Identification of Empirical Relationship between the North Atlantic Oscillation and International Tourism Demand to the Balearic Islands

Mª Soledad Otero Giráldez

Department of Applied Economics, University of Vigo, Lagoas-Marcosende s/n, 36310 Vigo, Spain

Email: sotero@uvigo.es; Phone: 34-986813528 Fax.: 34 986812401

Marcos Álvarez-Díaz

Department of Economics, University of Vigo, Lagoas-Marcosende s/n, 36310 Vigo, Spain

Email: marcos.alvarez@uvigo.es; Phone: 34-986813523 Fax.: 34 986812401

Manuel González Gómez

Department of Applied Economics, University of Vigo, Lagoas-Marcosende s/n, 36310 Vigo, Spain

Email: mglez@uvigo.es ; Phone: 34 812504 Fax.: 34 986812401

Abstract

The number of studies devoted to analyze international tourism demand is vast; however, even today, the impact of climate and weather on tourism is receiving only a limited attention. This article highlights the importance of meteorological conditions on Tourism. Specifically, we study the empirical influence of the most important mode of variability in the northern atmospheric circulations, the North Atlantic Oscillation, on international tourism demand. Our empirical evidence demonstrates the existence of a causal relationship between the NAO and the tourist arrivals from United Kingdom and Germany to the Balearic archipelago (Spain). The analysis is based on traditional techniques usually applied in Natural Science such as cross-correlation functions and the Granger Causality test, and on a novel and flexible methodology called ARDL bounds testing approach. The adoption of the ARDL modelling approach becomes a very appropriate and attractive procedure when discovering relationships between variables. In summary, the finding of a statistical relationship between NAO and tourism underlines that the evolution of this atmospheric phenomenon can be of great interest for social researchers to explain international tourism flows.

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1-. INTRODUCTION

Tourism has become one of the fastest and largest growing economic sectors in the world. According to the World Tourism Organization (UNWTO), international tourism generated US$ 944 billion in 2008, and the worldwide contribution of this sector to the Gross Domestic Product (GDP) is calculated approximately at 5 percent. In spite of the importance of tourism, there is a shortage of in-depth study on the mechanisms that drive international tourism demand. The great majority of the studies on this topic focus on a series of psychological and, above all, socio-economic factors such as population, income level, relative prices, currency foreign exchange rate and marketing expenditures on promotional activities (Lim, 1999; Law and Au, 1999). Although socio-economic factors are unquestionably relevant in explaining tourism flows, other kind of factors could be also important such as climate and meteorological factors.

Tourism is a climate-dependent industry, as a lot of tourist activities heavily rely on specific weather conditions (skiing activities, seaside tourism…); therefore, it is obviously reasonable to consider climate and meteorological conditions as significant determinants of international tourism demand. However, relatively little systematic research has been carried out on this topic because climate and weather are usually seen to be constant or a random factor out of control of researchers and managers (Berritella *et al.*, 2006). Relatively recently, a number of studies analyzed the impact of climate and meteorological variables on tourism. The most widely-used variables were temperature, rainfall, wet days, cloud cover, humidity, sunshine and wind speed (Maddison, 2001; Agnew and Viner, 2001; Agnew and Palutikof, 2006). However, the inclusion of these variables in a tourism demand model could lead to some econometric problems since they are highly correlated to each other (multicolinearity problems).

One key variable to summarize meteorological information, and potentially useful to explain Tourism, could be the recurrent pattern of atmospheric variability observed over the North Atlantic Ocean and known as the North Atlantic Oscillation (NAO). The phenomenon is formally defined as an anomalous difference in the atmospheric pressure between the subtropical high-pressure belt, (around the latitudes of 35º- 40º in the Northern Hemisphere and centered near the Azores) and the subpolar low-pressure belt (centered over Iceland) (Hurrell *et al.* 2003). The NAO has an important impact on the climate variability of the Northern Hemisphere, and it has a significant influence on the temperature, storms, precipitations and wind speed observed predominantly in the Atlantic zone and in the Mediterranean region (Greatbatch, 2000). For that reason, the analysis of the NAO can be of great interest for tourism researchers because it could be considered as a general descriptor of the climate and meteorological conditions in the Atlantic and Mediterranean regions.

