Technical University of Applied Sciences

Wildau Institute of Technology

Statistics and forecasting methods Report

Airlines On-Time Statistics and Delay Causes

AVIMA 2018

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Statement of authorship

We hereby declare that we are the sole authors of this project paper and that we have not used any sources other than those listed in the bibliography and identified as references.

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Place, Date

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Jim Jacob

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1 Abstract

Aviation is being the most dynamic business sectors in the world, Flight delays affect passenger travel satisfaction and increase in airline costs. From the United States Department of Transportation aviation data, we have analysed the causes of delay in three airports from 2004 to 2018 using descriptive analysis.

2 Introduction

Apart from our individual interests, we share a dream of being in aviation field from our childhood, how the airliners and the airport is working along to attain the on-time performance. Main factors affecting on-time performance of airlines are Weather, National Aviation System issues (NAS), Security issues, Carrier issues, Aircraft Arrival etc…

To understand the Business Intelligence of an airliner, On-time performance and delay causes directly impact on cost components and cost factors such as Fuel, Maintenance, Crew, Aircraft depreciation, rental, lease, Airport charges, Ground and Passenger handling, Aircraft Operator passenger cost and many others.

Categories definition

Air Carrier: The cause of the cancellation or delay was due to circumstances within the airline's control (e.g. maintenance or crew problems, aircraft cleaning, baggage loading, fueling, etc.).

Weather: Significant weather conditions that, delays or prevents the operation of a flight such as tornado, blizzard or hurricane.

National Aviation System (NAS): Delays and cancellations refer to a broad set of conditions, such as non-extreme weather conditions, airport operations, heavy traffic volume, and air traffic control.

Late-arriving aircraft: A previous flight with same aircraft arrived late, causing the present flight to depart late.

Security: Delays or cancellations caused by evacuation, re-boarding, inoperative screening equipment.

3 Description of data sources

In order to achieve project objectives, data of delay and on-time operation of airlines in the US from the United States Department of Transportation. The data were collected from 2003 to 2018 included monthly recorded for all 32 airlines operating

over 80 airports scattered on the US territory. The dataset had attributes in unit of number of operation namely total operation, flights that were canceled or diverted, total delay flights. Delayed operation included postponed flights by causes of Weather, Carrier, National Aviation System, Security, Late Arrival in number of operations and minutes.

Calculation - Data handling

Since the dataset obtained was large, and with limitation in processing all of it, 3 airports in the list were picked randomly for calculation and compared namely Denver international airport (DEN), Miami international airport (MIA), Boston Logan international airport (BOS).

Calculation of Mean Value was mainly used with the following formula:

$$\text{Mean}$$
$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

For each selected airport, for every month, all the attributes of data are the sum of total airlines.

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year	t	Row Labels	Total operatio	Total delayed	weather delay	Total delay %	average total delay %		weather delay %	average weather delay %	
2004	1	1	5612	1339	116.35	23.85959	Jan	21.25068	2.073236	Jan	1.157266
	2	2	5356	1233	55.35	23.02091	Feb	19.91442	1.03342	Feb	0.978819
	3	3	5791	874	32.49	15.09238	Mar	20.01052	0.561043	Mar	0.590891
	4	4	5534	868	20.11	15.68486	Apr	19.03428	0.36339	Apr	0.519149
	5	5	5583	974	30.06	17.44582	May	19.89156	0.53842	May	0.60996
	6	6	5334	1346	61.09	25.23435	Jun	25.65364	1.145294	Jun	1.173902
	7	7	5508	1425	67.6	25.87146	Jul	26.2141	1.227306	Jul	1.20202
	8	8	5505	1393	72.16	25.30427	Aug	23.22978	1.310808	Aug	0.980479
	9	9	4943	709	28.99	14.34352	Sep	17.32363	0.586486	Sep	0.534776
	10	10	5244	641	17.15	12.22349	Oct	15.60746	0.32704	Oct	0.308463
	11	11	5273	811	38.86	15.38024	Nov	15.68726	0.736962	Nov	0.273355
	12	12	5572	1596	112.99	28.64322	Dec	24.52035	2.027818	Dec	1.17613
2005	13	1	5567	1335	117.93	23.9806			2.118376		
	14	2	5135	935	52.42	18.20837			1.020837		
	15	3	5779	1462	62.57	25.29849			1.082713		
	16	4	5374	868	25.11	16.15184			0.46725		

A time variable t was added to the dataset in order to plot full series graphs of the data.

