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### **Forecast of Hotel Overnights in the Autonomous Region of the Azores**

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## RESUMO/ABSTRACT

### **Forecast of Hotel Overnights in the Autonomous Region of the Azores**

This paper concentrates on the application of various time series methods in order to forecast the monthly overnights in Azorean hotels. The aim is to find out the degree to which the forecast of overnights segmented by country of origin, presents smaller errors when compared with the forecast of the total overnights in the Region. The appropriate forecasting method by a tourist's country of origin, is also analyzed so that potential optimal combinations of separate forecasts can be found in order to forecast the total overnights in Azores.

JEL classification: C53, C22.

**Keywords:** Tourism Forecasting, Time Series, Accuracy Comparisons.

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## Forecast of Hotel Overnights in the Autonomous Region of the Azores

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## 1. Introduction

In the last 11 years the number of overnights in the Portuguese Autonomous Region of the Azores has increased five times. The impact of this increase in employment, in the balance of payments and in the economy in general has been very significant. Tourism planning is essential since the tourism industry has contributed to a significant share of the gross national product (8%).

Forecasting assumes a fundamental role in tourism planning, according to Archer (1987): *“Forecasting should be an essential element in the process of management. No manager can avoid the need for some form of forecasting: a manager must plan for the future in order to minimize the risk of failure or, more optimistically, to maximize the possibilities of success.”*

Taking into consideration the above, this paper concentrates on the application of various time series methods in order to forecast the monthly overnights in hotels located in the same region between January 2002 and December 2004. Forecasts are based on monthly data covering the January 1993 to December 2001.

The objective is to find out the degree to which the forecast of overnights segmented by country of origin, presents smaller errors when compared with the forecast of the total overnights in the Region. The appropriate forecasting method by a tourist's country of origin, is also analyzed so that potential optimal combinations of separate forecasts can be found in order to forecast the total overnights in Azores.

This paper is divided in six sections. After the introduction there is a brief review of the literature regarding tourism demand forecasts. The third and fourth sections define the methodology applied and describe the data used, respectively. The results are presented and analyzed in the fifth section. In the last section, the most important conclusions as well as future research recommendations are presented.

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## 2. Brief Literature Review

According to Chu (1998a) there are various forecasting techniques available that can be chosen based on the following criteria: the precision of the forecast results, whether the technique is easy to use or not, the cost involved it and whether the forecasting results can be rapidly obtained. As can be seen by the following quote, precision is the most important forecasting characteristic: *“The accuracy of the forecasts will affect the quality of the management decision... In the tourism industry, in common with the most other service sectors, the need to forecast accurately is especially acute because of the perishable nature of the product. Unfilled airline seats and unused hotel rooms cannot be stockpiled”* (Archer, 1987).

Makridakis *et al.* (1998) divide forecasting methods into the following two categories: quantitative and qualitative methods (according to Witt and Witt (1995) the number of qualitative forecasts for the tourism industry is very limited). Quantitative methods are more precise than qualitative methods (Makridakis and Hibon, 1979). Quantitative techniques can be divided into causal models and time series models. While causal models use functional relations between variables, time series modeling uses past information about the variable in order to estimate its future values. According to the literature, when the objective is to perform short term forecasts, methods based on time series should be used. On the other hand, when the objective is to forecast, as well as explore the impact of independent variables on the forecasted variable, causal methods should be used (Chu, 1988a).

In the literature survey, the naïve prediction models tend to produce more robust results in comparison to the more sophisticated models (Martin and Witt, 1989; Sheldon, 1993; and Song and Witt, 2000). According to Kulendran and King (1977) and Kulendran and Witt (2001), even the prediction models that incorporate the most recent techniques developed in econometric models still present less robust results than the naive methods.

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Recently, Song, Witt and Jensen (2003) have analysed the precision of 6 alternative econometric models in tourism prediction. Their conclusions reveal that the results are only slightly more precise in the short-run predictions of sophisticated models than those of simpler time series univariate models.

According to a literature review conducted by Sheldon and Var (1985) covering tourism demand forecasting, the most used forecasting method was time series. According to Witt and Witt (1995) time series models for tourism forecasting are applied when the goal is to compare the forecasting results from the different methods. According to these authors, most studies calculate the degree of accuracy using the same sample that was used as a basis for the estimations.

In a study by Chu (1998b) using six techniques (time series approaches: *Naïve I*, *Naïve II*, *Linear Trend*, *Sine Wave*, *Holt-Winters* and *ARIMA*) in order to forecast tourism demand in ten countries (Japan, Taiwan, South Korea, Hong-Kong, Philippines, Indonesia, Singapore, Thailand, Australia and New Zealand), the *ARIMA* method was the most accurate for nine of the ten countries in the study, using *MAPE (Mean Absolute Percentage Error)* as the criteria for accuracy.

As far as the causal methods are concerned and the models' complexity has increased with time (Witt and Witt, 1995). The same authors also say that even though the results obtained with this methodology are considered satisfactory, their quality is doubtful given that most studies do not test model specification. Within tourism demand causal forecasting methods, we emphasize the Gravitational and Neural Networks models. As Sheldon and Var (1985) state, gravitational models are based on gravitational law principles, where the degree of interaction between two geographical areas varies directly with the concentration of people and inversely with distance. These models have been successfully applied in order to forecast the international tourism flows. There are few studies about neural networks. Their objective is to reduce the shortcoming of time series models given that these cannot anticipate variations that not based on past data. On the other hand, time series models do

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not have the limitations of traditional causal models such as multicollinearity between independent variables (Law, 2000)

### 3. Methodology

Given this study's objective, various time series techniques were used in order to forecast the number of overnights in the Azores, namely: *Naïve I* (NI), *Naïve II* (NII), Classic Decomposition (CD), Exponential Smoothing of *Holt-Winters* with seasonality (HW) and SARIMA.

The forecasts based on *naïve* techniques are obtained through the following formulas:

$$\hat{F}_{t+1}^{NI} = Y_t \quad \text{and} \quad \hat{F}_{t+1}^{NII} = Y_t \left[ 1 + \frac{Y_t - Y_{t-1}}{Y_{t-1}} \right], \text{ where: } \hat{F}_{t+1}^{NI} \text{ is the forecast for period } t+1 \text{ using}$$

*Naïve I* technique;  $\hat{F}_{t+1}^{NII}$  is the forecast for period  $t+1$ , using *Naïve II* technique and;  $Y_t$  is the observation of period  $t$ .

These two techniques are frequently mentioned in the tourism industry forecasts as stated by Witt and Witt (1995) and Chu (1998b), amongst others. These techniques are mostly used when the objective is to compare their performance with more sophisticated forecasting techniques. In the *Naïve* methods, the forecast of the next period is made based on the real observations of the previous period.