The dynamic evolution of the NAO is usually characterized by mean of an index (NAOI). The study of the index provides information about the climatic variations of the North Hemisphere depending whether it takes a value greater or less than zero. In general, the index shows two different phases of the NAO, one negative and the other one positive. A value of the NAOI less than zero implies that the NAO is in a negative phase. Therefore, there is a lower-than-normal sea level pressure over the Azores and, simultaneously, a higher-than-normal sea level pressure over the Iceland region. As a result of these anomalies, the Atlantic storm fronts move to the south causing anomalously large amount of precipitations and a higher-than-normal temperature in

Europe, in the western Mediterranean and in the southeastern of North America. On the other hand, the Scandinavian countries show a drier and colder-than-normal weather.

On the other hand, a value of the NAOI greater than zero involves that the NAO is in a positive phase. There is a higher-than-normal sea level pressure over the Azores together with a lower-than-normal sea level pressure over the Iceland region. In general, this phase is associated with drier and colder than normal conditions in Europe, in the western Mediterranean and in the southeastern of North America. On the contrary, wet and warm conditions are observed from Iceland through Scandinavian.

Nowadays, there is an invigorated interest in analyzing empirically the possible relationship of the NAOI and a wide range of weather and oceanography variables, and its impacts on specific marine and terrestrial ecosystems (Hurrell *et al.*, 2003). However, the economic connections have not been deeply explored until now. Through the effects on weather conditions, the NAO has also an indirect influence on certain economic activities. Some studies have empirically demonstrated the influence of the NAO on the agriculture sector (Gimeno *et al.*, 2002; Kim and McCarl, 2005), the energy sector (Cherry *et al.*, 2005) and marine transport (Woolf *et al.*, 2003). Nevertheless, the influence of the NAO on the tourism sector has not been studied yet, and this gap must be filled in order to understand better how tourism works. For that reason, the main objective of this study is to empirically analyze if the NAO has a important effect on international tourism demand using a traditional statistical analysis and a more sophisticated technique called the Autoregressive Distributed Lag model (ARDL) (Pesaran and Shin, 1999). The use of the ARDL model implies a methodological improvement in comparison with previous studies that applied a simple cross-correlation approach to study the connections between the NAOI and other variables; or those that made use of the Granger Causality Test (Wang *et al.*, 2004; Mosedale *et al.* 2006).

The analysis here is centered on analyzing the impact of the NAO on the number of international tourist arrivals to a specific tourism-dependent area: The Balearic Islands. The tourism industry in this Spanish region is the main generator of employment and income, accounting direct or indirectly for around 60 percent of the Balearic Gross Domestic Product. In consequence, government and local industry are very interested in knowing more about the determinants of tourism in the Balearic Islands.

The rest of the paper is organized as follows. After this introductory section, a description of the data and methodology is provided. In Section Three, the results are discussed. Finally, Section Four closes the paper with a summary of the main findings.

2. DATA AND METHODOLOGY

2.1. Data description

There is no a universally accepted index to describe the temporal evolution of the NAO phenomenon. One of the most used indicators of NAO activity was developed by Hurrel (1995), and is formally defined as the mean value of the difference between the normalized sea level pressure between Lisbon (Portugal) and Stykkisholmur (Iceland) during the winter months (December, January, February and March). The winter value is supposed to describe appropriately the whole year beginning that January (Gimeno *et al.*, 2002; Cherry *et al.*, 2005). The data for the NAO index can be directly downloaded from the web page of the National Center for Atmospheric Research (http://www.cgd.ucar.edu/cas/jhurrell/indices.html).

