Analysis of airport efficiency in liberalized aviation industry.

A DEA approach

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11/28/2019

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Application case

- As regards the management of airport infrastructure, Colombia has followed the regional tendency of **concessioning the management of such infrastructure to the private sector**, as are also the cases of Brazil, Peru, Chile, Argentina, Mexico, among others.
- Thus, since the mid-1990s, and in several periods known as generations, **the Colombian government has concessioned** several airports in the country, a total of 19 until now, including the **largest and most important ones**, which manage most of the air traffic in the whole network.
- As a result of the public policies, both of privatization and public and private investment in airport infrastructure, together with deregulating policies in the airline business sector, where airfares are completely liberalized since 2012, **passenger transport (total) has increased 863%** during the last two and a half decades.

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Application case

DATA ABOUT AIRPORTS WITH 100% PRIVATE GOVERNANCE

Airport city	IATA Code	Year of privatization	PAX (2017)
Carepa	APO	2008	205362
Medellín	EOH	2008	1070158
Rionegro	MDE	2008	7325740
Barranquilla*	BAQ	2015	2576253
Cartagena	CTG	2010	4590151
Valledupar	VUP	2010	387634
Quibdó	UIB	2008	372618
Montería	MTR	2008	938460
Bogotá	BOG	2007	24694288
Riohacha	RCH	2010	149980
Santa Marta	SMR	2010	1686025
Cúcuta	CUC	2010	875519
Providencia	PVA	2007	71091
San Andrés	ADZ	2007	2328104
Barrancabermeja	EJA	2010	128895
Bucaramanga	BGA	2010	1565482
Corozal	CZU	2008	82675
Cali	CLO	2000	4858057

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Theoretical foundations

- The methodology of **Data Envelopment Analysis** (a result of Rhodes' PhD dissertation and an extension of Farell's work) which is used in this research, is considered a **non-parametric** solution to estimate **productivity** of input factors in a system and the results of its transformation in a process with the use of **linear programming**.
- Faced with a set of **units** considered as productive and **which can be compared** with each other because their process of resources transformations is similar (and, thus define a framework for comparison), they name these productive units **DMU** (Decision Making Units) and define three types of efficiency to achieve this comparison:
  - **Technical efficiency**: the unit with the **highest productivity** between units of the **same size** is chosen as a unit of reference.
  - **Scale efficiency**: reflects the ability of DMU to use resources or factors in **optimal proportions**.
  - **Global efficiency**: the unit with the **highest productivity** of those under study is chosen as a unit of reference.

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Theoretical foundations

- The **efficiency relations** are measured with the **coefficient** obtained between the output results (outputs) of the system and the resources supplied at the beginning (inputs) with the following criteria:
  - **Oriented Inputs**: seek, given the level of outputs, the maximum proportional reduction in the vector of inputs, while it remains on the border of production possibilities. **A unit is not efficient if it is possible to reduce any input without altering its outputs**.
  - **Oriented Outputs**: seek, given the level of inputs, the maximum proportional increase of outputs, while remaining within the border of production possibilities. **A unit is not efficient if it is possible to increase any output without increasing any input and without reducing any other output**.

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Methodological conceptualization

DEFINITION OF INPUT AND OUTPUT VARIABLES FOR THE ANALYSIS

DMU	INPUTS	OUTPUTS
Airports (17): **ADZ, SMR, CTG, PVA, MDE, CLO, APO, MTR, VUP, RCH, BOG, CZU, UIB, EJA, BGA, EOH, CUC.**	1. Number of runways. 2. Length of runways. 3. Number of aircraft parking positions on the platform. 4. Built area in passenger terminal building. 5. Apron area. 6. Number of airlines. 7. National destinations. 8. International destinations. 9. Number of employees	1. Operations (take-offs / landings) 2. Passengers carried. 3. Air cargo transported. 4. Load factor (ratio between available seats and passengers onboard). 5. Aeronautical revenue. * 6. Non-aeronautical revenue. *

* This variable will be used only for four airports (BGA, BOG, CLO y CTG), since it is not available for the rest of the airports.

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Methodological conceptualization

The model DEA-CCR will be used, the model is presented as follows:

$$Max_{u,v} \; ho = \frac{\sum_{r=1}^{s} U_r \, Y_{ro}}{\sum_{i=1}^{m} V_i \; X_{io}}$$

subject to:

$$\frac{\sum_{r=1}^{s} U_r \, Y_{rj}}{\sum_{i=1}^{m} V_i \, X_{ij}} \leq 1 \; \forall \, j: 1..n$$

$$U_r, V_i \; \geq 0 \; \forall \, r: 1..2 \quad \forall \, i: 1 \ldots . m$$

where:

ho: Objective function. Measurement of efficiency.

Yrj: i-th output of j-th DMU.

Xij: i-th input of j-th DMU.

Vi,: weights of inputs respectively (program solutions).

Ur: weights of outputs respectively (program solutions).

