An ARIMA-GARCH-Bootstrap based method applied for forecasting the air passenger demand

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In the case of the airline industry, demand is the number of passengers that are willing to fly between two different airports, cities and regions.

Forecasting air pax demand is important for

1. business opportunities
2. increase of airport infrastructure and the enhancement of new markets
3. open new routes
4. maximize investments

A good forecast guarantees the economic viability of the air transportation business because it reduces risks for lack of potential market.

Airlines have to forecast pax demand to understand the evolution of the air transportation industry and then know the number of seats they need to supply in each route at certain period of time.

It is therefore necessary to ensure that infrastructure designers and planners take into account the forecast growth for the lifetime of an airport reaches the expectations of its original planning.
In airline industry, different forecasting methods have been applied for forecasting airlines pax flow. The forecasting methods can be divided into time series methods, causal methods and judgmental methods. All methods are suitable for different purposes.

Samagio and Wolters (2010) compare Holt-Winters, damped trend exponential smoothing and ARIMA models for estimating passenger’s volume from 2008 to 2010 at Lisbon airport. They found that damped trend model calculates the most reliable results.

Carmona-Benitez et al. (2013) developed a passenger traffic forecast based on Grey Model. They introduce a damping factor to smooth the exponential behavior of the Grey Model calculations.

On the other hand, some studies have used different distributions for forecasting pax demand: Zeni (2001) examines Normal, Gamma and Weibull distributions. Carmona-Benitez (2012) analyzed the log normal distribution for approximating the behaviour of pax demand distribution.
In this paper, the methodology were set up by analyzing The United States domestic air transport market from January 1990 to April 2014 (Bureau of Transportation Statistics (BTS)).

We are interested in analyze the behaviour of pax demand in order to decide which forecasting method should be used.
Holt-Winters Additive is an exponential smoothing method which assigns exponentially decreasing weights as the observation gets older.

The additive method is preferred when the seasonal variations are roughly constant through the series.
ARIMA models have been used for forecasting a time series which can be made to be stationary.

The ARIMA model consist of lags of the dependent variable and/or lags of the forecast errors.
Grey Model

The Grey model is a time series forecasting model with time-varying coefficients.

These coefficients are renewed as the new data become available. It means, the more recent data have more influence than old data.

One of the advantages is that it can forecast a series using only a few data.
ARIMA-GARCH-Bootstrap Model

This model is actually a combination of ARIMA and GARCH models and Bootstrap for the distribution.

We assume that the passenger demand follows the next model

\[ P_t = \mu_t + \sigma_t \varepsilon_t \]
ARIMA-GARCH-Bootstrap Model

\( \mu_t \) is modeled using ARIMA

\( \sigma_t \) is modeled using a GARCH(1,1) model and,

the distribution of \( \varepsilon_t \) is approximated using bootstrap.

The bootstrap procedure implemented was proposed by Pascual et al. (2006).
### Diebold-Mariano Test

<table>
<thead>
<tr>
<th>Model</th>
<th>Grey</th>
<th>ARIMA</th>
<th>Holt – Winters</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARIMA – GARCH – Bootstrap</td>
<td>0.0164</td>
<td>0.0070</td>
<td>0.0294</td>
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<tr>
<td>Grey</td>
<td></td>
<td>0.9835</td>
<td>0.9835</td>
</tr>
<tr>
<td>ARIMA</td>
<td></td>
<td></td>
<td>0.1943</td>
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</tbody>
</table>

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### SPA Test

<table>
<thead>
<tr>
<th>Model</th>
<th>Squared Error Loss</th>
<th>SPA Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARIMA – GARCH – Bootstrap</td>
<td>4.5757E + 11</td>
<td>0.7710</td>
</tr>
<tr>
<td>Grey</td>
<td>1.4049E + 16</td>
<td>0.0000</td>
</tr>
<tr>
<td>ARIMA</td>
<td>1.3127E + 12</td>
<td>0.0000</td>
</tr>
<tr>
<td>Holt – Winters</td>
<td>1.7565E + 12</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

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Summary of Conclusions

• We analyze the characteristics of the US pax demand in order to properly forecast it.
• We implement the most commonly used or developed models for estimating and forecasting the air transportation pax demand.
• When trying to establish the superiority between two models we use Diebold and Mariano (1995) and for testing superior predictive ability of a benchmark compared to the alternatives we use the SPA test of Hansen (2005)
• We conclude with both comparing methodologies that the ARIMA-GARCH-Bootstrap model outperform its competitors.