between 12 and 17. There are 20 physical lanes, which means that there was free capacity at most of the occasions when extreme waiting times occurred.

2. Data and descriptives

2.1 Data

We have received the following data from the Danish Transport and Construction Agency.

- Waiting times, 15 minute bins, from November 1st, 2015, to July 31st, 2016.
- Number of lanes open, 15 minute bins, from November 1st, 2015, to July 31st, 2016.
- Number of passengers departing by each airplane from November 1st, 2015, to July 31st, 2016.

The latter file provides us with the number of passengers that departs from Copenhagen Airport. We use the time stamp in the file to aggregate them into 15 minute bins. The time stamp is in UTC. We have converted it to Danish time, taking daylight time saving into account.

We do have information about the number of travellers that actually used the central security check (CSC) on a given day. We find this share to be 0.777 as described in section 2.2. This is used to scale down the number of passengers on departing planes to the number of passengers that used CSC, i.e. excluding transit, fast track, etc.

2.2 Descriptives

The following figures uses all available data for the second period where demand, number of open lanes, waiting times are available, i.e. the period November 1st, 2015, to July 31st, 2016. Figure 2 shows the average number of open lanes across the average day in 15 minute intervals (red curve) and the average number of passengers embarking planes (blue curve). The time stamps on the demand is the actual take-off time, which should occur some time after passengers pass through security.

The number of passengers per 15 minutes fluctuates between approximately 300 and 600 persons from 6 am to 9 pm with the exception of the morning peak which has 700 persons. Not all of these pass through the central security since there are fast track and other additional lanes. Comparing the total number of passengers passing the CSC to the total number of departing passengers, we find the share of 0.77 for this period.

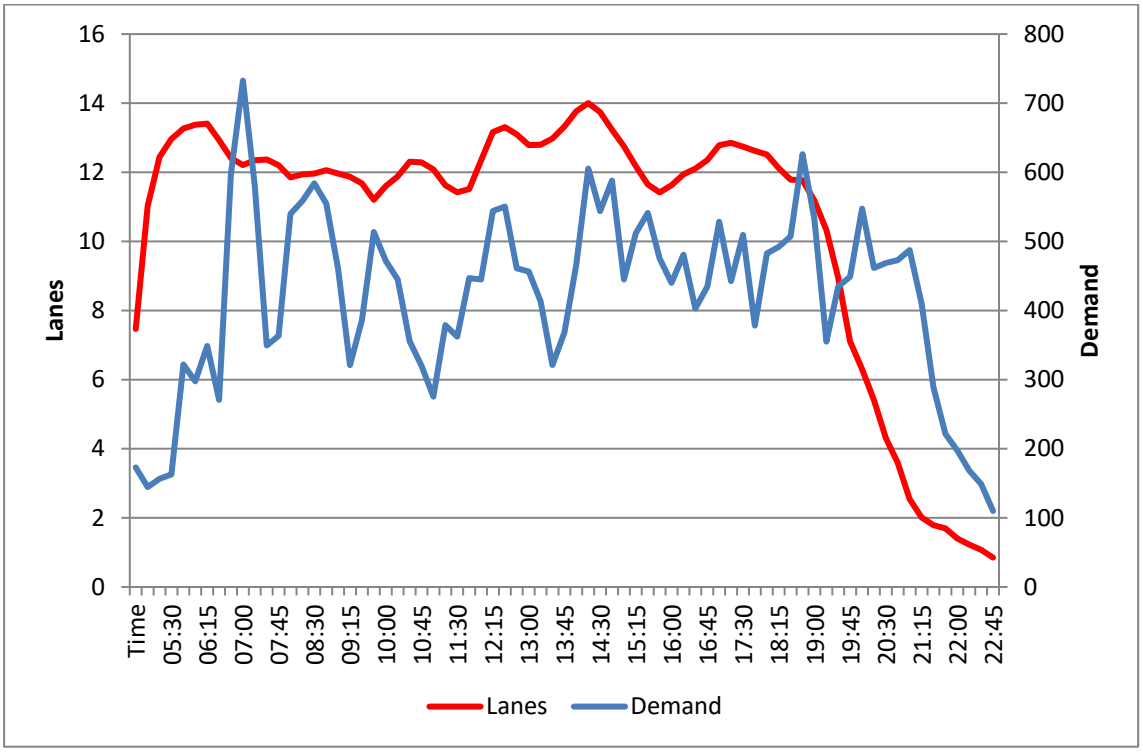

Figure 2 Average hourly demand and open lanes

Figure 3 shows the average waiting time in CSC (blue curve) and the average number of open lanes (red curve) for every 15 minute interval. The waiting time graph shows a morning peak as well as a late afternoon peak. It also shows some variation in the middle of the day not related to the peak hours.