r: i-th output

j: i-th input

s: total number of outputs

m: total number of inputs

n: total number DMU

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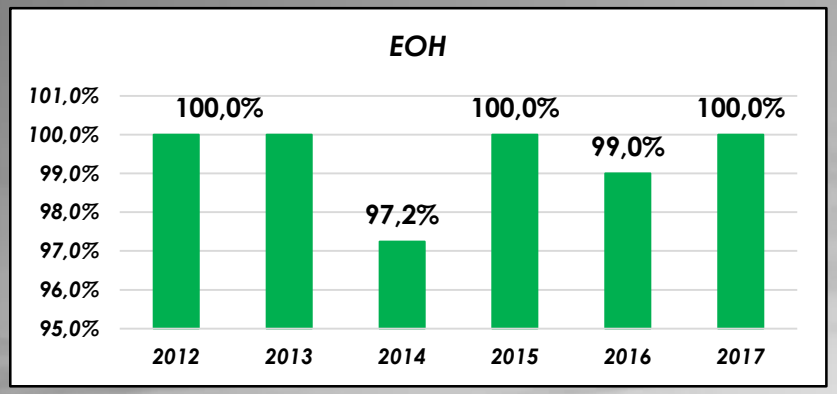
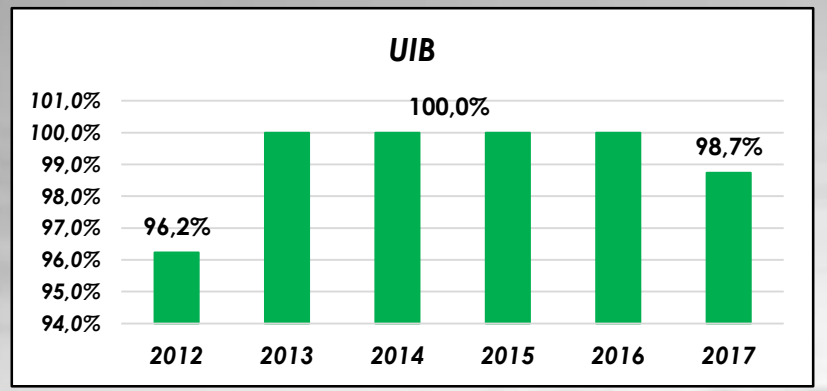
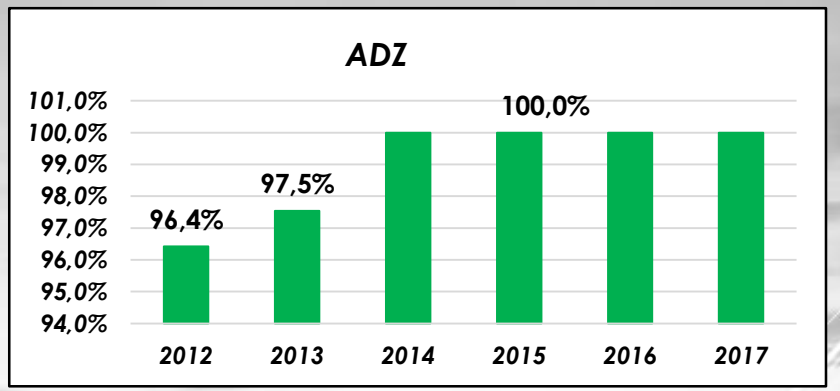
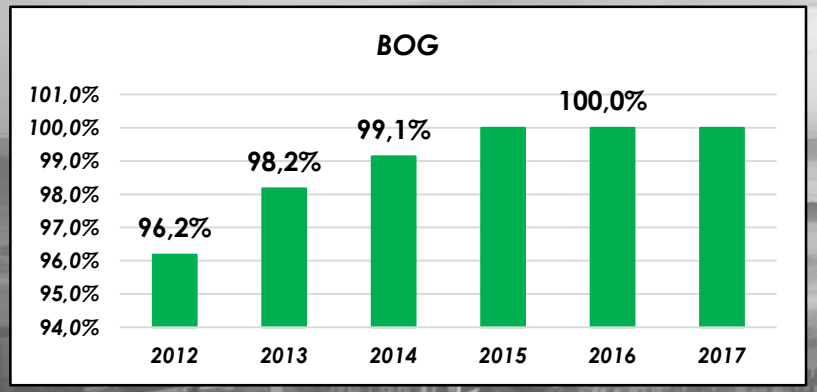
Results

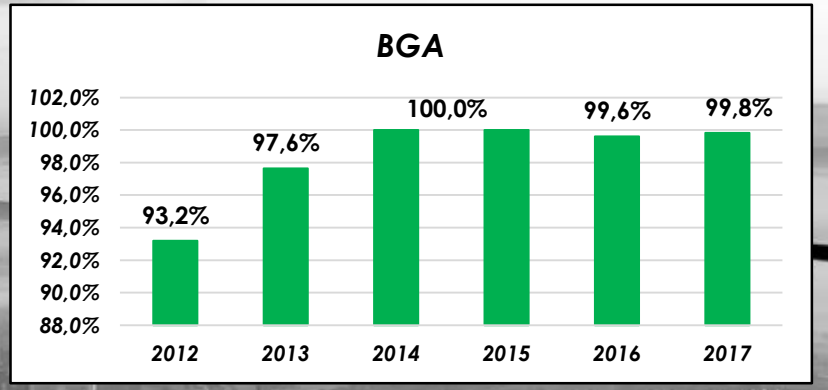
- The results obtained are presented with information about inputs and outputs in 17 Colombian airports during the research period 2012-2017











Values of efficiency in privatized airports, 2012-2017 period. Comment: only 4 outputs were considered in this measurement ("income" variables were not included).

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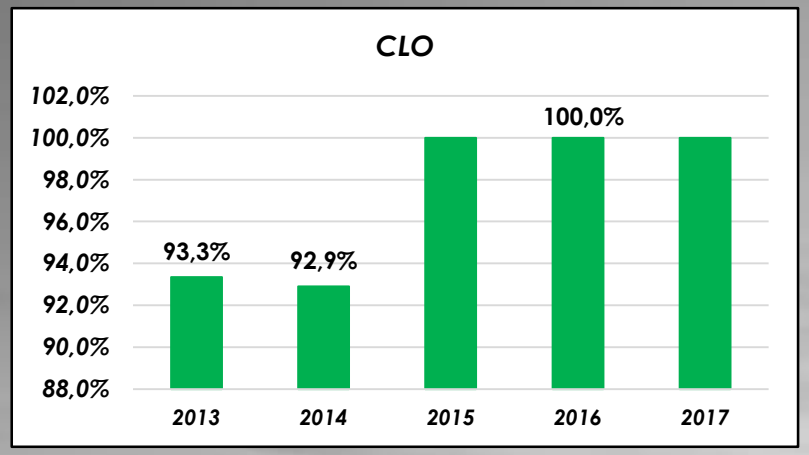