First total operation, total delayed flight and weather delayed flight were taken into account. Total delayed flight and weather delay flight were transferred into percentage over total operation, subsequently these values of the same month were averaged from 2004 to 2018 to get a set an average value from Jan to Dec.

	Sum of Total operatio	Sum of total on-time	Aircraft Arriving Late	Security delay	Carrier delay	Weather delay	National Aviation System
Absolute value	5977.983	4752.404	369.4048	3.137697	365.3653	47.09663	440.5748
Percentage	100%	79.50%	6.18%	0.05%	6.11%	0.79%	7.37%

Secondly, total operation of an opted aerodrome was broken into 6 categories including on-time operation, and 5 other delayed causes, then these figures are calculated into percentage of total operation and depicted on a pie-chart.

Thirdly, raw data of weather delays were also averaged on a monthly basis from 2004 to 2018 in order to compare with percentage results.
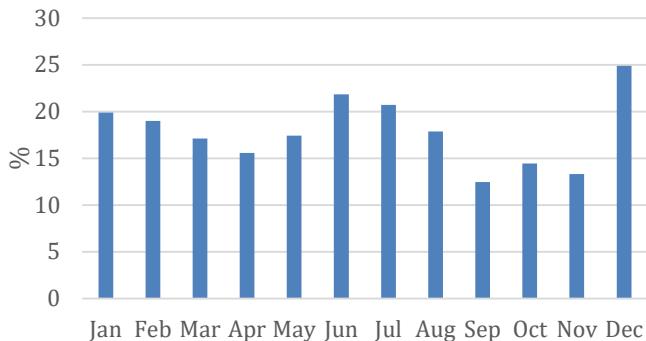
Additionally, linear regression method is also used to find out the regression between total operation and late arrivals rate on monthly average basis as well as whole series of time.

4   Denver international airport (DEN) - Lavanya

Total delay rate and total operations are calculated through Excel and represented as below:
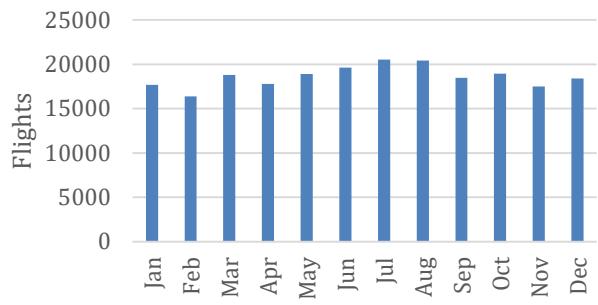
Total delay rate and total operations

Seasonal average % delay for Denver (2004-2018)

Seasonal average Total operations for Denver(2004-2018)
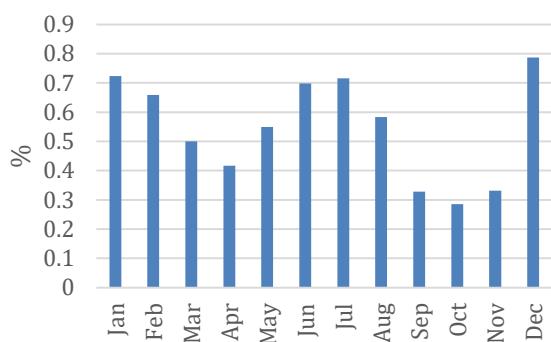
| High rate of delayed operations in high season form Dec to Jan and from Jun to Aug.	On absolute values, highest flights of total operations observed throughout the year.
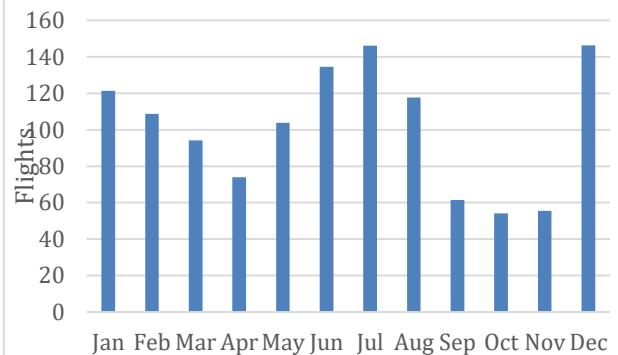
Weather delay rate and absolute weather delays