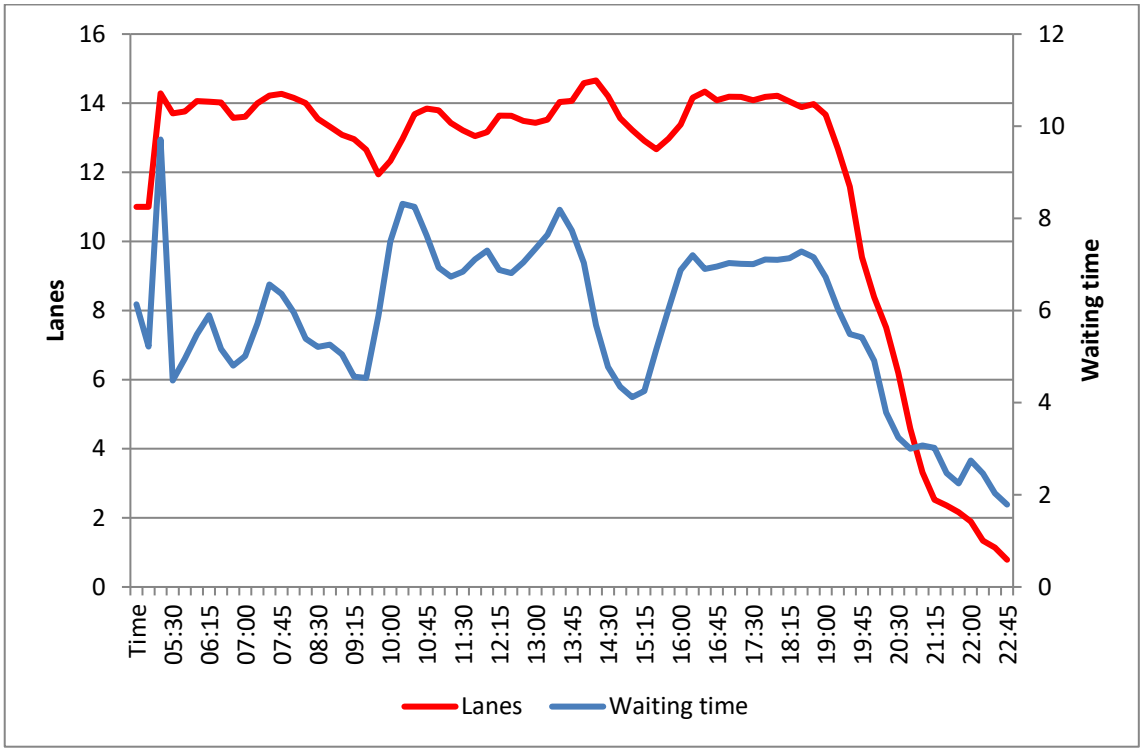

Figure 3 Empirical distribution of average waiting time and average open lanes

Figure 4 shows the average waiting time as well as the 5% and 95% quantiles over the average day. 5% of waiting times are shorter than the 5% quantile, while 5% of waiting times are longer than the 95% quantile. It is seen that the variation is higher for 15 minute intervals where the average waiting time is high. But while the morning peak has the highest average waiting time, the longer waiting times as captured by the 95% quantile is seen to be higher in the midday peak and the afternoon peak. The 95% quantile is mostly 2 and sometimes 3 times larger than the average waiting time. The 95% quantile is also larger than the 10 minutes maximum waiting time recommended by IATA (Danish Transport and Construction Agency, [3]) during much of the day, which means that the waiting time exceeds 10 minutes more than 5% of days at these times.

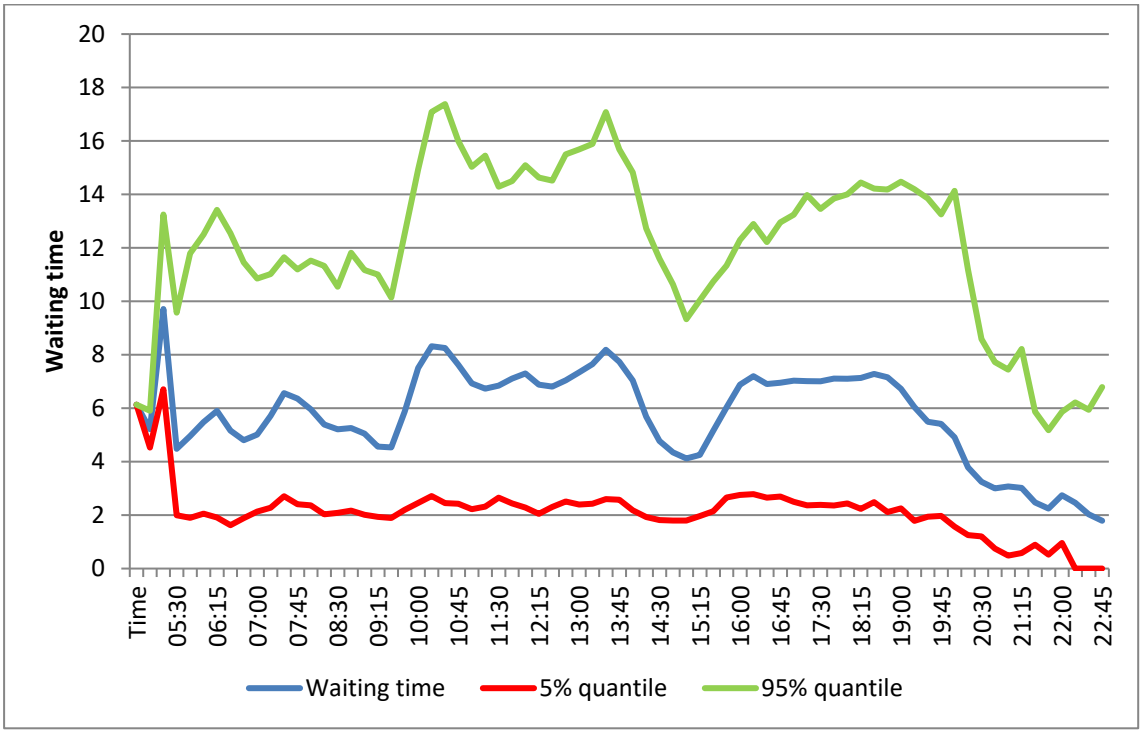

Figure 4 Average quarterly waiting time together with the 5% percentile and the 95% percentile across the day