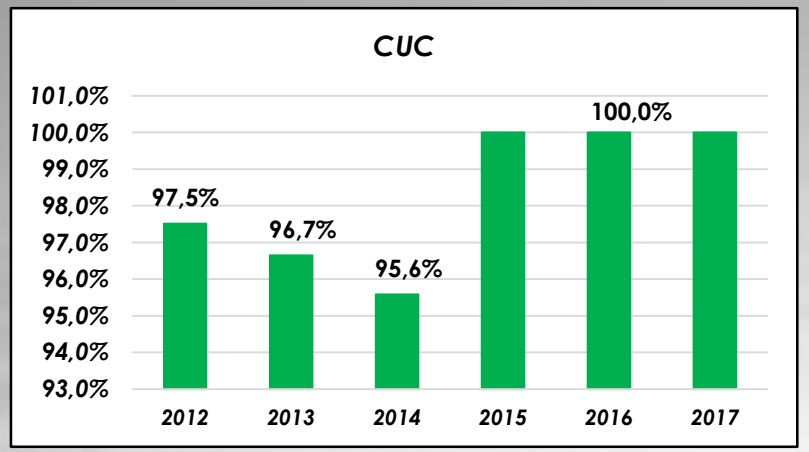

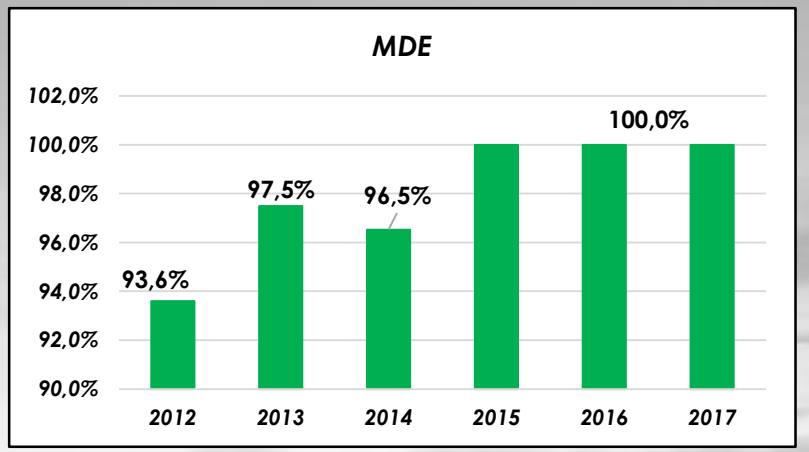

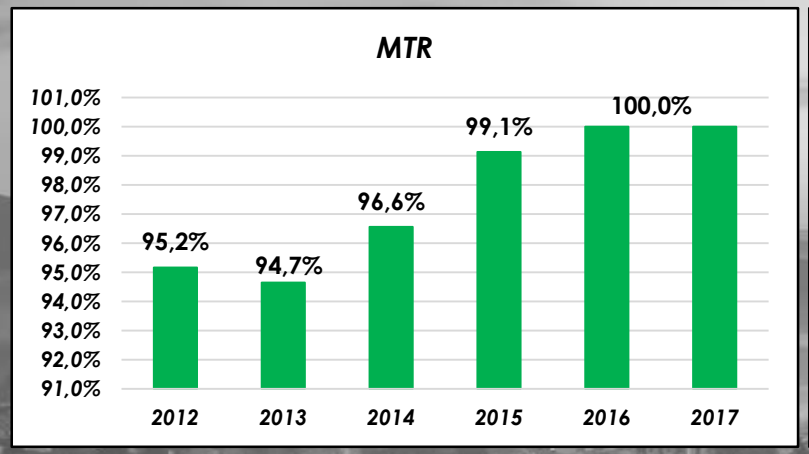

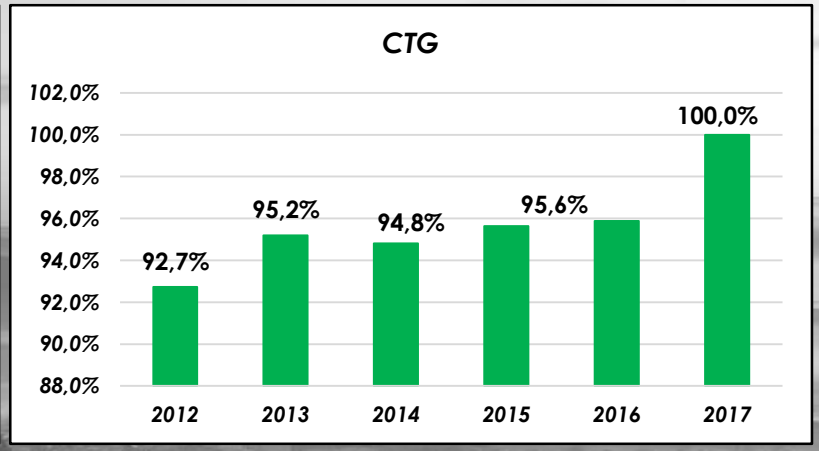

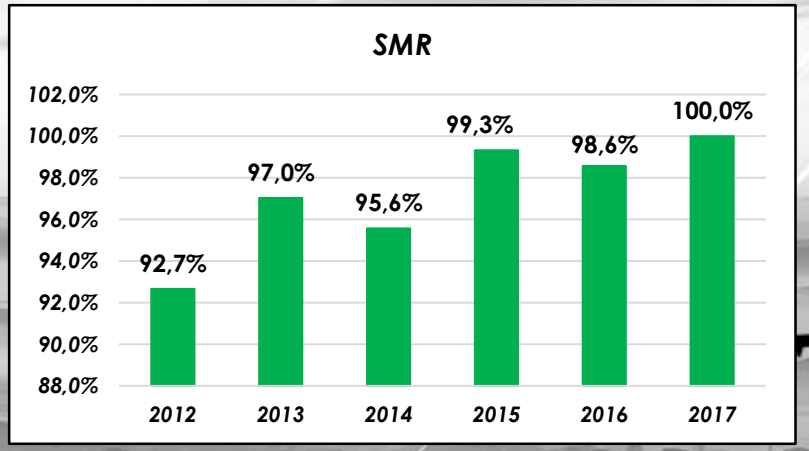

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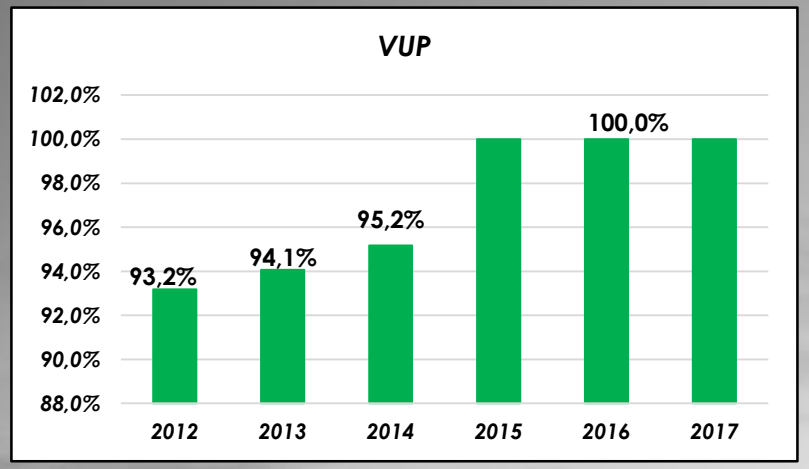