Similarly weather delayed percentage also observed significantly from Dec to Jan, Jun to Aug. The rate in Dec is around two times larger than Nov.

Seasonal average variation in % weather delay for Denver (2004-2018)

Seasonal average weather delay for Denver (2004-2018)
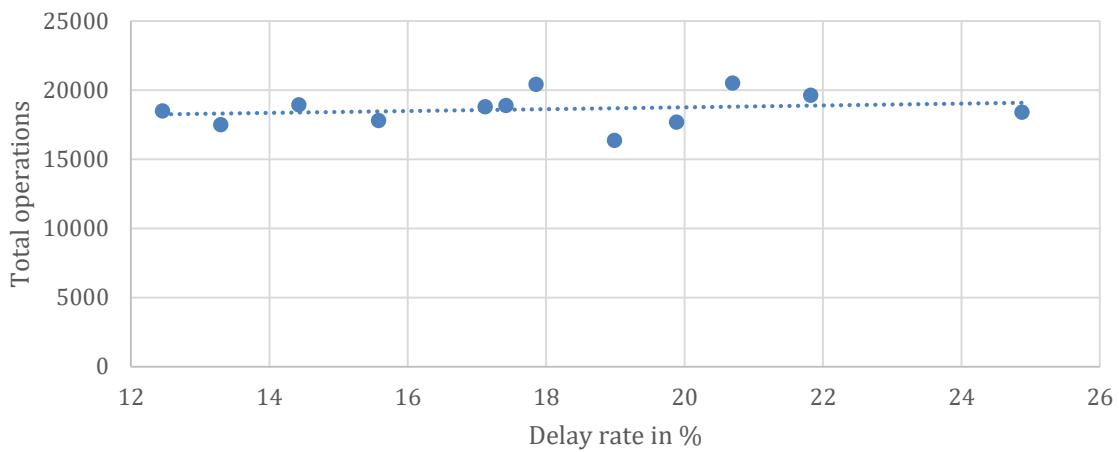
The same trend happens for absolute flights delayed by weather cause. Highest months are Dec, Jan, Jun to Aug, and the figure for Dec is almost two times higher than the one for Nov.

Delay rate and total operation regression

With $R^2 = 0.0411$, there is not a high regression between delay rate and total operation.

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Total operation against delay rate on average (2004-2018)
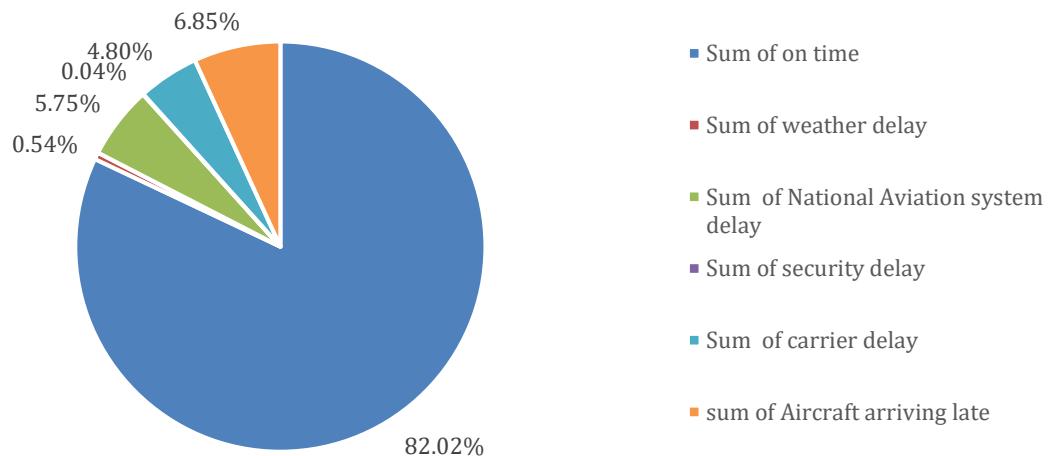
$y = 67.115x + 17426$
$R^2 = 0.0411$