Figure 5 shows the empirical cumulative distribution function of waiting time. The median waiting time is 4.47 minutes. 25% of waiting times are larger than 7.53 minutes, 10% of waiting times are larger than 11.07 minutes, while 5% of waiting times are larger than 13.20 minutes.

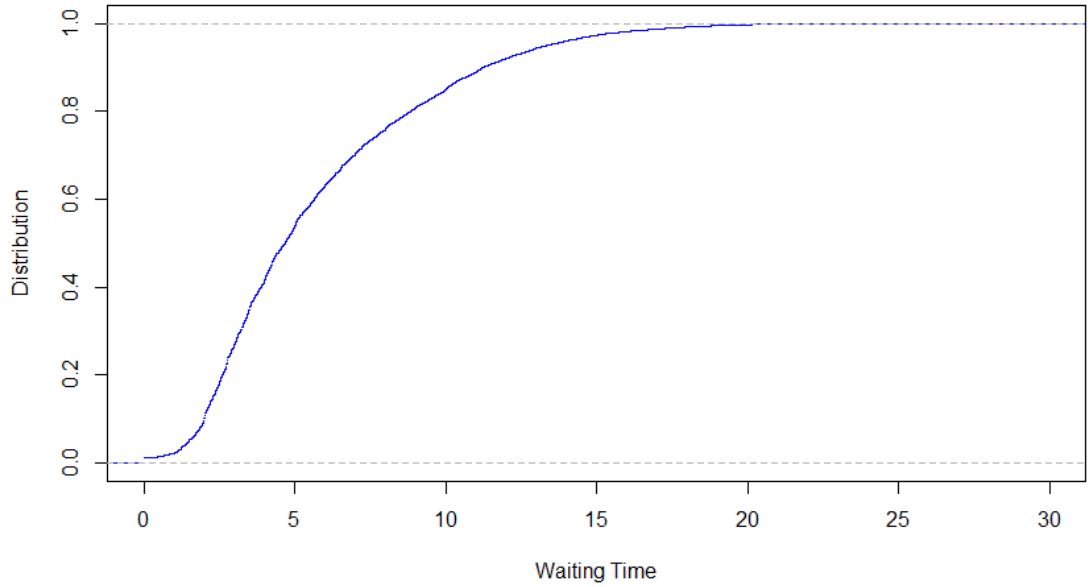

Figure 5 Empirical cumulative distribution of quarterly waiting times

3. Comparison of data sets

3.1 Development in waiting times, demand and capacity

In this section we compare the waiting time, demand, and capacity across periods of data. The two periods do not cover the same months of the year, which means the comparison may be affected by seasonal effects. The next section compares the parts of the data covering the same months in 2015 and 2016.

Figure 6 compares the overall waiting time distributions in the two time periods. The distribution has shifted slightly to the right indicating that waiting times have become slightly higher overall.

