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Original Article

Testing for structural breaks in tourist movements in the European Union

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Abstract:
The aim of the article is to identify structural breaks in empirical time series for tourist arrivals and departures in the European Union in the years 1995-2018. Tourism is a branch of economy strongly susceptible to negative shocks such as epidemics, social unrest, economic crisis, political turmoil, terrorist attacks, and legal changes.They are immediately visible in decreasing interest in tourist trips. Structural breaks not only distort the structure of econometric analysis but also hinder a decision making process for both entrepreneurs (travel agencies, hotels, restaurants etc.) and customers. Each econometric model is only a certain more or less accurate mathematical and statistical tool to describe the phenomenon one is interested in. An irregular course of the process (phenomenon) over time may not be a sufficient reason to turn to the simplest linear statistical-econometric tools. Therefore, this paper uses tests for single and multiple structural breaks, i.e.Perron test, Andrews and Zivot test as well as Bai and Perron test. These tests were used to confirm the presence of structural breaks in the empirical time series. The results indicate that structural breaks in the tourism departures and arrivals in the EU coincide with the dates of economic crises, particularly the recession in the years 2008-2009 and Eurozone crisis in 2013. The results of forecasting tourist departures and arrivals are promising in the short run. It is recommended to monitor a sequence of forecastsif they are usedin the decision making processes.
Key Words: structural break, economic crises, tourism industry, time series model, forecasting

Introduction

The aim of the article is to identify and discuss structural breaks in empirical time series for tourist arrivals and departures in the European Union in 1995-2018. It is assumed that they result from economic dynamics and business cycles. The current epidemic situation has a different origin because it was caused by external factor i.e. a coronavirus spread all over the world. Nevertheless it resulted in a serious structural change. Another example of unexpected change for the tourism industry and the whole EU economy was the financial crisis at the end of the first decade of the 21st century. The more rapid change of the in tourist industry can result from accession of countries to the EU structures and the expansion of the Schengen area, leaving the EU by the United Kingdom and migration of refuges from the Middle East and Africa. Additionally, one can point to terrorist attacks (Spain, France, Germany, and the USA), nuclear disasters (Japan), earthquakes, volcanic eruptions, etc. The presence of structural breaks makes the use of linear econometrics tools not very accurate to reflect the structure of the studied phenomenon as well as forecasting. For this purpose, the article discusses and implementseconometric tests for structural breaks in tourism industry.

Several publications touched this problem in recent years. Lee and Chien (2008) investigated the co-movements and the causal relationships among real GDP, tourism development, and the real exchange rate in Taiwan. They adopted two different tourism variables i.e.international tourism receipts and number of international tourist arrivals. Tan and Tan (2013) investigated the convergence of Singapore's 15 major tourist source markets. Using monthly data for the period January 1994 to June 2011 they found out, among others, that 80% of the tourism markets support the evidence for convergence when multiple structural breaks are incorporated. Cró and Martins (2017) applied Bai and Perron (1998) test for structural breaks to examine international tourism arrival series for 25 countries and Madeira Island. They observed that tourism crises and disasters are largely consistent with the dates of breaks. On the other hand, Chowdhury (2018) reported dependence between exchange rate and world income and tourist arrivals to Australia. He found that appreciation of Australian dollar is responsible for decreasing number of tourist arrivals while increase in the world income increases arrivals in the long run. Also he found the presence of structural breaks in the analyzed time series.

Material & methods

The starting point of the study is defining the stationarity of the analyzed time series. Time series are considered to be stationary in the wide sense when their means and variances are stable over time and covariances are the functions of time lags. As the structural breaks in the time series are assumed typical tests for

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unit roots such as Augmented Dickey Fuller test (Dickey and Fuller, 1979) are inappropriate. The tests combining stationarity of the process with the presence of structural breaksneed to be used. These are: Perron test (1989, 1990, 1997), Andrews and Zivot test (1992) and Bai and Perron test (1998, 2003a 2003b). In the Perron test, depending on whether a structural break is in a constant, in a trend, or in a constant and in a trend, the test regressions take the form of a test sequence:

$$y_t = \mu_A + \theta_A DU_t + \beta_A t + d_A D(T_B)_t + \alpha_A y_{t-1} + \sum_{j=1}^{k} c_j^A \Delta y_{t-j} + e_t \quad (1)$$

$$y_t = \mu_B + \beta_B t + \gamma_B DT_t^* + \alpha_B y_{t-1} + \sum_{j=1}^{k} c_j^B \Delta y_{t-j} + e_t \quad (2)$$

$$y_t = \mu_C + \theta_C DU_t + \beta_C t + \gamma_C DT_t^* + d_C D(T_B)_t + \alpha_C y_{t-1} + \sum_{j=1}^{k} c_j^C \Delta y_{t-j} + e_t \quad (3)$$

where:
$DU_t = 1$, if t $> T_B$, 0 otherwise, $1 < T_B < T$,

$D(T_B)_t = 1$, if t = $T_B + 1$, 0 otherwise,

$DT_t^* = t - T_B$, if t $> T_B$, 0 otherwise.