With $R^2 = 0.0411$, there is not a high regression between delay rate and total operation.
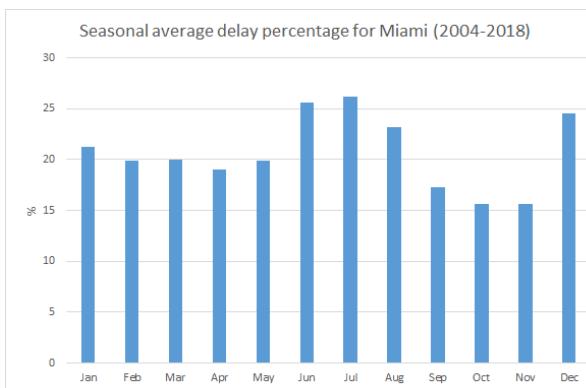
On-time performance and major delay causes

Average on-time performance of Denver airport
2004-2018

- Sum of on time
- Sum of weather delay
- Sum of National Aviation system delay
- Sum of security delay
- Sum of carrier delay
- sum of Aircraft arriving late

6.85%
4.80%
0.04%
5.75%
0.54%
82.02%
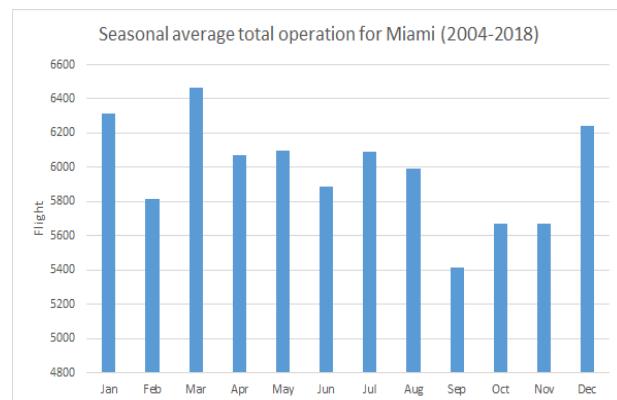
Average on-time rate is 82.02%, three major causes of delays are National Aviation System, Aircraft Arriving Late and Carrier delay.

5 Miami international airport (MIA) - Van
Total delay rate and total operations
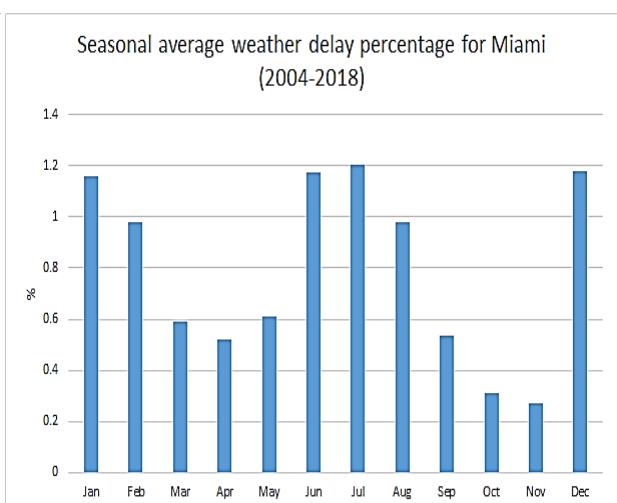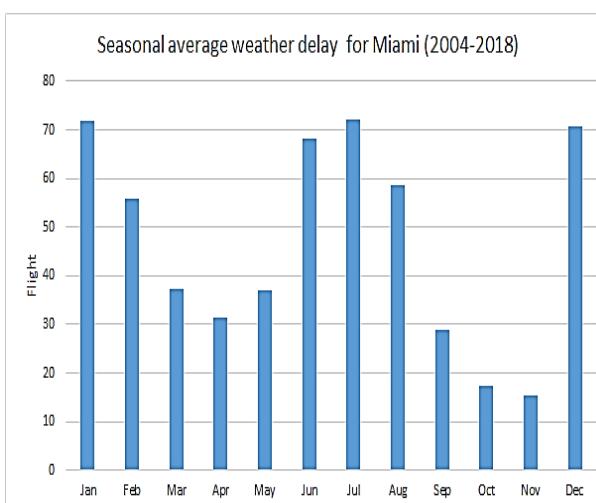
High rate of delayed operations in high season form Dec to Jan and from Jun to Aug