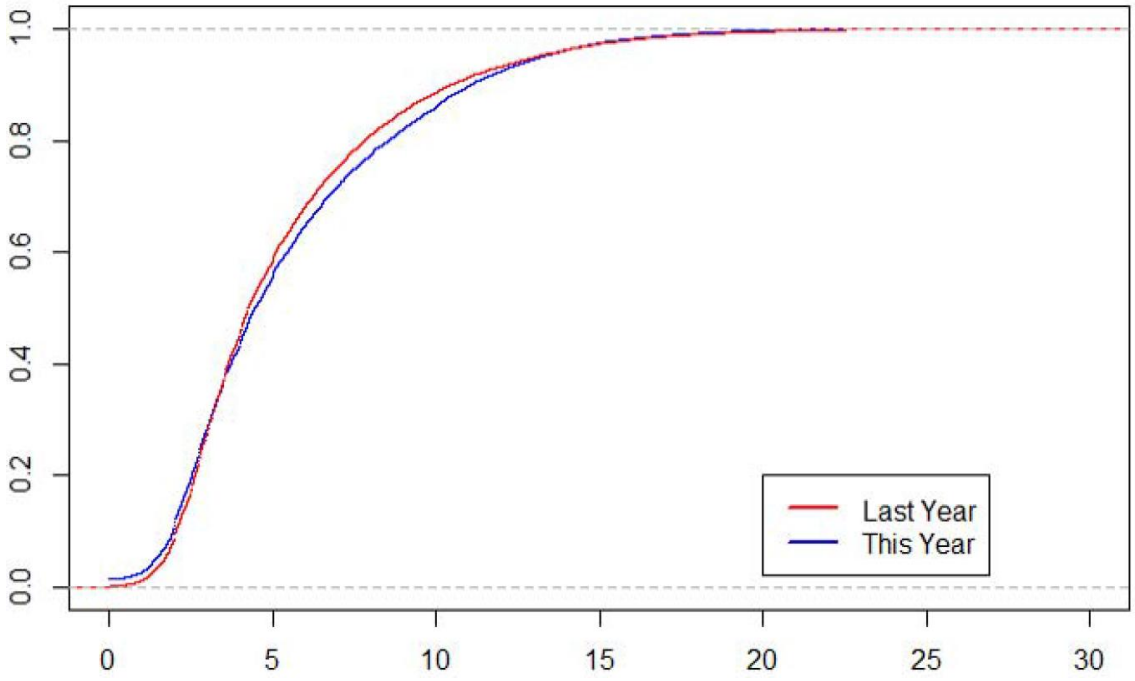

Figure 6 Comparison of waiting time distributions in the two data periods.

Figure 7 shows the development in average waiting times as well as the development in extreme waiting times described by quantiles. We see the same pattern as earlier that the morning peak has improved but the evening has worsened.

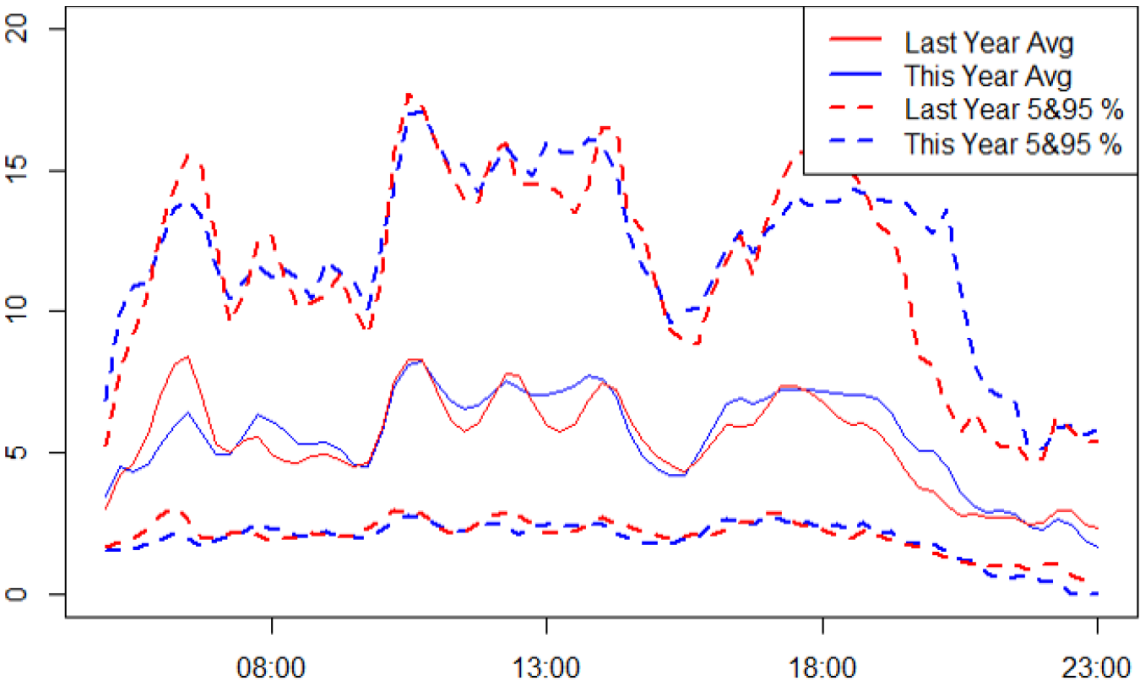

Figure 7 Comparison of average waiting time, 5%, and 95% quantiles across the day in the two data periods.

Figure 8 shows that the average demand is approximately the same for the two periods.