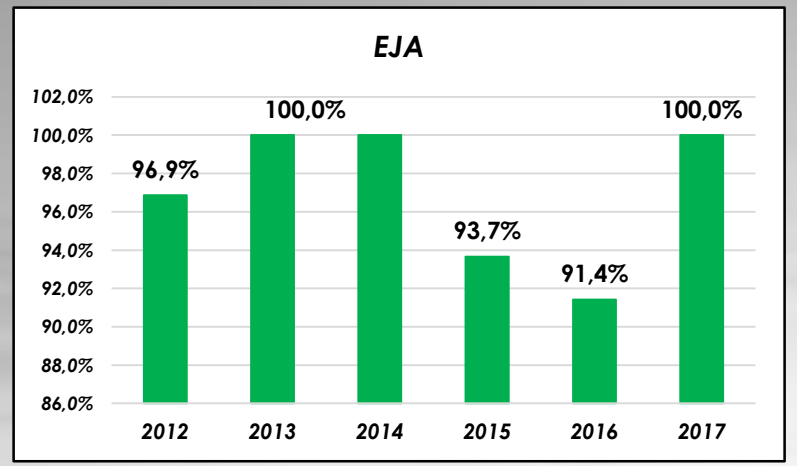

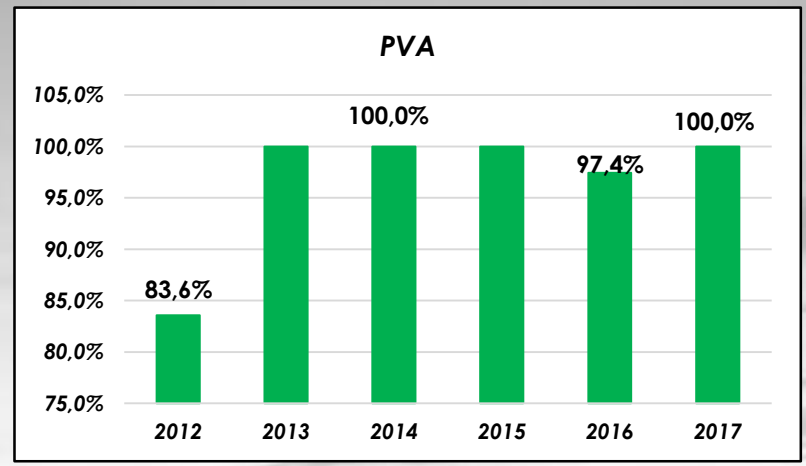

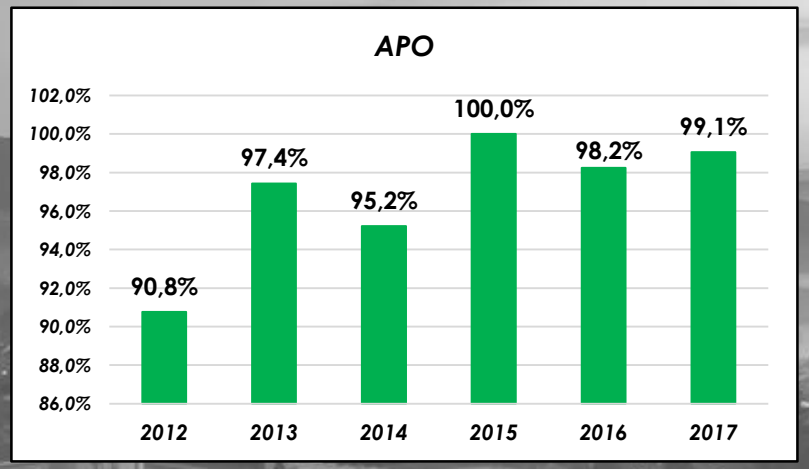

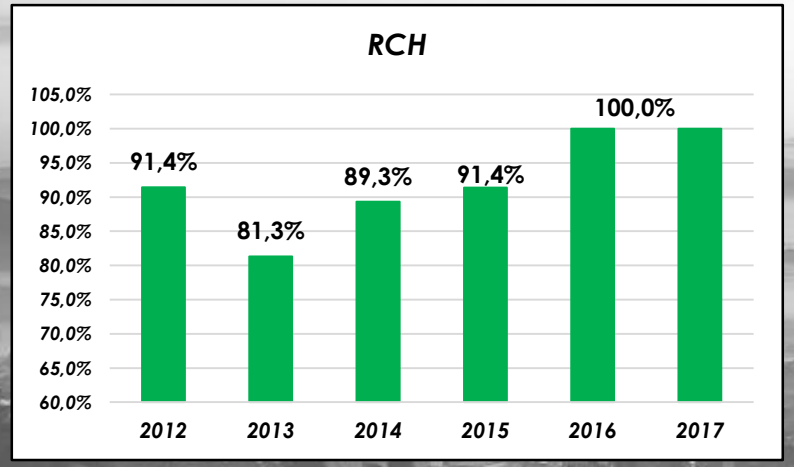

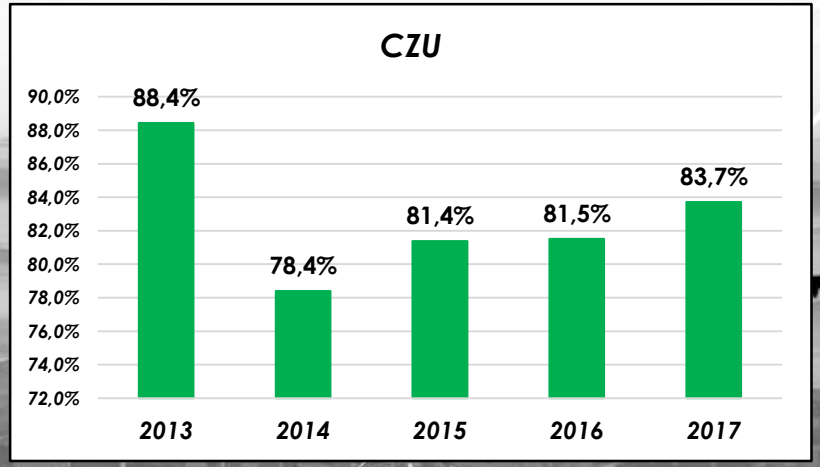