On absolute values, highest flight obtained in Dec, Jan and Mar
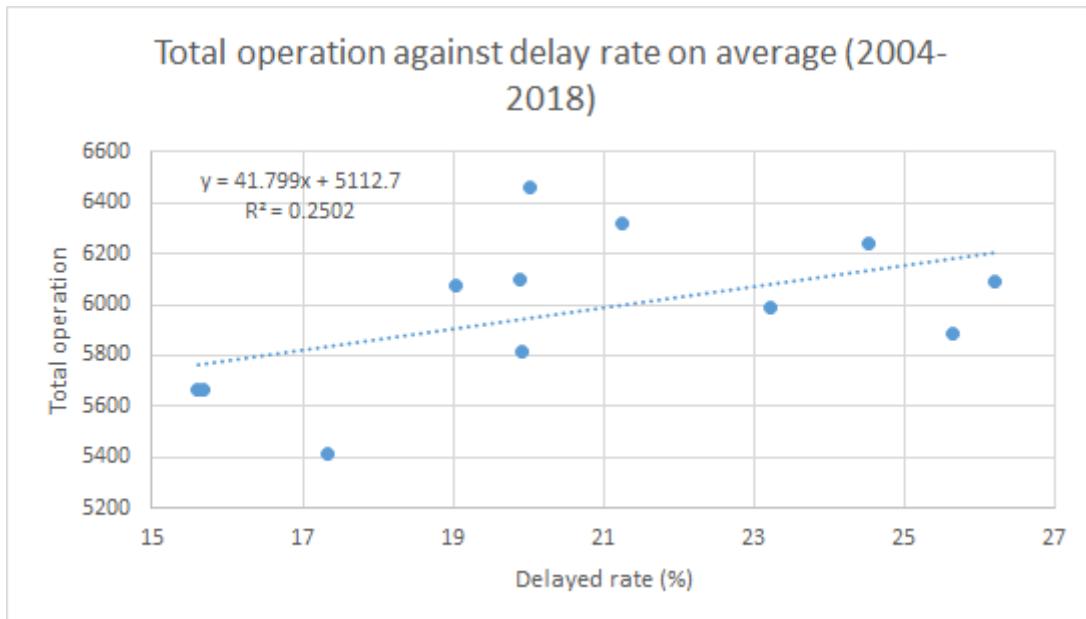
Weather delay rate and absolute weather delays