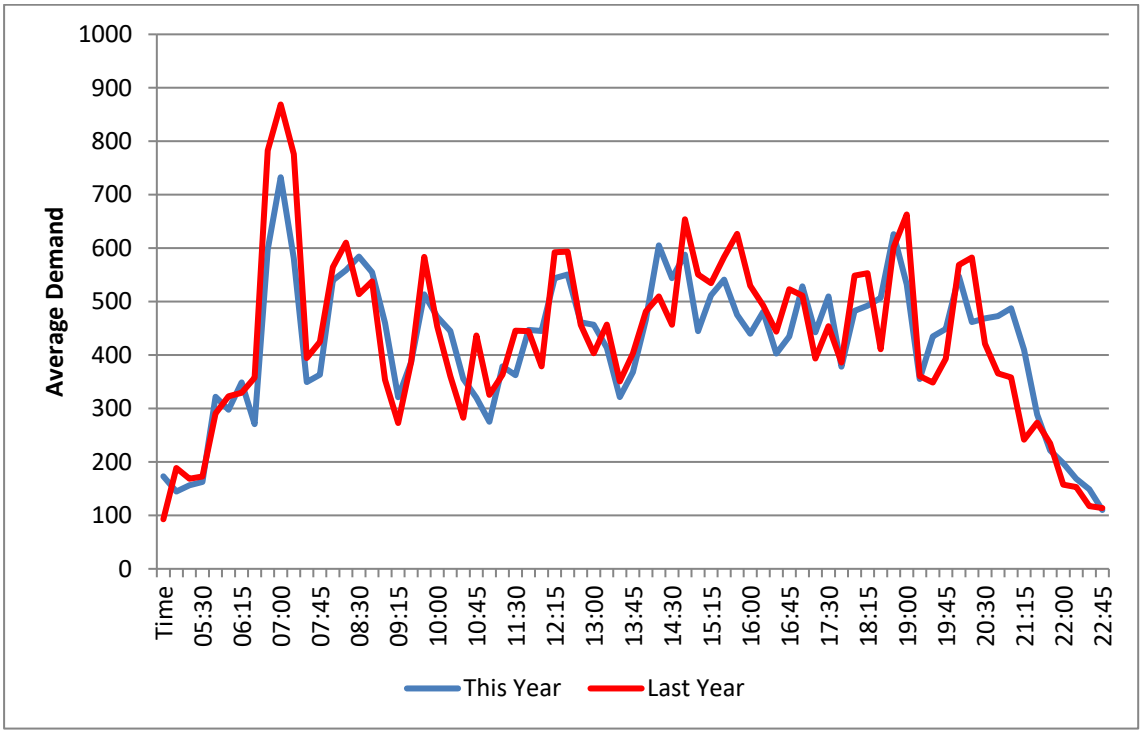

Figure 8 Comparison of average demand across the day in the two data periods.

Figure 9 shows that more lanes have been open on average in the new period.

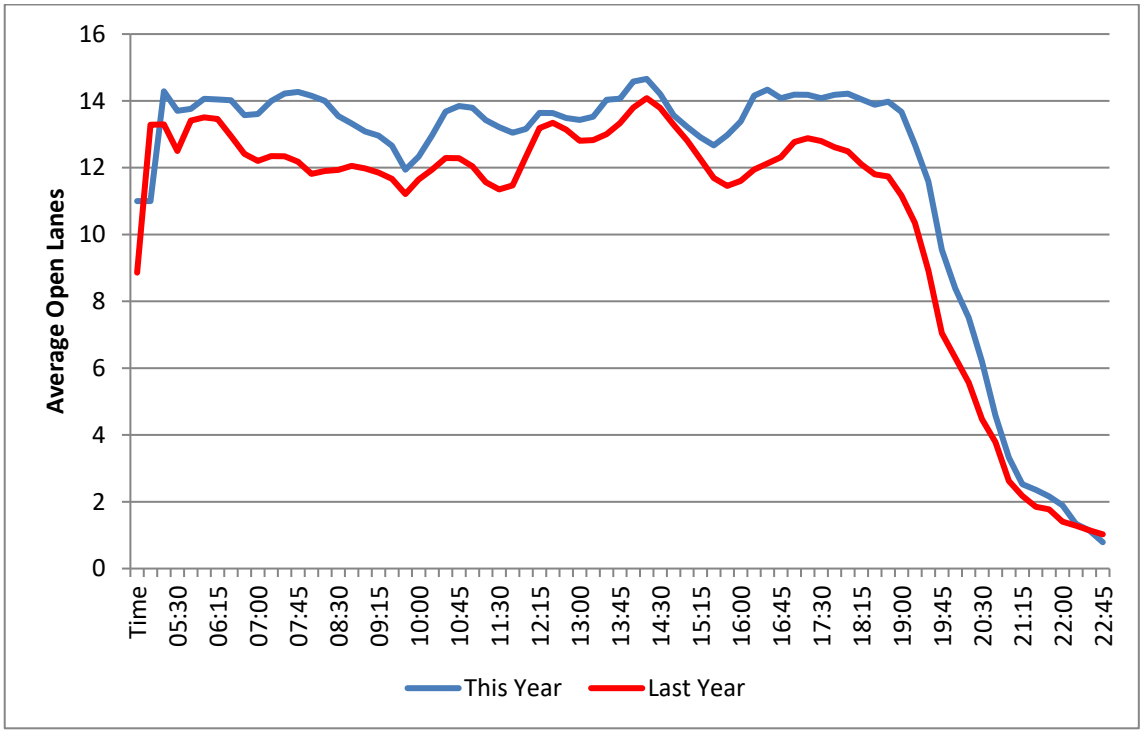

Figure 9 Comparison of average number of open lanes across the day in the two data periods.

Overall we conclude that there is no clear tendency in waiting times across the day except that the distribution of waiting times indicate slightly worse waiting times. We see that the morning peak is lower. But no reduction in waiting time for the remainder of the day. This has to be compared to a similar demand on average but a higher number of lanes. In conclusion for the full period we do not see any simple effect of the additional lanes on the average waiting times. This indicates one or more of the following

- Waiting times have increased for other reasons than changes in demand and capacity.
- Capacity may have been placed at time intervals with low waiting times.

To investigate this, we would have to estimate a non-linear regression model on the data, which is outside the current project. But to investigate further whether these conclusions are the consequences of the different seasons included in period one and two, we restrict our analysis to the same season in 2015 and 2016 in the next section.

3.2 Comparison of similar periods in 2015 and 2016

In this section we redo the analysis of Section 3.1 but this time restricted to the period March to July for which we have data both in 2015 and 2016. Figure 10 shows that average waiting times have been higher for 2016 than 2015 for these months almost for the entire day.