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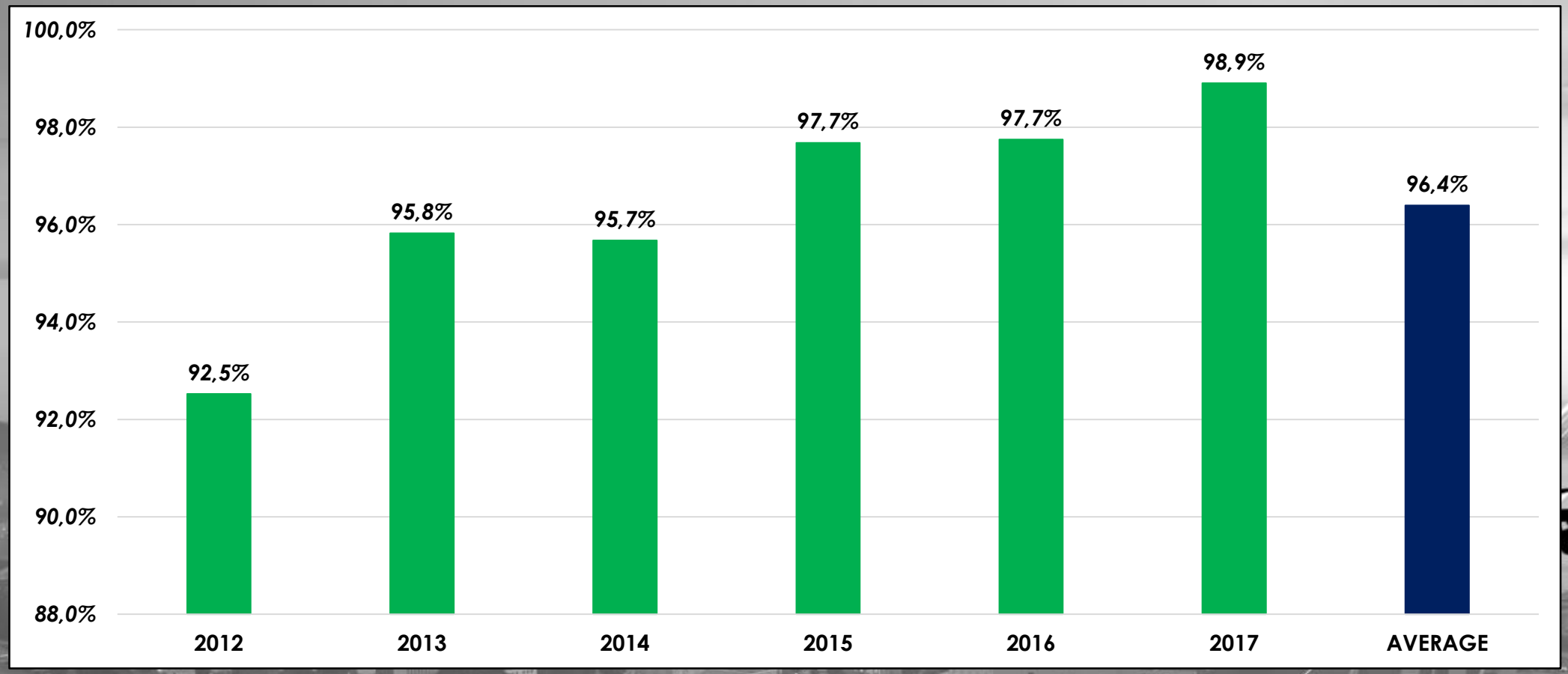
VALUES OF EFFICIENCY IN PRIVATIZED AIRPORTS, 2012-2017 PERIOD. ONLY 4 OUTPUTS WERE CONSIDERED IN THIS MEASUREMENT ("INCOME" VARIABLES WERE NOT INCLUDED)