The other variable object of analysis is the international tourism demand to the Balearic Islands, which can be adequately approximated by the number of tourist that visit the archipelago. There are other approximations such as tourism revenues, overnight stays or tourist expenditure; however, tourist arrival is the most popular measure of tourism demand (Song and Li, 2008). The analysis is restricted to visitors from Germany and United Kingdom. This constraint is justified because of the predominance of these two nationalities in the Balearic tourism (almost 80% of the tourist arrivals) and, secondly, because for both cases they are time series with enough entries to apply the statistical methods used in this study. The data were obtained from the yearly reports of CITTIB, the tourist statistical center belonging to the Balearic government, and available under request at www.inestur.es.

Finally, the sample period for both time series goes from 1980 to 2008; therefore, the final sample comprises a total of 29 years to carry out the statistical analysis.

2.2. Methodology

Three alternative methods of analysis are employed to statistically study the existence of an empirical relationship between the NAO and international tourism demands to the Balearic archipelago. In particular, the analysis is centred on the use of cross-correlation functions, the Granger causality test, and a novel, flexible and robust methodology known as Autoregressive Distributed Lag (ARDL) modeling.

A Cross-Correlation Approach

The use of cross-correlation functions (CCFs) is the most common analysis in natural science research to detect connections between the atmospheric variability described by the NAOI and different climatic, biological, and oceanographic variables (Hurrell, 1995; Gimeno *et al.*, 2002; Orfila *et al.*, 2005, among many others). Nevertheless, it must be recalled that this analysis should be handled with care since if each one of the analyzed series has a very high degree of autocorrelation, then the nonzero values of the cross-correlation function do not necessarily imply a true relationship between the two time series (Katz, 1988). In other words, the presence of autocorrelation can lead to a spurious relationship between the variables and, therefore, the cross-correlation analysis would be completely wrong. For that reason, in order to avoid possible fictitious cross-correlations, it is necessary to remove all of the autocorrelation in each time series and then cross-correlate that which remains. If the identical method of removing autocorrelation is applied to each variable, the true cross-correlation between variables is preserved (DeLurgio, 1998).

In this study we specifically followed the procedure explained in Orfila *et al.* (2005) and Cañellas *et al.* (2010). We start assuming that each one of the time series under study follows an autoregressive process with additive Gaussian noise. Consequently, the procedure implies to fit a p-order autoregressive model (AR(p)) for x_t of the form

$$x_t = \alpha_0 + \alpha_1 \, x_{t-1} + ... + \alpha_p \, x_{t-p} + e_t \quad (1)$$

and a q-order autoregressive (AR(q)) for y_t

$$y_t = \mu_0 + \mu_1\, y_{t-1} + ... + \mu_p\, y_{t-q} + u_t \quad (2)$$

where x_t and y_t are the original time series that show autocorrelation, $\{\alpha_i\}_{i=0}^{p}$ and $\{\mu_j\}_{j=0}^{q}$ are the coefficients that must be optimally estimated in order to get non-autocorrelated residuals $\{e_t\}_{t=1}^{T}$ and $\{u_t\}_{t=1}^{T}$. The order *p* and *q* of the autoregressive will be those that minimize the Akaike Information Criterion (AIC) (Akaike, 1973). Finally, the residuals in (1) and (2) will be the filtered series to be cross-correlated.