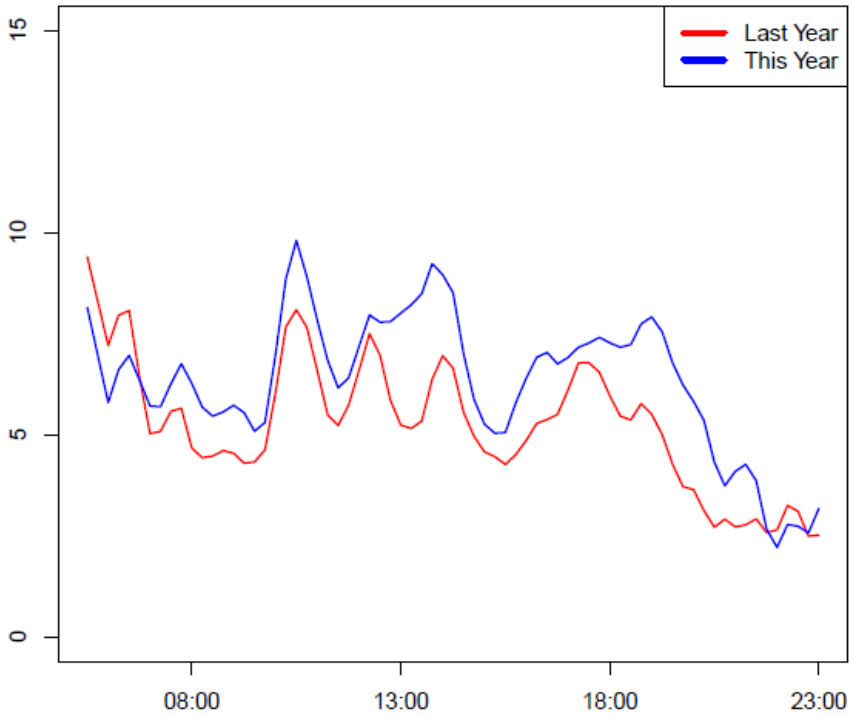

Figure 10 Comparison between 2015 and 2016 of average waiting time from March to July

As Figure 11 shows demand has increased as well so this could be a cause for the increase waiting times.

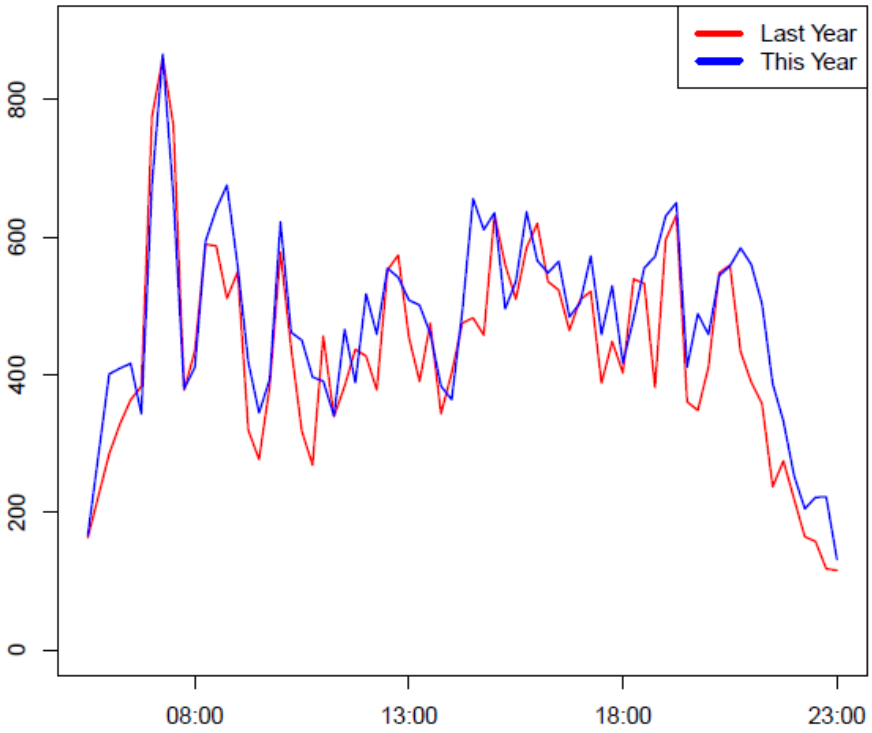

Figure 11 Comparison between 2015 and 2016 of demand from March to July

To quantify the increase, we have calculated the monthly increase as seen in Table 1.

Table 1 Monthly increase in demand from 2015 to 2016

Month	2015	2016	Ratio
March	802,516	896,828	1.12
April	801,382	878,697	1.10
May	917,311	995,128	1.08
June	1,020,473	1,121,583	1.10
July	1,104,699	1,232,282	1.12

Figure 12 shows the number of open lanes for these months in both years. It shows that the average number of lanes is consistently higher in 2016 than in 2015.