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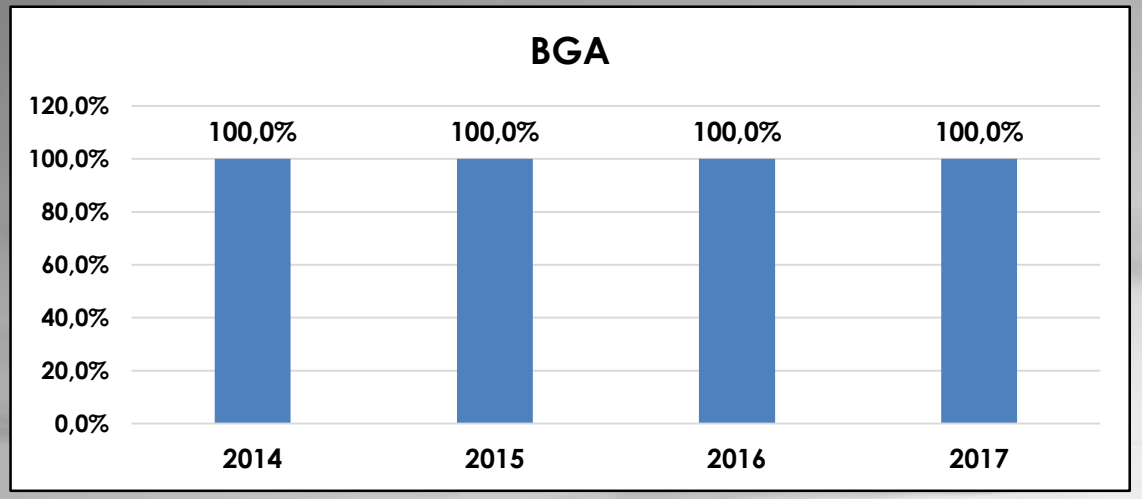
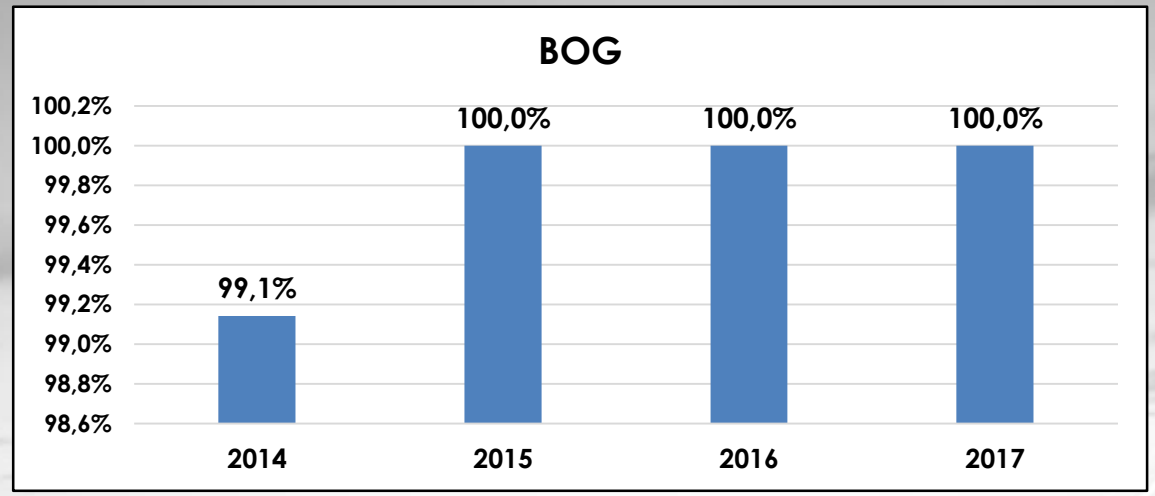
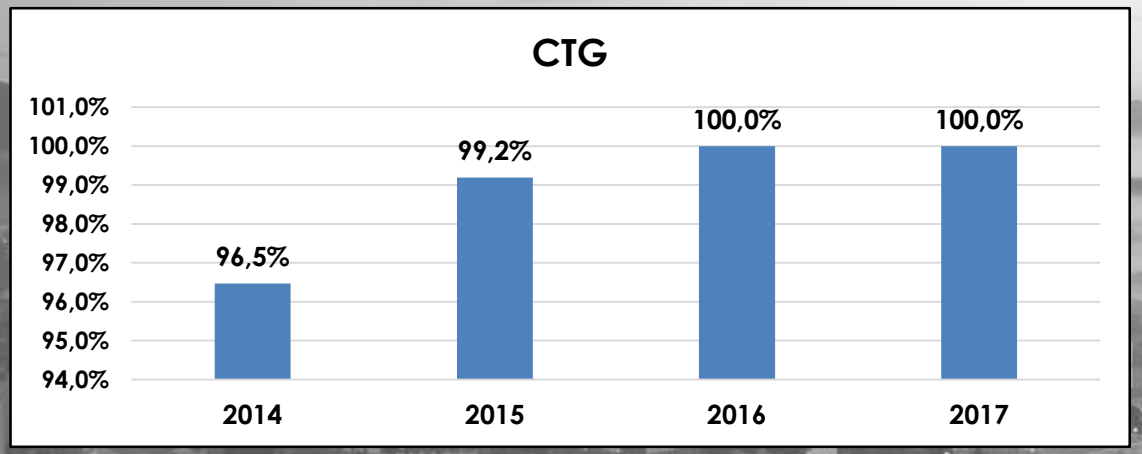
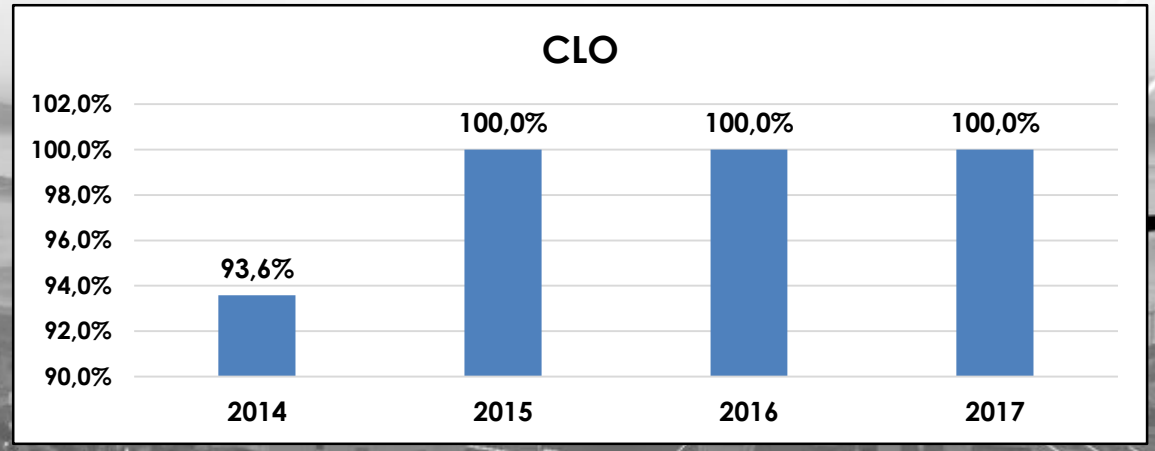
MEASUREMENT OF EFFICIENCY IN PRIVATIZED AIRPORTS, 2014-2017 PERIOD.