In the classic decomposition technique,  $Y_t = S_t + T_t + E_t$ , the data used was logarithmic<sup>2</sup>. The trend variable ( $T_t$ ) was calculation using centered moving average with order 12, based on 13 observations. The first and thirteenth observations were given half the weight of the remaining observations. Seasonality ( $S_t$ ) corresponds to the difference between observed overnights ( $Y_t$ ) and the trend ( $T_t$ ) each month. The error component ( $E_t$ ) is the difference between  $Y_t$  and the sum of  $\hat{T}_t$  and  $\hat{S}_t$ .

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<sup>2</sup> In order to make the variance of the series stationary.

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The exponential smoothing *Holt-Winters* technique with seasonality was applied using software *ITSM: Forecast 6.0 (PEST)*. In order to make the series' variance stationary we used the *Box-Cox*<sup>3</sup> transformation with *lambda* equal to zero.

The SARIMA models for each case were initially identified through correlation chart analysis of the series (ACF – *Autocorrelation Function* and PACF – *Partial Autocorrelation Function*). After identifying the potential models, the model was selected through *AICc* – *Akaike's Information Criterion corrected*, due to the significance of the estimated coefficients (test *t*)<sup>4</sup> and to the fact that it's a white noise model (visualizing ACF and PACF of the residuals and Ljung-Box *Q*<sup>5</sup> statistic). The SARIMA model estimation was done through the Maximum likelihood method using *ITSM software: Forecast 6.0 (PEST)*. Before estimating the coefficients we formed a *Box-Cox* transformation with *lambda* equal zero – as not to eliminate the static of the series' variance – and we calculated the first difference<sup>6</sup> and the seasonal difference<sup>7</sup>. We saw a significant correlation between the observations lagged by one interval multiple of twelve – in order to make the process static in average.

The five techniques were applied to the total overnights and to overnights grouped by country of origin. In the last case, and for each method, we forecasted overnights by the tourist's country of origin; afterwards these were all added up in order to evaluate the accuracy of the total overnights forecast method.

The quality of forecasting methods accuracy was evaluated using MSE and MAPE. Given that various scales influence the MSE indicator, and as mentioned by Makidrakis *et al.* (1999), more emphasis is placed on the average absolute error percentage assuming no contradicting evidence.

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<sup>3</sup> *Box-Cox* transformation: 
$$X_t = \begin{cases} \frac{Y_t^\lambda - 1}{\lambda}, \lambda \neq 0 \\ \ln(Y_t), \lambda = 0 \end{cases}$$

<sup>4</sup>  $H_0$ : Coefficient = 0 e  $H_1$ : Coefficient  $\neq 0$ .

<sup>5</sup>  $H_0$ :  $\rho_1 = \rho_2 = \dots = \rho_n = 0$  e  $H_1$ : There is at least one  $\rho_i \neq 0$ .

<sup>6</sup>  $\nabla X_t = X_t - X_{t-1} = (1 - B)X_t$

<sup>7</sup>  $\nabla_{12} X_t = X_t - X_{t-12} = (1 - B^{12})X_t$

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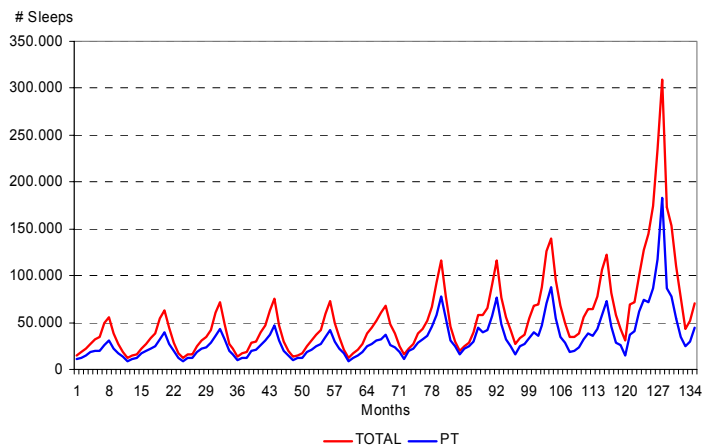
#### 4. Description of Data

This paper uses monthly data of the overnights in the Azores taking into account the tourist's country of origin. The total number of overnights in the Azores was subdivided by seven countries of origin: Portugal (PT); Germany (G); Spain (SP); United States of America (USA); France (FR); United Kingdom (UK); Northern European Countries (NC) and; Other Countries (OC) - figure 1 and 2.

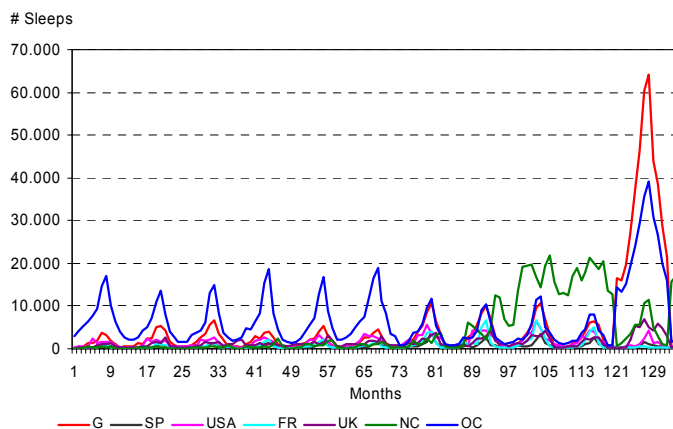
The Northern European Countries include Denmark, Finland, Norway and Sweden. Other Countries include countries that do not represent a significant share of total overnights in the Azores.

The total sample is composed of 139 monthly observations, between January 1993 and March 2004, published by the Regional Office of Azorean Statistics (ROAS).

**Chart 1 – Overnights in the Azores between January 1993 and March 2004 - Total overnights of Portuguese tourists**



**Chart 2 – Overnights in the Azores between January 1993 and March 2004 – Overnights by tourist's country of origin**



According to ROAS, of the total overnights sample, 60,87% are tourists from Portugal's mainland, 9,92% are German tourists, 8,17% are North European tourists, 2,89%, 2,61%, 1,50% and 1,12% are American, English, French and Spanish tourists, respectively. The remaining tourists (12,93%) come from other countries.

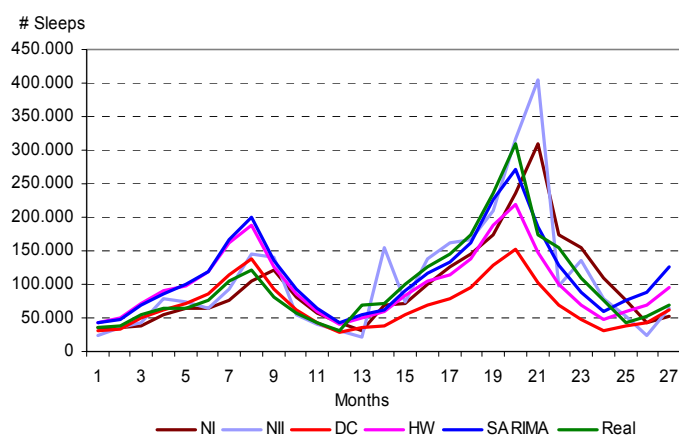
The total data as well as the segmented data sample reveal a strong seasonal pattern but do not present seasonal characteristics as far as the average and the variance are concerned.