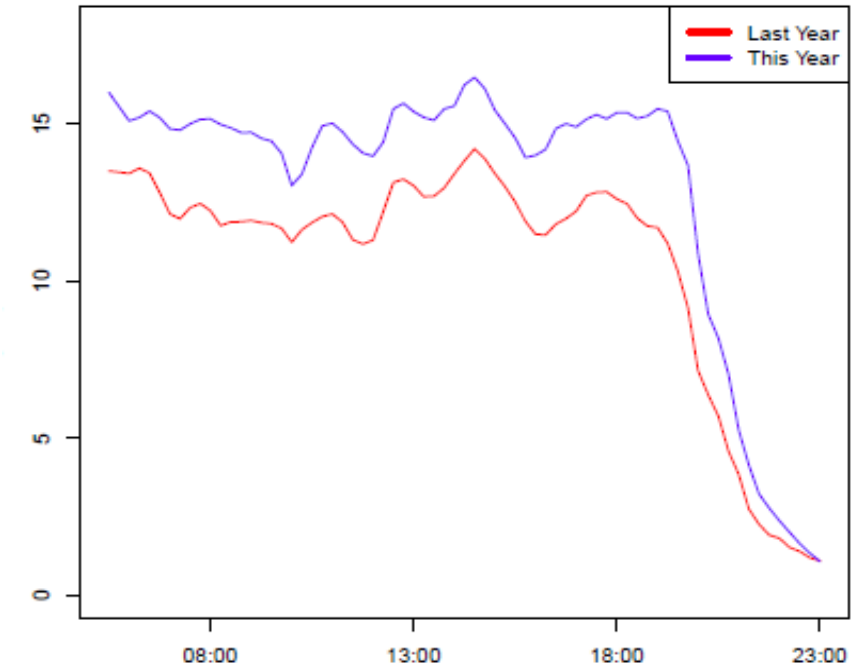

Figure 12 Comparison between 2015 and 2016 of capacity from March to July

Overall the comparison of the same months in the two years confirm the conclusions of the previous section. Again we see an increase in open lanes that has not lead to the expected drop in waiting times.

This could happen if

- waiting times are non-linear with respect to number of open lanes and the capacity has been increased at times with low waiting time but not sufficiently at times with higher waiting times. Descriptive statistics is not enough to entangle the effect.
- there has been a structural change. This we cannot see from descriptive statistics but we could detect this in a reestimation.

It could be the case that a change in security procedures has increased the time required to process each passenger. If that is the case, then it would be possible to verify this explanation by comparing waiting time data before and after a change in the security procedure.

Another potential explanation is that the number of passengers with carry-on bagage has increased, which might also have increased the processing time per passenger in the security check. This potential explanation could be checked by splitting the demand on low-cost vs network carriers, under the assumption that low-cost carriers have more passengers with carry-on bagage.

4. Data censoring

After it was decided to investigate the data from November 2015 to August 2016, it was discovered that the data received were affected by censoring of the waiting time variable. This is described in more detail by the Danish Transport and Construction Agency [2]. A sensor registering when passengers go for the security check was placed such that long queues for the security could spill back beyond the location of the sensor. This introduced upper censoring of the waiting time variable. Since this censoring happens for high demand days but to a varying extent depending on the queue in front of the starting point it is very difficult to account for this censoring in data only including censored data. We can however conclude that

- The mean waiting time is downwards biased in the censored data
- The variability is downwards biased in the censored data

Both of these observations mean that we would expect a reestimation on uncensored data (if that was somehow possible) to indicate higher benefits as compared to those found in the previous report. While the effects are difficult to identify from censored data alone we have illustrated the effect on the two figures below. These show a comparison of the mean waiting time and the 95% quantile of waiting time for March-April 2015 compared to 2016 and the same for September-October. Assuming that demand has risen similarly between the same two periods from 2015 to 2016, we would expect a similar relationship between the waiting times.