The Granger Causality Test

The second procedure employed here is based on the causality concept developed by Granger (1969). This author presented an approach for testing causality between two variables that has been widely applied in many economic studies; however, its use is scarce in climate research (Mosedale *et al.* 2006). The procedure starts constructing simple causal models

$$x_t = \alpha_0 + \alpha_1\, x_{t-1} + ... + \alpha_p x_{t-p} + \beta_1\, y_{t-1} + ... + \beta_p\, y_{t-p} + \varepsilon_t \quad (3)$$

and

$$y_t = \mu_0 + \mu_1\, y_{t-1} + ... + \mu_p\, y_{t-p} + \delta_1\, x_{t-1} + ... + \delta_p\, x_{t-p} + u_t \quad (4)$$

where x_t and y_t are two stationary time series , and the residuals of the models ε_t and u_t must be uncorrelated white-noise series. As usual in this kind of analysis, the best order *p* for the equations is selected by minimising an Information Criterion, for example the Schwarz Criterion (Schwarz, 1978). The definition of causality in the sense of Granger implies that y_t is causing x_t if it is proved that some estimated coefficient β_i is statistically non-zero. Similarly x_t is causing y_t if it is demonstrated that some δ_i is statistically non-zero. Moreover, if both of these events occur, it is said to be a feedback relationship between x_t and y_t. The null hypothesis of the contrast with two restrictions is that y_t does not Granger-cause x_t in the first regression and that x_t does not Granger-cause y_t in the second regression. The statistical test used to contrast these hypotheses is the conventional F-test.

An ARDL Bounds Testing Approach

During the last years, considerable attention has been paid to testing for the existence of short and long run relationships between variables based on the use of different cointegration techniques (Engle and Granger, 1987; Johansen and Juselius, 1990). However, all of these methods can be only applied when the variables are integrated of the same order. This technical requirement implies a severe limitation of the traditional cointegration techniques. In order to overcome this restriction, Pessaran *et al.* (2001) suggested the *ARDL Testing Bounds Approach* to testing for the existence of a long-run relationship between variables which is applicable irrespective of whether the underlying variables are I(0) or I(1) or a mixture of both. The ARDL approach to cointegration implies estimating the conditional error correction model (ECM):

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p-1} \alpha_i \cdot \Delta y_{t-i} + \sum_{j=0}^{p-1} \mu_j \cdot \Delta x_{t-j} + \delta \cdot t + \phi \cdot y_{t-1} + \vartheta \cdot x_{t-1} + \varepsilon_t \quad (5)$$

where the symbol Δ represents the first-difference operator, y_t is the number of international tourist arrivals, x_t is the value of the NAOI, t is the tendency, the parameters ϕ and ϑ are the long run coefficients, α_i and μ_j the short run coefficients and ε_t represent the residuals. The optimal number of lags of the ECM is determined using a specific criterion of selection (for example, the Akaike Information Criterion).

Following Pesaran *et al.* (2001), our testing procedure of a long run relationship between tourist arrivals and NAOI is based on two alternative statistics. The first one is the *F-test* on the joint null hypothesis that the coefficients on the level variables lagged are jointly equal to zero ($H_0 : \phi = \vartheta = 0$). The second statistic is an individual *t-test* on the lagged dependent variable ($H_0 : \phi = 0$). These statistics have a non-standard distribution under the null hypothesis that there exists no relationship between y_t and x_t, irrespective of whether these variables are purely I(0), purely I(1) or a mixture of both. However, Pesaran *et al.* (2001) derived their asymptotic distributions under the null and proposed critical value bounds which allow us to accept or reject the null hypothesis. Therefore, if the statistics fall outside of their respective critical upper bound, then we reject the null hypothesis and we have evidence of a long-run relationship (indicating cointegration). If the statistics are below their respective critical lower bound, then we cannot reject the null hypothesis of no cointegration. Finally, if the statistics lies between the upper and lower critical bounds, then the inference is inconclusive.

3. EMPIRICAL RESULTS

Cross-Correlation Analysis

A first step to carry out a cross-correlation analysis between the NAOI and the number of tourist arrivals is to remove the autocorrelation existing in the original time series using an AR(p). Figure 1 depicts the choice of the optimal order of the autoregressive for each series. In all cases, the optimum order that minimizes the AIC is p=1, and the residuals obtained after filtering the original data did not exhibit significant autocorrelations. Therefore, the residual series can be used in the analysis to detect significant cross-correlations not due to co-temporality. Specifically, the residuals of the NAO index were cross-correlated with each one of the residuals of the international tourist arrivals series.