Given that one of the objectives it to test the accuracy quality of each technique, the sample was subdivided into two parts: January 1993 to December 2001; and January 2002 to March 2004. The error measurement of the various methods was based on the forecast interval between January 2002 and March 2004. The period of January 1993 to December 2001 was the base period used for the estimation of the forecast models.

## 5. Results and Analysis

The following charts show the comparison between the monthly overnights forecasts in the Azores based on five different methods and the actual overnights between January 2002 and March 2004. Chart 3 uses the total data sample and chart 4 uses a segmented data sample.

**Chart 3 – Actual and forecasted monthly overnights in the Azores of total data between January 2002 and March 2004**



**Chart 4 – Actual and forecasted monthly overnights in the Azores of subdivided data between January 2002 and March 2004**

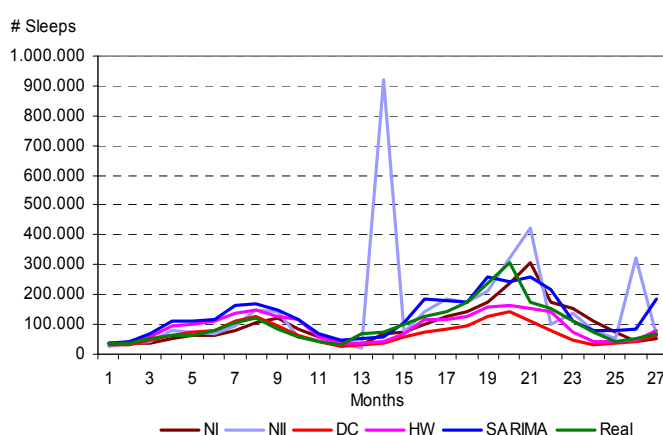


Table 1 presents the *ex-post* forecast errors in both cases, namely: the total overnights in the Azores based on the total data sample (chart 3); and overnights (chart 4) segmented by tourist's country of origin. In this table, the total overnights forecast based on the segmented data set applies the same method for all eight countries of origin separately.

According to the MAPE error measurement criteria it can be seen that, except with the *Naïve* and SARIMA methods, the forecast of total overnights in the Azores using the data segmented by country of origin is more precise than the forecast using the total data. We can

also see that among all methods used, the Classic Decomposition is the one that seems most accurate for both the total and the segmented data sample.

**Table 1 – Measurement of total overnights error in the Azores considering ex-post forecasts with total data and segmented data, between January 2002 and March 2004.**

| Error measure<br>Technique                  | MSE           |                | MAPE      |              |
|---|---------------|----------------|-----------|--------------|
|   | Aggregate     | Disaggregate   | Aggregate | Disaggregate |
| <i>Naïve I</i>                              | 1.509.395.151 | 1.509.395.151  | 28,16%    | 28,16%       |
| <i>Naïve II</i>                             | 2.757.875.523 | 32.211.003.132 | 28,4%     | 85,85%       |
| <i>Holt-Winters</i>                         | 1.322.705.238 | 1.746.299.908  | 33,7%     | 29,53%       |
| <b>Classic Decomposition</b>                | 2.722.541.255 | 2.666.284.504  | 27,4%     | 26,48%       |
| <b>SARIMA* (1,1,1) (0,1,1)<sub>12</sub></b> | 1.024.544.190 | 2.118.816.522  | 34,3%     | 44,38%       |

\* The ARIMA parameters are applied only to aggregate estimates

If we analyze the data using the MSE criteria we reach a different conclusion. In this case we can see that the SARIMA method is the one that presents the most accurate results for the total data sample. For the segmented data sample, the Naïve I method is the best. As opposed to other methods, only the Classic Decomposition method presents the biggest accuracy when applied to the segmented data sample.

In short, out of all methods considered, the one with the lowest MSE is the SARIMA method, when using the total data sample. In the case of the segmented data sample the lowest MAPE is obtained using the Classic Decomposition method.

The most significant SARIMA model estimate results in each case (table 1 and 2) are included in the appendix.

According to table 2 and considering the MSE criteria, the *Naïve I* method gives the best ex-post forecasts for all countries with the exception of Portugal where the best model is SARIMA. Note that this exception is important in the total overnights forecast for the Azores since Portuguese tourists from Portugal's mainland represent over 60% of total overnights.

**Table 2 – Error measurement of the forecast of overnights by country of origin in the Azores between January 2002 and March 2004.**

| Origin Country \ Technique     | Naïve I     | Naïve II       | Classic Decomposition | Holt - Winters | SARIMA                        |               |
|--------------------------------|-------------|----------------|-----------------------|----------------|-------------------------------|---------------|
|                                |             |                |                       |                | Model                         | Error         |
| <b>MSE</b>                     |             |                |                       |                |                               |               |
| Portugal (PT)                  | 709.558.350 | 1.843.351.419  | 595.798.787           | 727.446.122    | (0,1,2) (0,1,1) <sub>12</sub> | 396.815.102   |
| Germany (G)                    | 66.310.863  | 12.852.062.743 | 595.798.787           | 444.405.707    | (0,1,1) (0,1,1) <sub>12</sub> | 547.057.629   |
| Spain (SP)                     | 286.321     | 1.397.397      | 345.304               | 563.673        | (4,1,0) (0,1,1) <sub>12</sub> | 1.226.272     |
| United States of America (USA) | 926.902     | 2.471.339      | 3.412.727             | 3.177.182      | (0,1,1) (1,1,0) <sub>12</sub> | 4.102.824     |
| France (FR)                    | 770.461     | 1.423.731      | 3.649.512             | 4.090.225      | (3,1,1) (0,1,1) <sub>12</sub> | 3.410.122     |
| United Kingdom (UK)            | 1.515.076   | 25.851.991     | 2.970.991             | 3.278.553      | (0,1,1) (1,1,0) <sub>12</sub> | 7.469.403     |
| Nordic Countries (NC)          | 21.007.923  | 3.042.615.732  | 98.171.021            | 1.125.542.987  | (0,1,2) (1,1,1) <sub>12</sub> | 4.727.153.590 |
| Other Countries (OC)           | 25.997.577  | 1.716.913.976  | 196.316.099           | 233.070.255    | (3,1,0) (0,1,1) <sub>12</sub> | 142.632.736   |
| <b>MAPE</b>                    |             |                |                       |                |                               |               |
| Portugal (PT)                  | 31,89%      | 38,97%         | 25,54%                | 28,22%         | (0,1,2) (0,1,1) <sub>12</sub> | 28,62%        |
| Germany (G)                    | 351,48%     | 410,17%        | 73,36%                | 99,97%         | (0,1,1) (0,1,1) <sub>12</sub> | 62,09%        |
| Spain (SP)                     | 49,01%      | 82,59%         | 73,91%                | 92,29%         | (4,1,0) (0,1,1) <sub>12</sub> | 139,23%       |
| United States of America (USA) | 54,94%      | 63,06%         | 139,14%               | 127,85%        | (0,1,1) (1,1,0) <sub>12</sub> | 128,86%       |
| France (FR)                    | 56,10%      | 73,03%         | 342,76%               | 331,69%        | (3,1,1) (0,1,1) <sub>12</sub> | 308,43%       |
| United Kingdom (UK)            | 104,48%     | 123,24%        | 248,17%               | 140,29%        | (0,1,1) (1,1,0) <sub>12</sub> | 62,43%        |
| Nordic Countries (NC)          | 110,56%     | 171,11%        | 172,36%               | 680,77%        | (0,1,2) (1,1,1) <sub>12</sub> | 1410,89%      |
| Other Countries (OC)           | 66,54%      | 122,55%        | 53,05%                | 57,74%         | (3,1,0) (0,1,1) <sub>12</sub> | 59,90%        |