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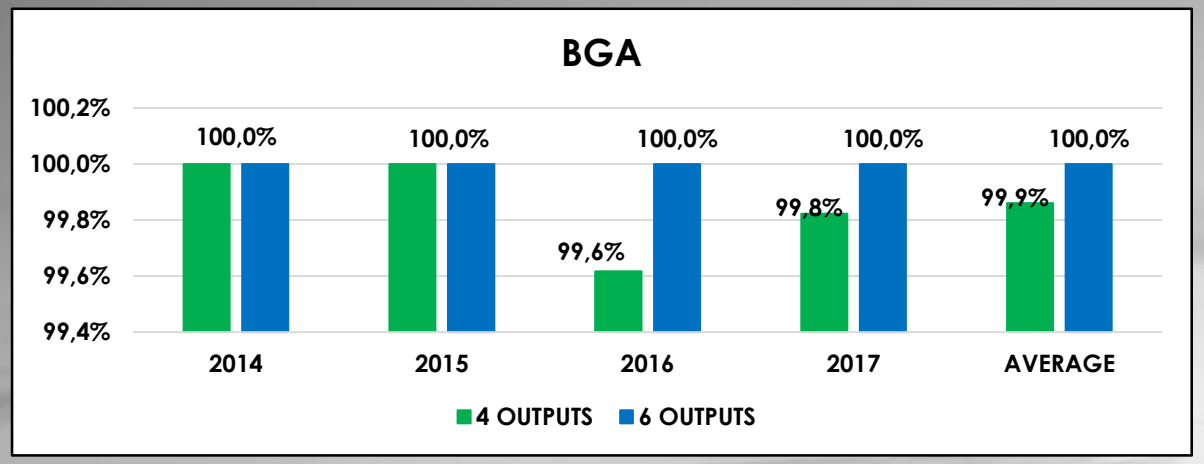
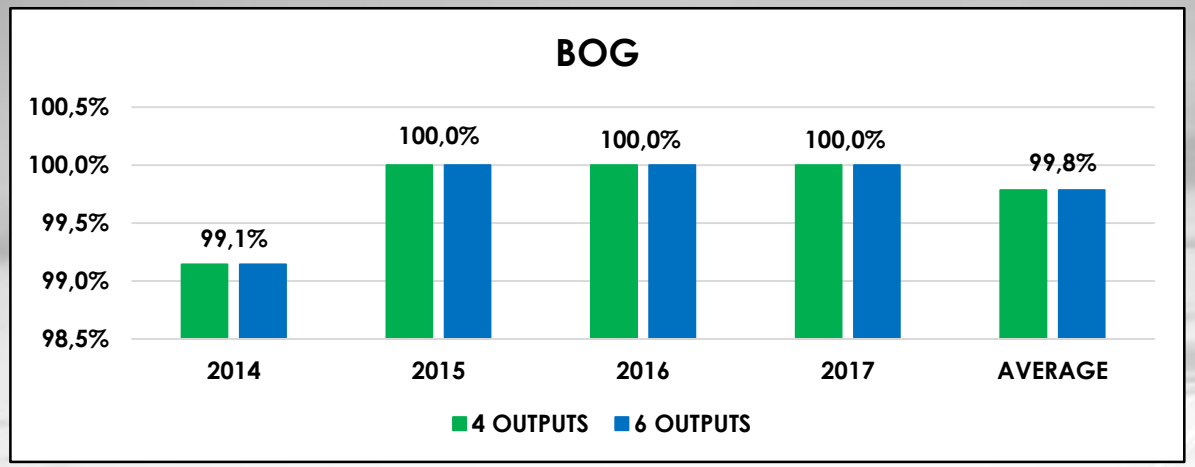
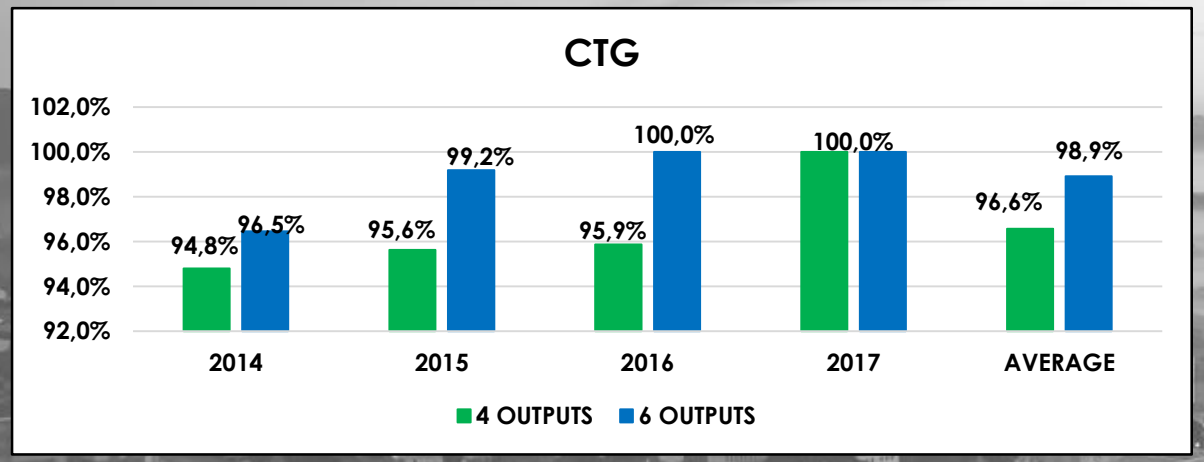
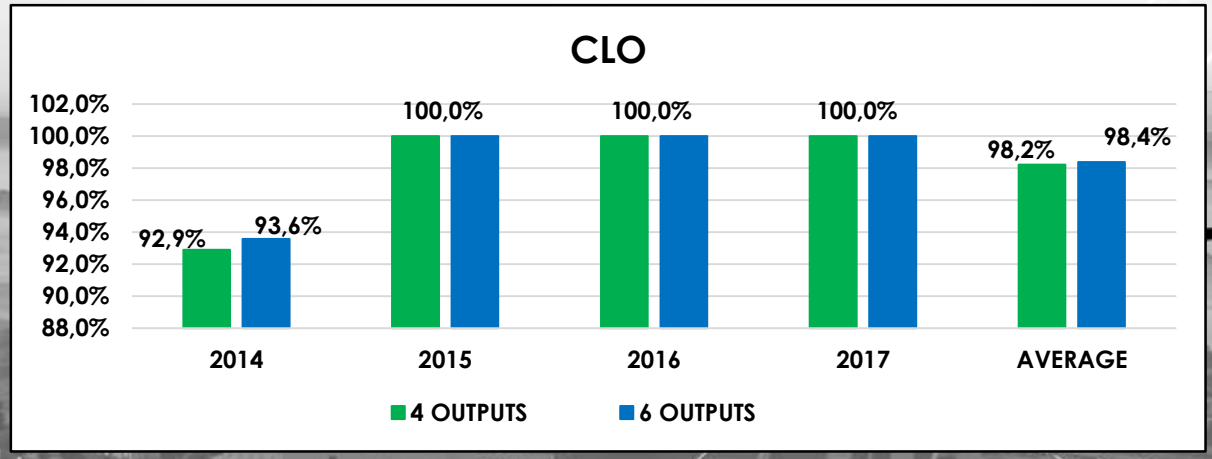
COMPARISON OF EFFICIENCY IN THE MEASUREMENT WITH AND WITHOUT "INCOME" VARIABLES, 2014-2017 PERIOD