Figure 2 and Figure 3 show graphically the sample cross-correlation function for the German and British case, respectively. Moreover, these figures also display the intervals of confidence necessary to examine the statistical significant of the cross-correlation coefficients. The intervals are empirically constructed by means of a Montecarlo simulation. To do so, 5000 time series were randomly generated with the same characteristics as a random white variable and with the same standard deviation as the residuals of the NAO index. Then, each one of these artificial variables was cross-correlated with the residual series of tourism arrivals. An empirical distribution of each cross-correlation coefficient for each lag is computed. Using this empirical distribution a confidence interval with a specific significant level is built, in this case the significance is determined at 95%.

As we can observe in Figure 2, NAOI is statistically cross-correlated with the German tourist arrivals at lags $\tau = 4$ and $\tau = 7$, and no significant cross-correlations are detected to other lags. On the other hand, the relationship between NAOI and tourist arrivals from United Kingdom is not as clear as in the German case. Examining Figure 3, only a slight significance relationship is found for the cross-correlation coefficient at lags $\tau = 2$ and $\tau = 7$.

The Granger Causality Test

In order to apply the Granger Causality test, it is first necessary to verify that the time series are stationary. For this purpose, the conventional non-parametric Phillips-Perron test (PP) (Phillips and Perron, 1988), and the Augmented Dickey-Fuller test (ADF) (Dickey and Fuller, 1981) are used for testing stationary; in particular, the existence of a unit root in the time series. The results, reported in Table 1 and Table 2, show that the NAOI is stationary. On the other hand, tourist arrivals from Germany and United Kingdom are both non-stationary time series. As they are integrated of order one, a common practice to get stationary is to take first differences. Therefore, first-differenced time series were used in the case of German and United Kingdom tourist arrivals.

Given that all series are now stationary, it is feasible to apply the Granger Causality Test. Table 3 shows the null hypothesis to be contrasted, and the values and p-values of the test. As it can be seen, the test has associated a p-value of 0.01 and 0.036 for the German and United Kingdom arrivals, respectively. Therefore, it can be rejected the null hypothesis that the NAO does not have a causal effect on the number of tourist arrivals to the Balearic Islands from Germany and United Kingdom. Moreover, an analysis of the sensitivity of the results reveals that the choice of the lag length is not a critical issue. That is, the test is robust to different number of lags considered in the analysis. Therefore, the Granger Test verifies statistically that a climatic phenomenon as the NAO has a Granger causal relationship with the international tourism demand to the Balearic archipelago.

An ARDL Bounds Testing Approach

The ARDL approach allows us to verify the existence of a long run relationship between two variables without knowing if they are integrated of order one or zero [I(1) or I(0)]. However, we need to be sure that variables are not of a higher order [I(d), with d>1]. For this reason, it is necessary to analyze the order of integration using a combination of statistical tests. As it was already mentioned above, the ADF and PP tests reveal that the NAOI is stationary [I(0)], and the tourist arrivals are both non-stationary time series at their levels, but stationary at first differences; so they are integrated of order one [I(1)].

Once that the order of integration is known not to be greater than one, the next step is to apply the bounds testing approach to cointegration proposed by Pesaran *et al.* (2001). Following these authors, the Akaike's information criterion (AIC) was used in selecting the optimum lag length (p) in equation (5).

Table 4 and Table 5 provide the results of the bounds test for cointegration between NAOI and tourist arrivals from United Kingdom and Germany to the Balearic archipelago, respectively. The bounds testing analysis is carried out under three different scenarios as suggested by Pesaran *et al.* (2001). The first one considers an ARDL model with restricted deterministic trends (F_{IV}), the second one a model with unrestricted deterministic trends (F_V t_v) and, finally, a model without deterministic trends (F_{III} and t_{III}). In these tables the critical values for F and t statistics are also shown and they were taken from Pesaran *et al.* (2001).