Under MAPE criteria, the Classic Decomposition method is the best method to the forecast Portuguese tourists overnights as well as to forecast overnights of tourists from other countries. The SARIMA model is the most appropriate to forecast overnights for tourists coming from Germany and United Kingdom. In all other cases, the best method was the *Naïve I* which seems to be the most accurate.

**Table 3 – Error measures for total overnights forecast for the Azores between January 2002 and March 2004, considering the best method for each country of origin<sup>8</sup>.**

| Origin Country \ Selection Criteria | MSE         |                 |        | MAPE          |                 |        |
|-------------------------------------|-------------|-----------------|--------|---------------|-----------------|--------|
|                                     | Naïve I     | Classic Decomp. | SARIMA | Naïve I       | Classic Decomp. | SARIMA |
| Portugal (PT)                       |             |                 | X      |               | X               |        |
| Germany (G)                         | X           |                 |        |               |                 | X      |
| Spain (SP)                          | X           |                 |        | X             |                 |        |
| United States of America (USA)      | X           |                 |        | X             |                 |        |
| France (FR)                         | X           |                 |        | X             |                 |        |
| United Kingdom (UK)                 | X           |                 |        |               |                 | X      |
| Nordic Countries (NC)               | X           |                 |        | X             |                 |        |
| Other Countries (OC)                | X           |                 |        |               | X               |        |
| <b>MAPE of Total Overnights</b>     | 715.234.677 |                 |        | 3.949.211.377 |                 |        |
| <b>MAPE of Total Overnights</b>     | 20,80%      |                 |        | 32,53%        |                 |        |

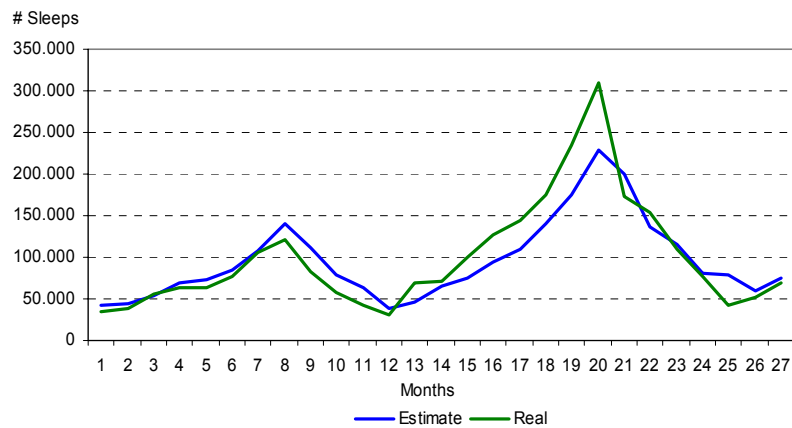
<sup>8</sup> The forecast of total overnights based on the segmented data sample derived from the sum of the forecast from the most accurate method for each one of the tourists' eight countries of origin.

Based on the previous table and trying to achieve the most accurate forecast of total overnights by country of origin, we have selected the forecasts of the most accurate method for each country of origin, taking into account the MSE and MAPE error measures.

The results presented in table 3 indicate that when the selection criteria of the forecast methods by country of origin is the MSE criteria, there are significant improvements in the total overnights forecast for the Azores using the segmented data sample (these forecasts show better error measures compared to all other methods used). On the other hand, when the selection criteria is the MAPE criteria, the accuracy measure in the forecast of total overnights based on the segmented data sample, is not superior to that of all other methods used.

The forecasts, as presented on table 2 (using the selection criteria MSE), and the actual values are compared in chart 5.

**Chart 5 – Forecasted and actual monthly overnights in the Azores based on the subdivided data sample for tourist’s country of origin, using the best method, between January 2002 to March 2004.**



In the case of *ex-ante* forecasts it is worthwhile noticing that the *Naïve I* method produces a flat forecast. Therefore its use could potentially give a worst accuracy estimate for this particular time series, when the *ex-ante* temporal forecast horizon is greater than one period. Similarly, the *Naïve II* method considers a set growth rate for *ex-ante* forecasts that cover more than one period. We conclude that this method may also be inadequate for heavily seasonal series. Therefore, if the goal is to conduct an *ex-ante* forecast covering more than

one period based on the segmented set (table 2), then we should take into consideration that the lowest MSE is reached by using the following methods: Classic Decomposition for overnights forecast of Spanish, English and Scandinavian tourists; *Holt-Winters* for overnights forecast of German and American tourists; SARIMA for overnights forecast of Portuguese and French tourists, as well as of tourists from Other Countries.

For the purpose of ex-ante forecasts coverage more than one period, the total overnight forecasts for segmented data set should be used according to the combination of the best method (selected by MSE), for each country of origin (not including the *Naïve* methods) given that the error measurement is more accurate using MAPE. This can be verified by table 1 and 4,

By looking at tables 3 and 4 we can see that the MSE and MAPE accuracy measure in forecasting the total overnights, considering the best method by tourist's country of origin, is consistent, contrary to other previous cases.

**Table 4 – Error measurement of total overnight forecast in the Azores between January 2002 and March 2002, considering the best method (excluding the *Naïve* methods) for each country of origin**

| Selection Criteria<br>Origin Country | MSE                |                   |        | MAPE               |                   |        |
|--------------------------------------|--------------------|-------------------|--------|--------------------|-------------------|--------|
|                                      | Classic<br>Decomp. | Holt -<br>Winters | SARIMA | Classic<br>Decomp. | Holt -<br>Winters | SARIMA |
| Portugal (PT)                        |                    |                   | X      | X                  |                   |        |
| Germany (G)                          |                    | X                 |        |                    |                   | X      |
| Spain (SP)                           | X                  |                   |        | X                  |                   |        |
| United States of America (USA)       |                    | X                 |        |                    | X                 |        |
| France (FR)                          |                    |                   | X      |                    |                   | X      |
| United Kingdom (UK)                  | X                  |                   |        |                    |                   | X      |
| Nordic Countries (NC)                | X                  |                   |        | X                  |                   |        |
| Other Countries (OC)                 |                    |                   | X      | X                  |                   |        |
| <b>MSE of Total Overnights</b>       | 1.793.824.437      |                   |        | 2.936.023.315      |                   |        |
| <b>MAPE of Total Overnights</b>      | 23,97%             |                   |        | 28,19%             |                   |        |

The high values for the different error measurements are probably due to the fact that between January 2002 and March 2004, the overnight pattern is atypical when compared to the standard overnights registered until December 2001 (there was a steady growth along

the years). In 2002 there was a slight decrease as compared to 2001, while in 2003 there was a strong growth (more than 100% as compared to 2001).