Similar to total delayed rate, weather delayed percentage happen significantly from Dec to Jan, Jun to Aug. The rate in Dec is around 5 times larger than Nov.
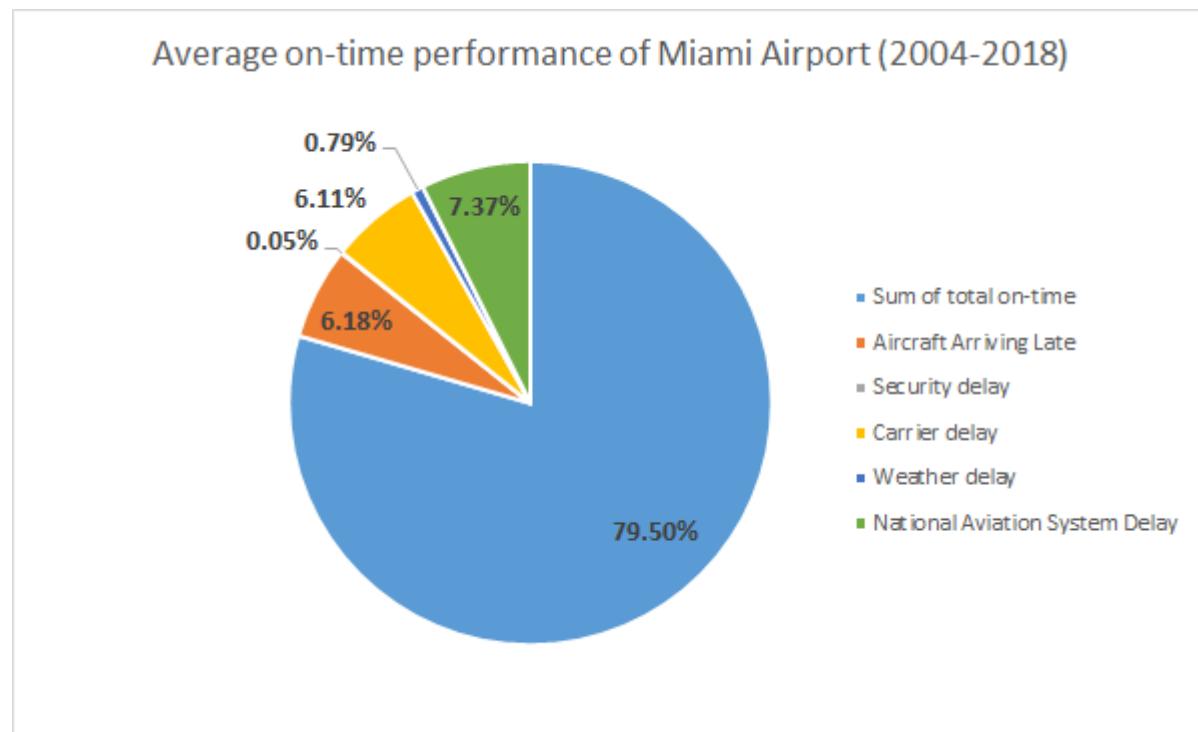
The same trend happens for absolute flights delayed by weather cause. Highest months are Dec, Jan, Jun to Aug, and the figure for Dec is almost 5 times higher than the one for Nov.

Delay rate and total operation regression

With $R^2 = 0.2502$, there is not a high regression between delay rate and total operation
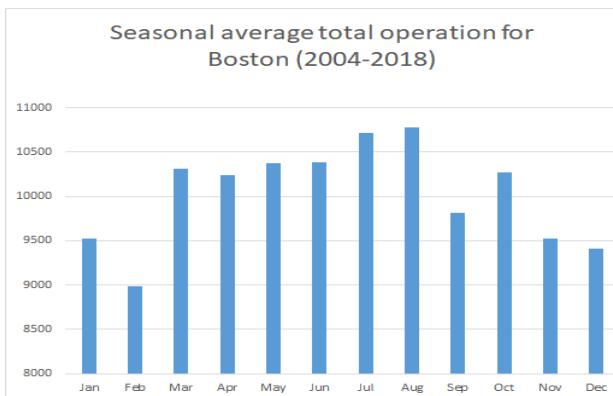
On-time performance and major delay causes
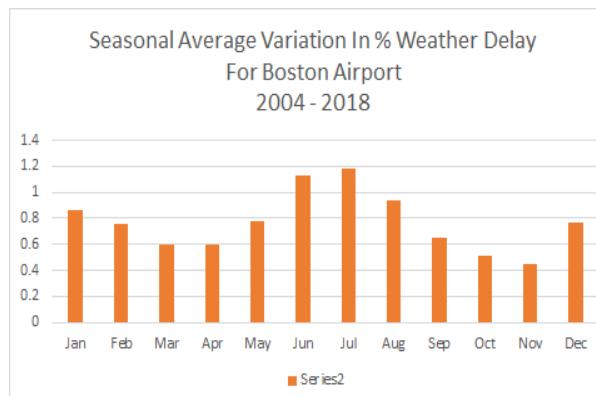
Average on-time rate is almost 80%, three major causes of delays are National Aviation System, Aircraft Arriving Late and Carrier.