Results in Table 4 suggest the existence of a level relationship (long-run causality) between the NAOI and tourist arrivals from United Kingdom to the Balearic

Islands. The F statistics lies above the upper bound of the critical values for all scenarios F_{III}, F_{IV} and F_{V}; therefore, it allows us to reject the null hypothesis $H_0 : \phi = \vartheta = 0$. Regarding the t-statistics, the results obtained in the scenario t_V corroborate the existence of a relationship between the variables since the test value allows us to reject the null hypothesis $H_0 : \phi = 0$. However, for the scenario t_{III} the statistic provides a value which lies between the upper and lower critical values; consequently, the inference is inconclusive.

On the other hand, results in Table 5 for the German case reveal that both the F and the t statistics are below their respective critical lower bound for all scenarios; therefore, they do not support the long-run relationship between the NAOI and tourist arrivals from Germany.

4. CONCLUSION

This research presents an empirical analysis that contributes to open the "black box" about the importance of climate and weather on international tourism flows. Specifically, the main objective here has been to demonstrate the empirical relationship between one of the most important mode of atmospheric variability, the North Atlantic Oscillation, and international tourism demand. For this purpose, we employ statistical techniques usually applied in Natural Sciences to discover significant connections between variables (a cross-correlation analysis and the Granger Causality test), and we also introduce a novel methodology known as the ARDL bounds testing approach. The empirical results applying all techniques corroborate the fact that the NAO has a significant influence on the number of tourism arrivals to the Balearic Islands. In particular, the NAO phase described by mean of an index was found to be associated with significant changes in the number of tourist arrivals. This finding is really important for natural and social researchers because it empirically evidences the impact of a climatic phenomenon on a social and economic activity.

Previous studies had already examined the influence of the NAO in some economic sectors such as energy and transport activities. However, the contribution of our investigation is two-fold. First, to the best of our knowledge, this paper constitutes the first time that the influence of the NAO on Tourism is studied. The second relevant contribution is that the inclusion of the ARDL approach implies a methodological improvement regarding those studies that have only used traditional techniques (cross-correlation functions and the Granger Causality test). The adoption of the ARDL modeling approach supposes a more robust and flexible methodology to discover relationships between variables. Nevertheless, this research is still a first step that opens a new research avenue that will require new efforts in the future.

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Table 1. Phillips and Perron test for unit root

Ho: variable has a unit root	t-statistic Models with Constant and Trend	t-statistic Models with Constant
NAO	-4.445173* (3)	-4.423531* (1)
German arrivals	-2.373036 (3)	-0.296345 (6)
British arrivals	-2.618303 (9)	-1.885406 (11)
Δ German arrivals	-4.380040* (1)	-4.471376* (1)
Δ British arrivals	-5.482706* (4)	-5.226123* (3)

Note: Δ is the first difference operator. Values in parenthesis specify the truncation lag for the Newey-West correction length used. * indicates significance at 5% level. Critical values are based on MacKinnon (1996).

Table 2. Dickey and Fuller test for unit root

Ho: variable has a unit root	t-statistic Models with Constant and Trend	t-statistic Models with Constant
NAO	-4.483430* (0)	-4.417141*(0)
German arrivals	-2.177113 (0)	-0.454708 (0)
British arrivals	-3.361824 (1)	-1.933828 (0)
Δ German arrivals	-4.382868* (0)	-4.474004* (0)
Δ British arrivals	-5.053248* (0)	-5.107392* (0)

Note: Δ is the first difference operator Values in parenthesis specify he lag length based on the Schwarz Information. Critical values from Mackinnon (1996). *denotes significance at 5 per cent level.