## 6. Conclusions

The results obtained with our data set for the Azores do not totally support the SARIMA models superiority in tourism forecasting.

This paper also shows that there is not always a consistency between the error measurement given by the MSE and the MAPE criteria's. This may be due to the existence of very different scales to measure the number of overnights in each tourist's country of origin.

The MSE accuracy measure is the best criteria to select the most accurate method by tourist's country of origin when the objective is to forecast the *ex-post* and *ex-ante* total overnights based on the segmented data sample. The forecast made by selecting the best method by country of origin, was the one that achieved the best results under all forecasting methods, whether using the total data sample, or the segmented data sample

In order to forecast the total overnights in the Azores for the following period based on the segmented data sample, the most accurate method is the SARIMA method for the overnights of Portuguese tourists and applying the *Naïve I* method for each one of the remaining countries of origin.

When the goal is to forecast the total overnights in the Azores, for a temporal horizon over one period seems to better to use the subdivided data and apply the following method: Classic Decomposition for overnights forecast of tourists from Spain, United Kingdom and Nordic Countries; *Holt-Winters* for overnights forecast of tourists from Germany and United States of America; SARIMA for overnights forecast of tourists from Portugal, France and Other Countries.

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Future research on this subject is concerned; it would be helpful to test ex-ante forecast accuracy based on causal models, particularly the gravitational model and the neural network model. The use of more sophisticated prediction models, like the ones used by Smeral and Witt (1996), Smeral (2004), and Witt, Song and Wanhill (2004), may reinforce the estimates precision due to the use of disaggregated data by country foreign.

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## 8. Appendices

The following data was obtained from ITSM – PEST, through the maximum likelihood method.

### Total Data Sample (Total)

Model: SARIMA (1,1,1)(0,1,1)<sub>12</sub>

### Estimated Model:

$$X(t) = .4543 X(t-1) + Z(t) - .8661 Z(t-1) + .000 Z(t-2) + .000 Z(t-3) + .000 Z(t-4) + .000 Z(t-5) + .000 Z(t-6) + .000 Z(t-7) + .000 Z(t-8) + .000 Z(t-9) + .000 Z(t-10) + .000 Z(t-11) - 1.000 Z(t-12) + .8662 Z(t-13)$$

### Standard deviation of the AR Coefficients:

.161089

### Standard deviation of the MA Coefficients:

|         |         |         |         |
|---------|---------|---------|---------|
| .111582 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .211135 |
| .000000 |         |         |         |

### Quality adjustment measures:

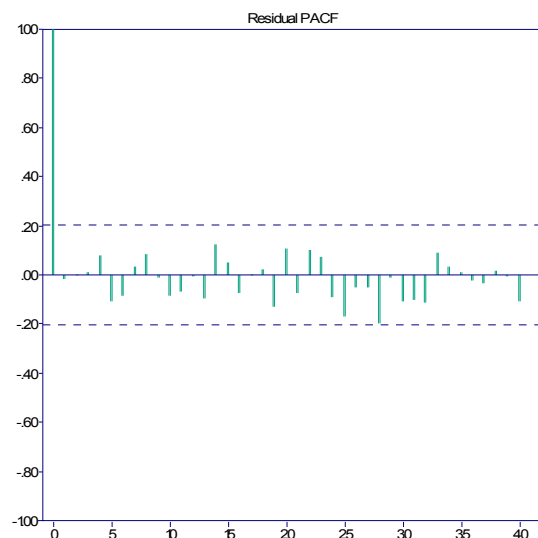
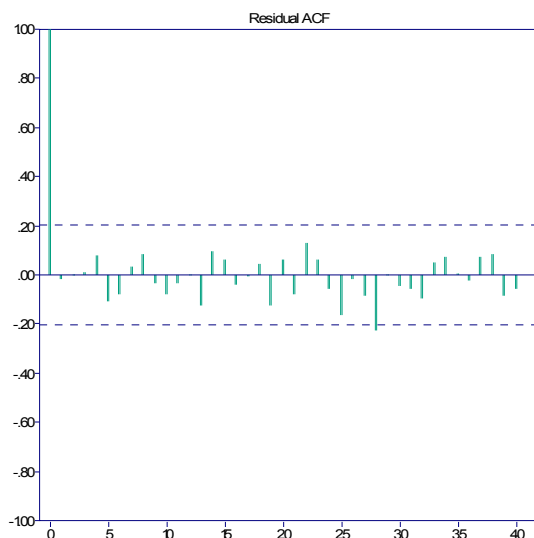
AICC = -199.484288

BIC = -220.829772

-2Log(Likelihood) = -207.928732

### White noise test:

Ljung - Box statistic = 23.350 Chi-Square ( 20 )



## Portugal (PT)

Model: SARIMA (0,1,2)(0,1,1)<sub>12</sub>

Estimated Model:

$$X(t) = Z(t) - .3366 Z(t-1) - .2182 Z(t-2) + .000 Z(t-3) + .000 Z(t-4) + .000 Z(t-5) + .000 Z(t-6) + .000 Z(t-7) + .000 Z(t-8) + .000 Z(t-9) + .000 Z(t-10) + .000 Z(t-11) - 1.000 Z(t-12) + .3366 Z(t-13) + .2182 Z(t-14)$$

Standard deviation of the AR Coefficients:

Standard deviation of the MA Coefficients:

|         |         |         |         |
|---------|---------|---------|---------|
| .100766 | .102656 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .229978 |
| .000000 | .000000 |         |         |

Quality adjustment measures:

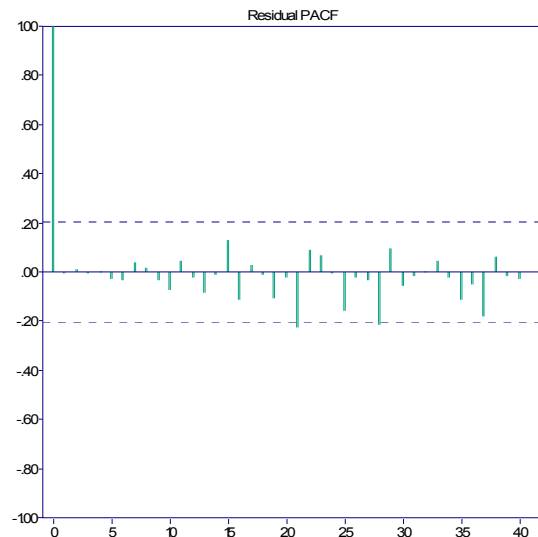
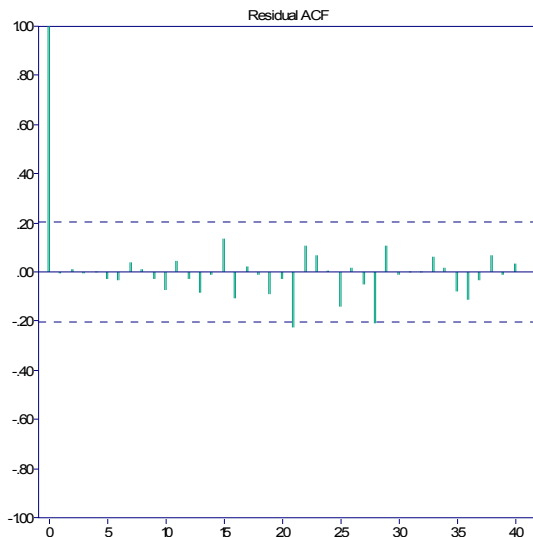
AICC = -149.488508

BIC = -173.999178

-2Log(Likelihood) = -157.932953

White noise test:

Ljung - Box statistic = 22.480 Chi-Square ( 20 )



## Germany (G)

Model: SARIMA (0,1,1) (0,1,1)<sub>12</sub>

Estimated Model:

$$X(t) = Z(t) - .5802 Z(t-1) + .000 Z(t-2) + .000 Z(t-3) + .000 Z(t-4) + .000 Z(t-5) + .000 Z(t-6) + .000 Z(t-7) + .000 Z(t-8) + .000 Z(t-9) + .000 Z(t-10) + .000 Z(t-11) - .6031 Z(t-12) + .3499 Z(t-13)$$

Standard deviation of the AR Coefficients:

Standard deviation of the MA Coefficients:

|         |         |         |         |
|---------|---------|---------|---------|
| .090294 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .153620 |
| .000000 |         |         |         |

Quality adjustment measures:

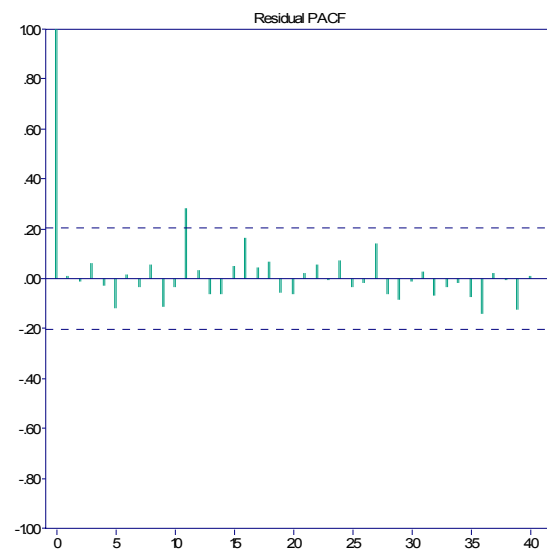
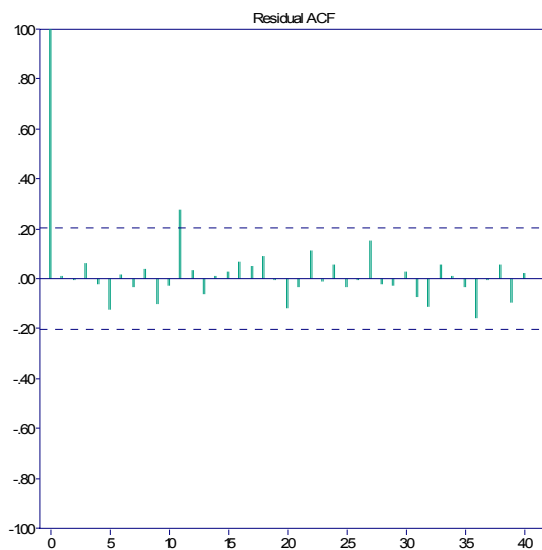
AICC = 44.061935

BIC = 39.846110

-2Log(Likelihood) = 37.798199

White noise test:

Ljung - Box statistic = 17.744 Chi-Square ( 20 )



## Spain (SP)

Model: SARIMA (4,1,0) (0,1,1)<sub>12</sub>

Estimated Model:

$$X(t) = - .7350 X(t-1) - .5172 X(t-2) - .4509 X(t-3) - .3378 X(t-4) + Z(t) + .000 Z(t-1) + .000 Z(t-2) + .000 Z(t-3) + .000 Z(t-4) + .000 Z(t-5) + .000 Z(t-6) + .000 Z(t-7) + .000 Z(t-8) + .000 Z(t-9) + .000 Z(t-10) + .000 Z(t-11) - .9921 Z(t-12)$$

Standard deviation of the AR Coefficients:

|         |         |         |         |
|---------|---------|---------|---------|
| .096565 | .113450 | .113449 | .096565 |
|---------|---------|---------|---------|

Standard deviation of the MA Coefficients:

|         |         |         |         |
|---------|---------|---------|---------|
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .012857 |

Quality adjustment measures:

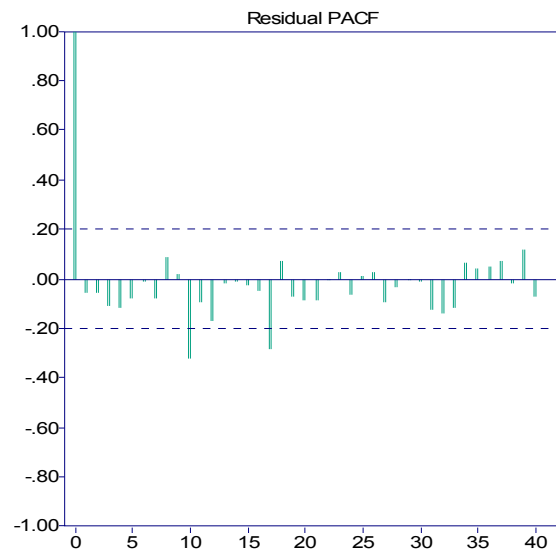
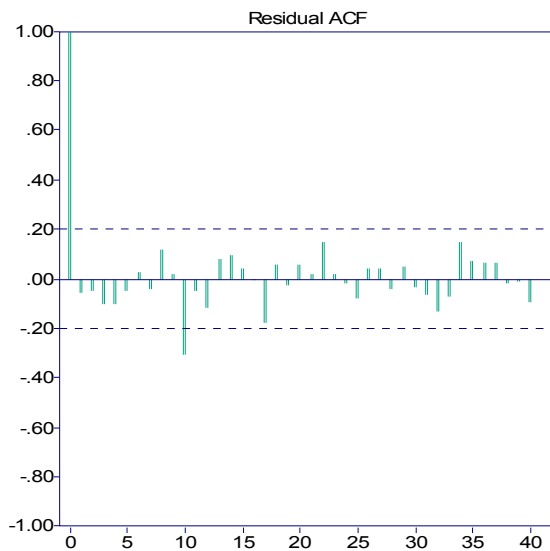
AICC = 102.986528