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Results

The results presented here lead to the following statements:

- The level (or index) of efficiency is independent of the size of the airport (measured as the volume of annual traffic managed). And even more relevant, **the efficiency index is also totally independent of the geographical location** of the airport (capital-city, interior or remote), of the economic status of the region (rich or poor), of the productive characteristic of the city / region (tourist, industrial, government, etc.) and the demography (population) of the city / region served by the airport

- **Efficiency levels have increased** during the analysis period, this indicates a solid consolidation of private management, or governance, of the airports.

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Results

- In those airports in whose analysis or measurement the variables " revenues " (aeronautical and non-aeronautical) have been considered, the efficiency index shown is the maximum (100%).

- Compared to the results in other similar studies, for the same airports and in similar time periods, the use of a greater number of variables (both inputs and outputs) in measurement increases the efficiency rates.

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Conclusions

- The analysis models presented in this work include one model with 9 a inputs and 4 outputs for 17 DMU (airports) in the 2012-2017 period and another model with 9 inputs and 6 outputs for 4 DMU in the 2014-2017 period. In comparison with similar research, it could be said that this research is the one that has **used most variables (inputs+outputs)** for measuring efficiency.
- When the results obtained in this research are compared with those of a previous study, where the same airports during the same period of time were analyzed but half of the variables were included, the estimation of average efficiency (for the same set of airports under study) obtained in this research shows an important (positive) difference, 96,4% as compared to 71% in the previous research. This result aims at the conclusion that increase in **the number of input and output variables has an impact**, at least in the sample analyzed, on the significant increase in the average global efficiency, **which does not necessarily imply that the efficiency measurement is more accurate**.

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Conclusions

- On the other hand, **when efficiency is estimated considering the variable "income"** and it is compared with the estimation that does not include it (analysis limited to only 4 airports), **the results show a very small difference**, which tends to increase if this variable is actually included. It should be pointed out that efficiency values in privatized airports have increased during the analyzed period under private governance and in a fully liberalized aviation market environment.

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