Table 3. Results of the Granger Causality Test

NULL HYPOTHESIS	Lags	F-Statistic	p-value
NAO does not Granger Cause German arrivals	4	4.88758	0.0100
NAO does not Granger Cause British arrivals	5	3.44631	0.0367

Note: The lag length is based on the Schwarz Information criterion and on the no correlation serial of the residuals.

Table 4. Critical values and bounds test for cointegration. Tourist arrivals from United Kingdom.

Scenario	Models with constant and trend	Models with constant and no trend	Critical Values for ARDL modelling approach
$\mathbf{F_{IV}}$	6.78*	-	(4.68, 5.15)
$\mathbf{F_{V}}$	10.01*	-	(6.56, 7.30)
$\mathbf{t_{V}}$	-4.45*	-	(-3.41, -3.69)
$\mathbf{F_{III}}$	-	6.368*	(4.94, 5.73)
$\mathbf{t_{III}}$	-	-3.14	(-2.80, -3.21)

Note: *indicates that the statistic lies above the upper level of the band. F_{IV} represents the F statistic of the model with unrestricted intercept and restricted trend, F_{V} represents the F statistic of the model with unrestricted intercept and trend, F_{III} represents the F statistic of the model with untrestricted intercept and no trend, t_{V} represents the t statistic of the model with deterministic linear trend and t_{III} represents the t statistic of the models without trend.

Table 5. Critical values and bounds test for cointegration. Tourist arrivals from Germany.

Scenario	Models with constant and trend	Models with constant and no trend	Critical Values for ARDL modelling approach
F_{IV}	3.01	-	(4.68, 5.15)
F_{V}	4.52	-	(6.56, 7.30)
t_{V}	-2.16	-	(-3.41, -3.69)
F_{III}	-	1.42	(4.94, 5.73)
t_{III}	-	-0.175	(-2.80, -3.21)

Note: *indicates that the statistic lies above the upper level of the band. F_{IV} represents the F statistic of the model with unrestricted intercept and restricted trend, F_{V} represents the F statistic of the model with unrestricted intercept and trend, F_{III} represents the F statistic of the model with untrestricted intercept and no trend, t_{V} represents the t statistic of the model with deterministic linear trend and t_{III} represents the t statistic of the models without trend.

Figure 1. Choice of the optimum p-order of the autoregressive for the time series