BIC = 88.560134

-2Log(Likelihood) = 90.031983

White noise test:

Ljung - Box statistic = 26.925 Chi-Square ( 20 )



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## United States of America (USA)

Model: SARIMA (0,1,1) (1,1,0)<sub>12</sub>

Estimated Model:

$$X(t) = .000 X(t-1) + .000 X(t-2) + .000 X(t-3) + .000 X(t-4) + .000 X(t-5) + .000 X(t-6) + .000 X(t-7) + .000 X(t-8) + .000 X(t-9) + .000 X(t-10) + .000 X(t-11) - .2331 X(t-12) + Z(t) - .7736 Z(t-1)$$

Standard deviation of the AR Coefficients:

|         |         |         |         |
|---------|---------|---------|---------|
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .112323 |

Standard deviation of the MA Coefficients:

.080587

Quality adjustment measures:

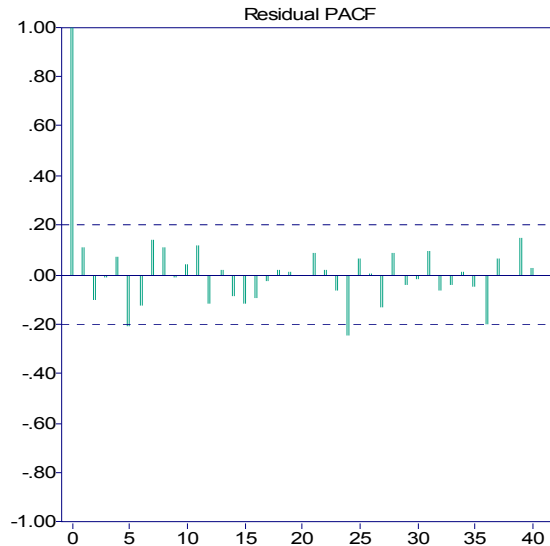
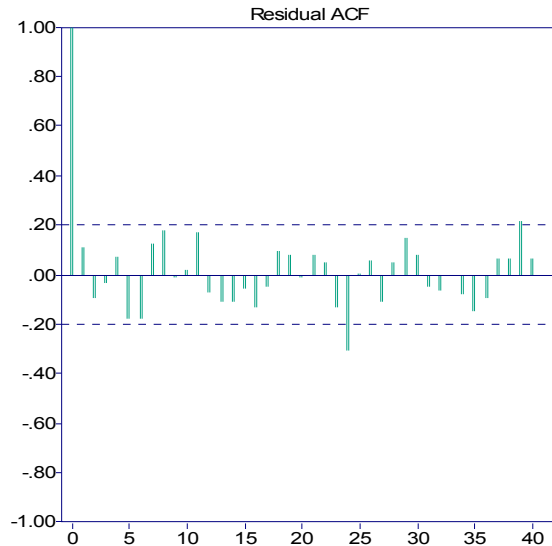
AICC = 77.374337

BIC = 77.923987

-2Log(Likelihood) = 71.110601

White noise test:

Ljung - Box statistic = 26.615 Chi-Square ( 20 )



## France (FR)

Model: SARIMA (3,1,0) (0,1,1)<sub>12</sub>

Estimated Model:

$$X(t) = - .5375 X(t-1) - .3913 X(t-2) - .2843 X(t-3) + Z(t) + .000 Z(t-1) + .000 Z(t-2) + .000 Z(t-3) + .000 Z(t-4) + .000 Z(t-5) + .000 Z(t-6) + .000 Z(t-7) + .000 Z(t-8) + .000 Z(t-9) + .000 Z(t-10) + .000 Z(t-11) - .7377 Z(t-12)$$

Standard deviation of the AR Coefficients:

.098099    .105436    .098429

Standard deviation of the MA Coefficients:

.000000    .000000    .000000    .000000  
 .000000    .000000    .000000    .000000  
 .000000    .000000    .000000    .119354

Quality adjustment measures:

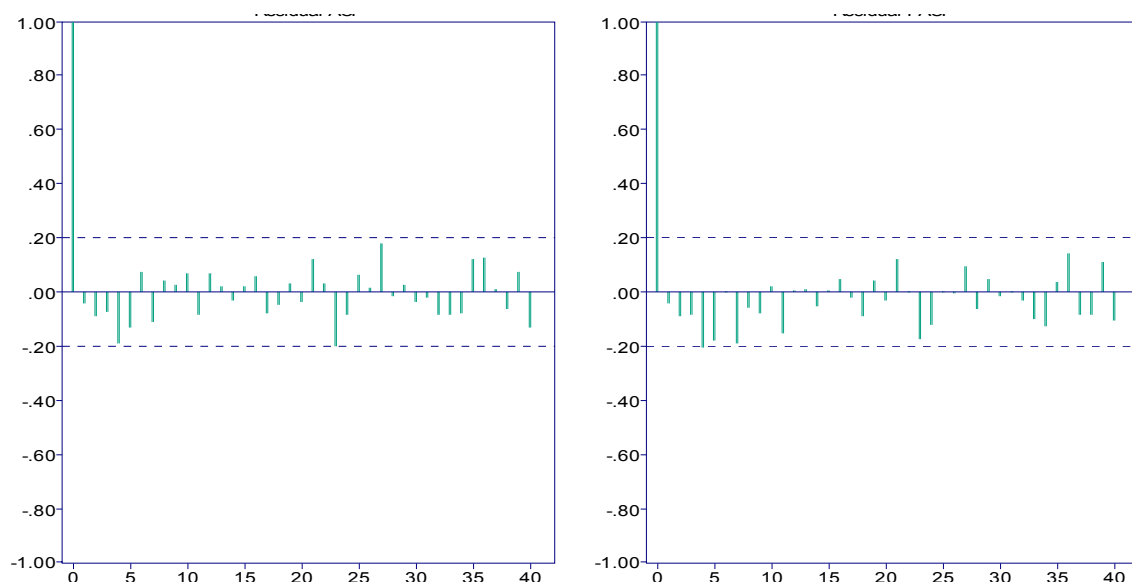
AICC = 150.036407

BIC = 145.915863

-2Log(Likelihood) = 139.362250

White noise test:

Ljung - Box statistic = 20.811 Chi-Square ( 20 )



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## United Kingdom (UK)

Model: SARIMA (0,1,1) (1,1,0)<sub>12</sub>

Estimated Model:

$$X(t) = .000 X(t-1) + .000 X(t-2) + .000 X(t-3) + .000 X(t-4) + .000 X(t-5) + .000 X(t-6) + .000 X(t-7) + .000 X(t-8) + .000 X(t-9) + .000 X(t-10) + .000 X(t-11) - .3160 X(t-12) + Z(t) - .2165 Z(t-1)$$