6 Boston Logan international airport (BOS) - JIM

Weather Delay Rate and Absolute Weather Delays
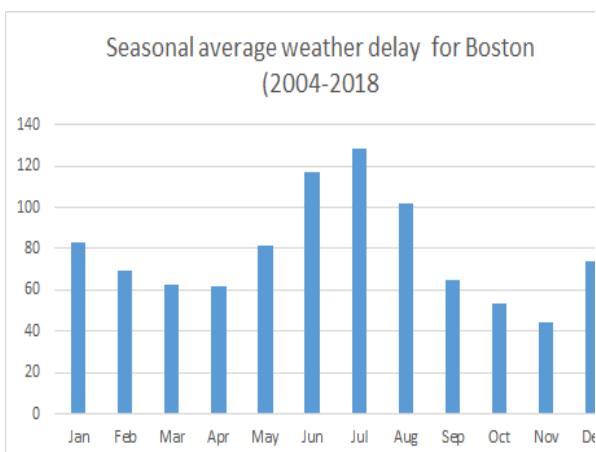
June, July and August are the highest seasons of weather delay, as well as December and January also shows slight hike compared to other months.
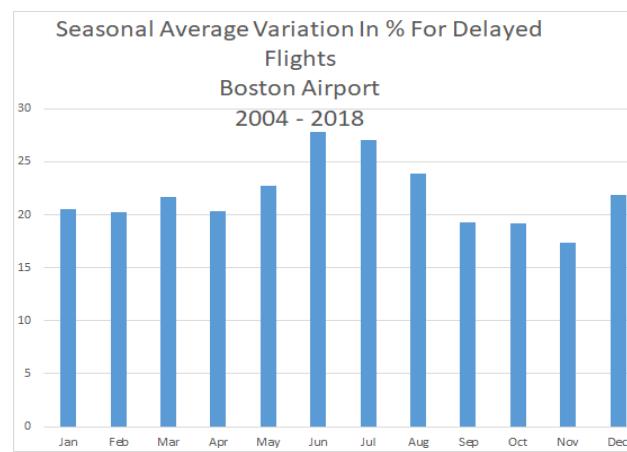
Weather delay percentage in Boston Logan International Airport is at its peak on June, July and August