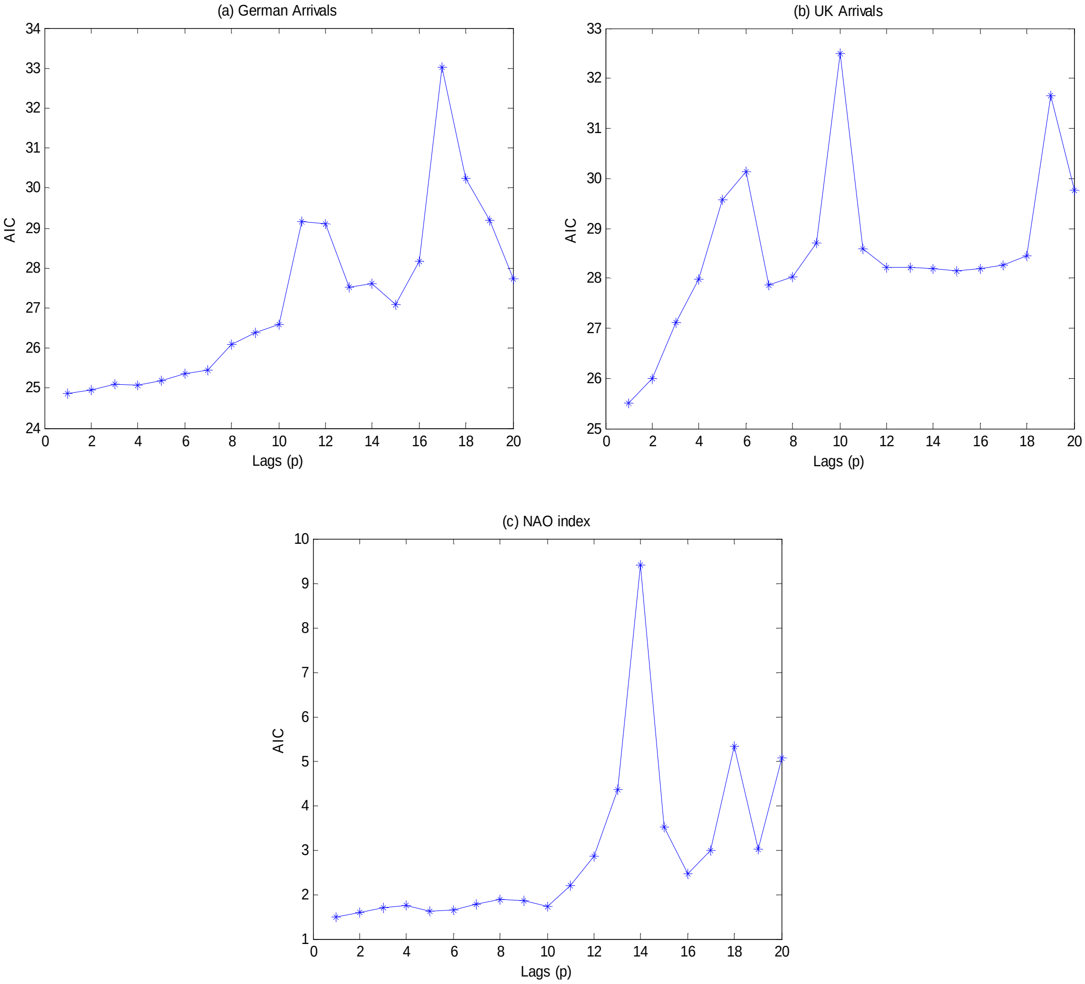

Figure 2. Sample cross-correlation between residuals of the NAO index and the residuals of the tourist arrivals from Germany.

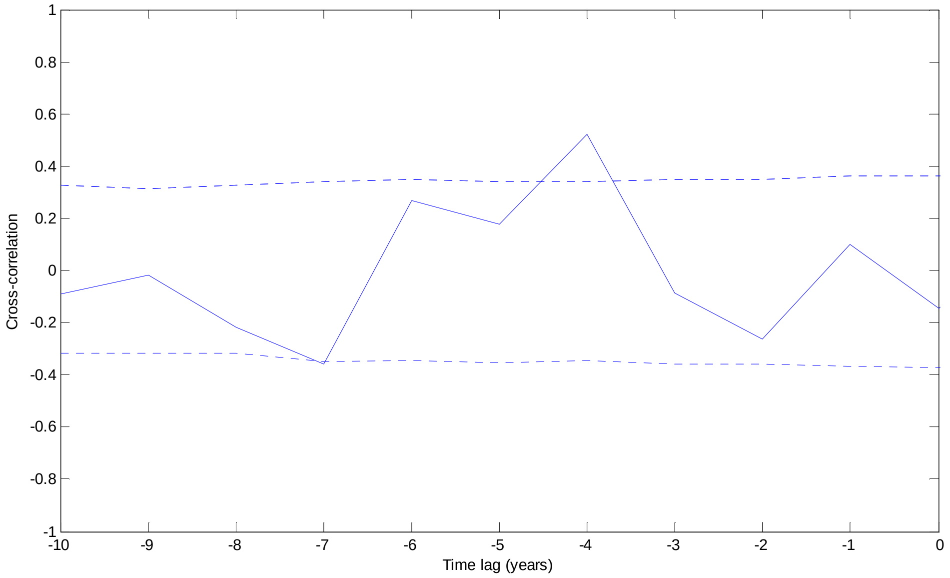

Figure 3. Sample cross-correlation between residuals of the NAO index and the residuals of the tourist arrivals from United Kingdom.