Standard deviation of the AR Coefficients:

|         |         |         |         |
|---------|---------|---------|---------|
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .106256 |

Standard deviation of the MA Coefficients:

.108605

Quality adjustment measures:

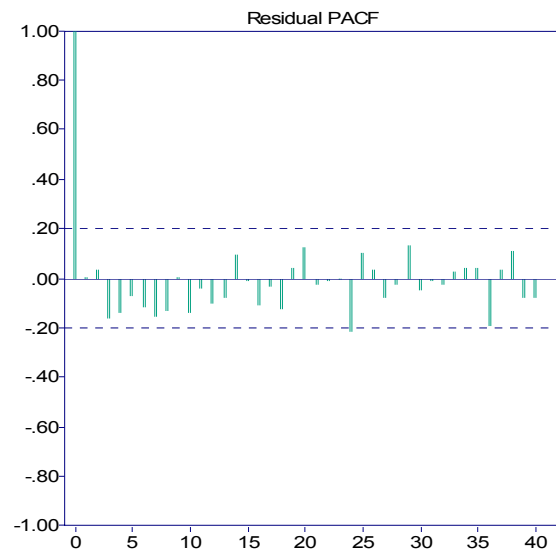
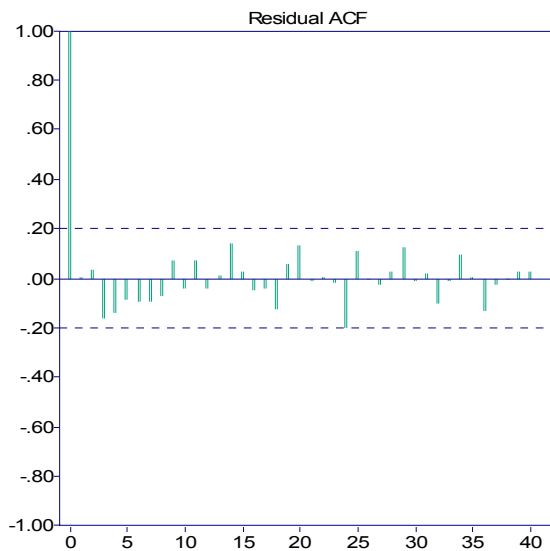
AICC = 118.152018

BIC = 116.653531

-2Log(Likelihood) = 111.888282

White noise test:

Ljung - Box statistic = 16.840 Chi-Square ( 20 )



## Northern European Countries (NC)

Model: SARIMA (0,1,2) (1,1,1)<sub>12</sub>

### Estimated Model:

$$X(t) = .000 X(t-1) + .000 X(t-2) + .000 X(t-3) + .000 X(t-4) + .000 X(t-5) + .000 X(t-6) + .000 X(t-7) + .000 X(t-8) + .000 X(t-9) + .000 X(t-10) + .000 X(t-11) + .2376 X(t-12) + Z(t) - .8845 Z(t-1) - .4863 Z(t-2) + .000 Z(t-3) + .000 Z(t-4) + .000 Z(t-5) + .000 Z(t-6) + .000 Z(t-7) + .000 Z(t-8) + .000 Z(t-9) + .000 Z(t-10) + .000 Z(t-11) - .9987 Z(t-12) + .8834 Z(t-13) + .4856 Z(t-14)$$

### Standard deviation of the AR Coefficients:

|         |         |         |         |
|---------|---------|---------|---------|
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .114678 |

### Standard deviation of the MA Coefficients:

|         |         |         |         |
|---------|---------|---------|---------|
| .165951 | .101448 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .000000 |
| .000000 | .000000 | .000000 | .234718 |
| .000000 | .000000 |         |         |

### Quality adjustment measures:

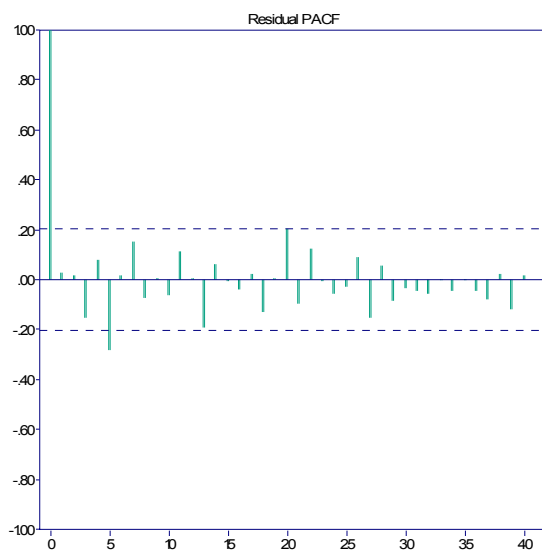
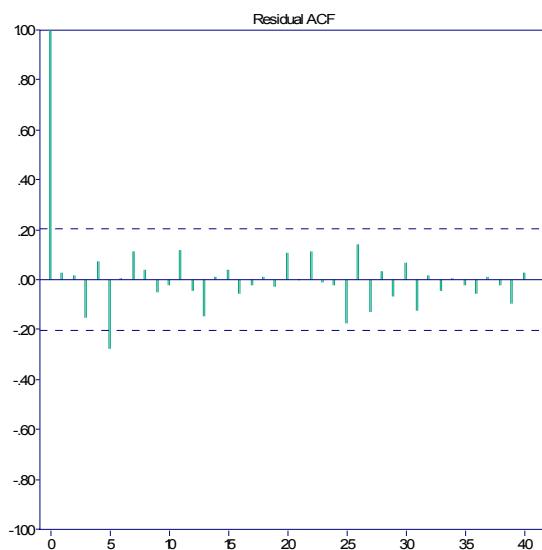
AICC = 200.601387

BIC = 142.957100

-2Log(Likelihood) = 189.927230

### White noise test:

Ljung - Box statistic = 20.286 Chi-Square ( 20 )



## Other Countries (OC)

Model: SARIMA (3,1,0)(0,1,1)<sub>12</sub>

Estimated Model:

$$X(t) = - .1973 X(t-1) - .06348 X(t-2) - .4113 X(t-3) + Z(t) + .000 Z(t-1) + .000 Z(t-2) + .000 Z(t-3) + .000 Z(t-4) + .000 Z(t-5) + .000 Z(t-6) + .000 Z(t-7) + .000 Z(t-8) + .000 Z(t-9) + .000 Z(t-10) + .000 Z(t-11) - .9987 Z(t-12)$$

Standard deviation of the AR Coefficients:

.093518    .095462    .093518

Standard deviation of the MA Coefficients:

.000000    .000000    .000000    .000000  
 .000000    .000000    .000000    .000000  
 .000000    .000000    .000000    .005155

Quality adjustment measures:

AICC = 4.101658

BIC = -15.342648

-2Log(Likelihood) = -6.572499

White noise test:

Ljung - Box statistic = 15.219 Chi-Square ( 20 )