Total Delay Rate and Total Operations
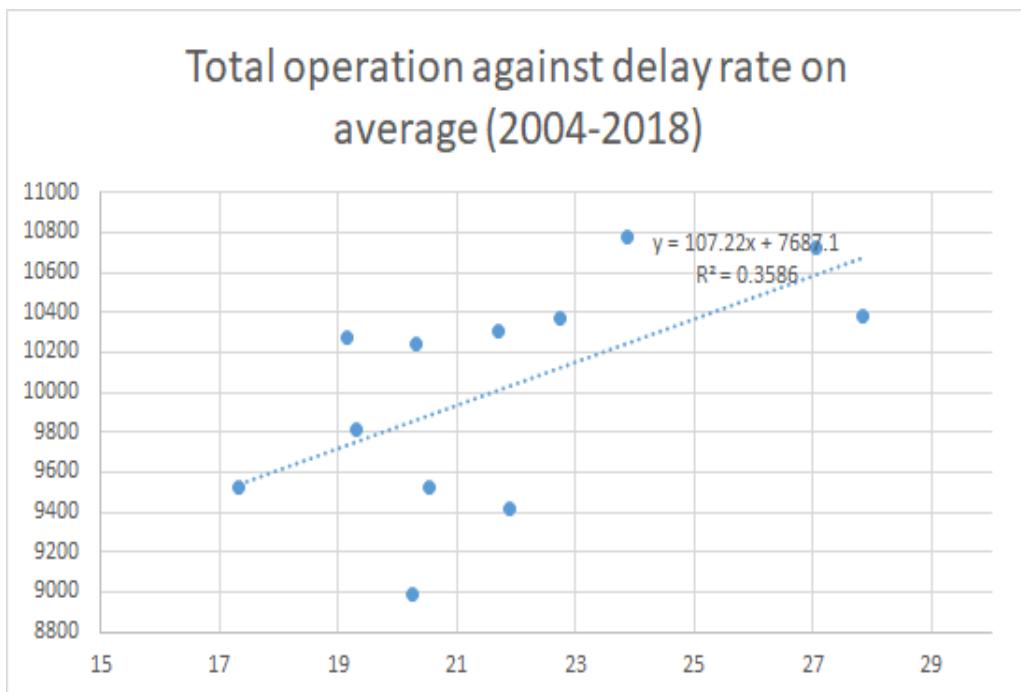
June and July are at the top in case of total delay percentage of Boston Logan International Airport.
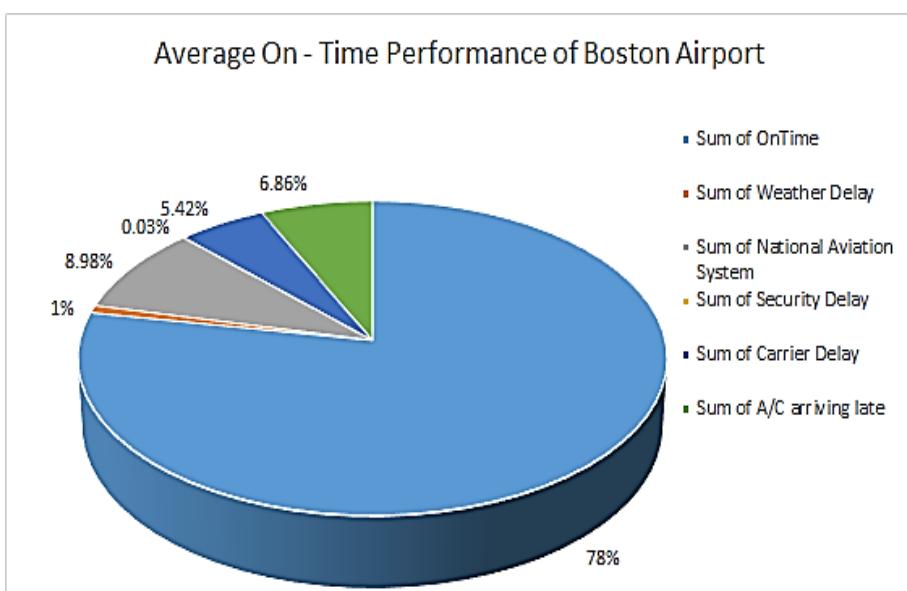
On absolute values, highest flight obtained in July, and August. February faces the lowest operations.

Delay Rate and Total Operation Regression

There is no a high regression between delay rate and total operation in Boston Logan International Airport. The regression is $R^2 = 0.3586$

On-Time Performance and Major Delay Causes

Average on-time performance of Boston Logan International Airport is 78%. Weather delay of 1% and security delay of 0.03% doesn't affects much on the on - time performance. National Aviation System delay, Carrier delay and aircraft arriving late are the main three causes affecting on -time performance.

7   Discussion of the results

From the results percentage of delay from weather of all the three airports are lower than 3%, weather category consists of extreme weather that prevents flying. There is another category of weather within the NAS category, which slows the operations of the system but does not prevent flying. Another attribution come from the weather-related delays included in the "late-arriving aircraft" category. Airlines do not report the causes of the late-arriving aircraft but it also possible that the flight arrive late because of the bad weather with in the route.

8   Sources and References

a) https://www.caa.co.uk/passengers/resolving-travel-problems/delays-and-cancellations/ → 09/02/2019.

b) Airline-Delay-Time-Series-Differentials-Autoregressive-Integrated-Moving-Average-Model.pdf → 09/02/2019

c) https://www.transtats.bts.gov → 02.02.2019

d) Lectures in Class

e) *https://www.researchgate.net/publication* → 02.02.2019

f) https://www.faa.gov/data_research/ → 08.02.2019