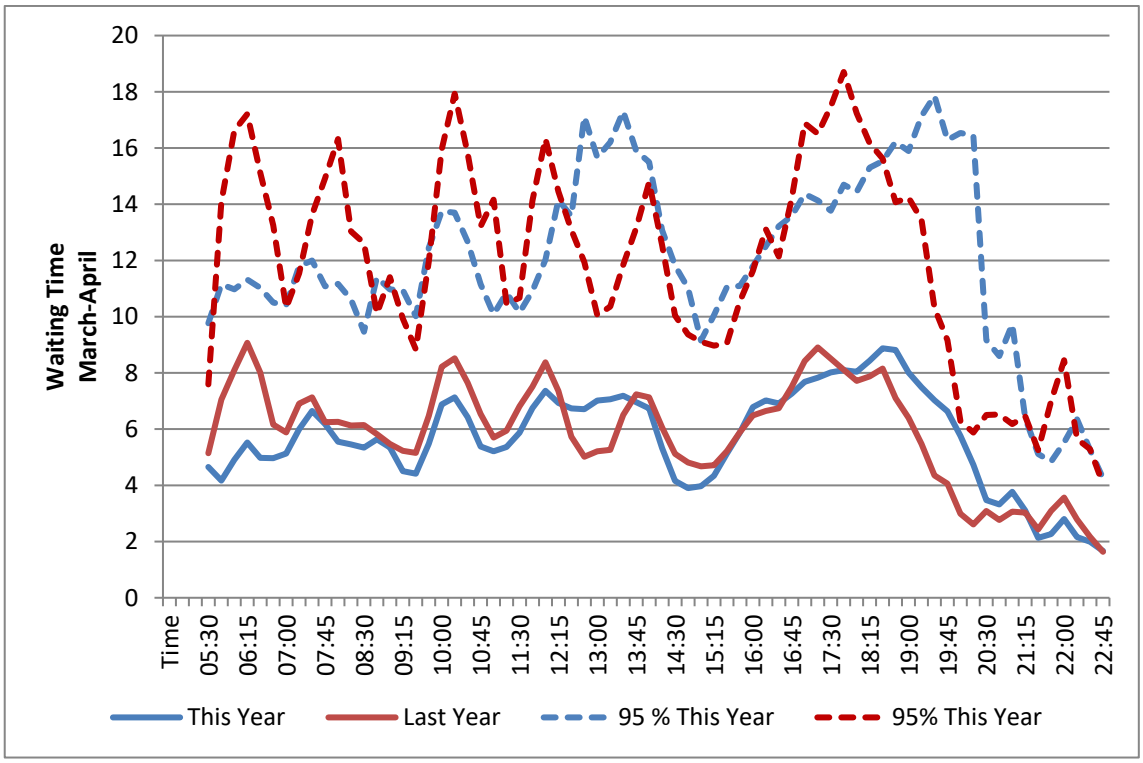

Figure 13 Comparison between 2015 and 2016 of waiting times in March-April

As can be seen in Figure 13 the waiting times are generally improved with the exception of the period around 1 pm and the evening. Figure 14 on the other hand shows a clear increase in waiting times for most of the day (even though the maximum number of lanes has increased by two). Furthermore, we notice that 95% waiting times are similar for March-April, the difference is quite high for the September October data, an indication that the censoring happened mostly during peak hours, i.e., 9 am to 11 am and 2 pm to 7:30 pm.

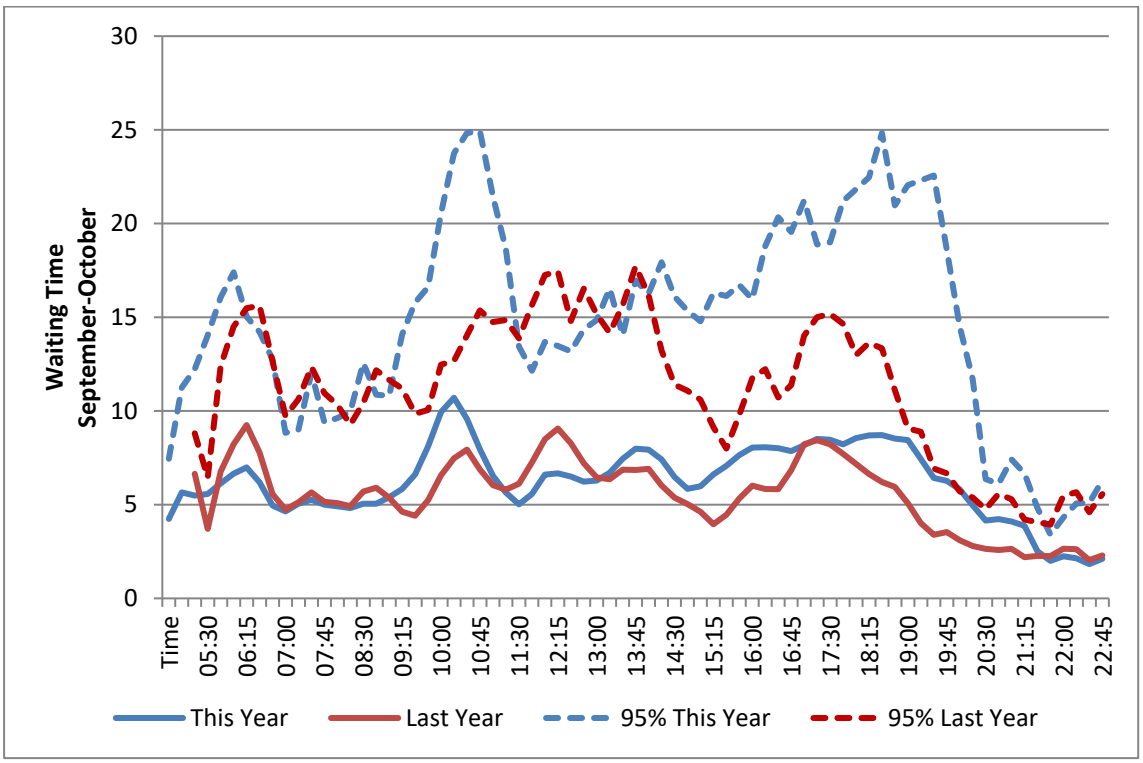

Figure 14 Comparison between 2015 and 2016 of waiting times in September-October

References

[1] M. Fosgerau, S. L. Mabit, and A. Ranjan, “Waiting times in Copenhagen Airport - An economic evaluation of delays in the central security check,” Transport DTU, 2016.

[2] Trafik- og Byggestyrelsen, “Validitet af ventetidsmålinger,” 2016.

[3] Trafik- og Byggestyrelsen, “Internationale anbefalinger og retningslinjer,” Dec. 2015.