In Andrews and Zivot test, the test regressions are very similar to Perron test. The authors of the test omit the variable 0-1 $D(T_B)_t$.

$$y_t = \mu_A + \theta_A DU_t(\lambda) + \beta_A t + \alpha_A y_{t-1} + \sum_{j=1}^{k} c_j^A \Delta y_{t-j} + e_t \quad (4)$$

$$y_t = \mu_B + \beta_B t + \gamma_B DT_t^*(\lambda) + \alpha_B y_{t-1} + \sum_{j=1}^{k} c_j^B \Delta y_{t-j} + e_t \quad (5)$$

$$y_t = \mu_C + \theta_C DU_t(\lambda) + \beta_C t + \gamma_C DT_t^*(\lambda) + \alpha_C y_{t-1} + \sum_{j=1}^{k} c_j^C \Delta y_{t-j} + e_t \quad (6)$$

where:
$DU_t(\lambda) = 1$, if t $> T\lambda$, 0 otherwise, $\lambda - breakpoint, \lambda = {T_B}/{T}$

$DT_t^*(\lambda) = t - T\lambda$, if t $> T\lambda$, 0 otherwise.

Bai and Perron (1998) formulated a linear regressionwith *m* structural breaksand*m + 1* regimes:

$$y_t = x_t'\beta + z_t'\delta_j + u_t \quad (7)$$

where:
$y_t -$ independent variable,
$x_t(px1) and z_t(qx1)$ – vectors of covariates,
$\beta and \delta_j$–are the corresponding vectors of coefficient,
$u_t -$is the disturbance term,

$t = T_{j-1} + 1, \dots, T_j$

$j = 1, \dots, m + 1$

Bai and Perron assumed that$T_0 = 0$ and $T_{m+1} = T$. The dates of structural breaks $T_1, \dots, T_m$ are assumed to be unknown. Equation (7) can be written in a matrix form (8):

$$Y = X\beta + \bar{Z}\delta + U \quad (8)$$

where:
$Y = (y_1, \dots, y_T)'$
$X = (x_1, \dots, x_T)'$
$U = (u_1, \dots, u_T)'$
$\delta = (\delta_1', \delta_2', \dots, \delta_{m+1}')'$

$\bar{Z}$ – a matrix which takes *m+1* valueson the main diagonalwhich depend on *m* structural breaks ($T_1, \dots, T_m$), $\bar{Z} = diag(Z_1, \dots, Z_{m+1})andZ_i = (z_{T_{i-1}+1}, \dots, z_{T_i})'$. Moments of structural breaks are established in the process of parameters estimation of equation (7), to ensure that the sum of squared residuals is the minimum. The null hypothesis in Bai and Perron test assumes no structural break. The alternative hypothesis allows for *k*structural breaks:

$H_0: m = 0$

$H_1: m = k$

To verify the null two statistics are calculated Fand supF:

$$F_T(\lambda_1, \dots, \lambda_k; q) = \left(\frac{T-(k+1)q-p}{kq}\right)\frac{\hat{\delta}'R'(R(\bar{Z}'M_X\bar{Z})^{-1}R')^{-1}R\hat{\delta}}{SSR_k} \quad (9)$$

where:

$\lambda_i = T_i/T$ for $i = 1, \dots, k$, $(R\hat{\delta})' = (\delta_1' - \delta_2', \dots, \delta_k' - \delta_{k+1}')$,

$M_X = I - X(X'X)^{-1}X'$

$$supF_T(k; q) = \sup_{(\lambda_1, \dots, \lambda_k) \in \lambda_\epsilon} F_T(\lambda_1, \dots, \lambda_k; q) \quad (10)$$

where:

$\Lambda_\epsilon = \{(\lambda_1, \dots, \lambda_k); |\lambda_{i+1} - \lambda_i| \geq \epsilon, \lambda_1 \geq \epsilon, \lambda_k \leq 1 - \epsilon\}$

Statistics sup F is a generalization of sup F considered by Andrews (1993) for k =1.
In the case of correlated residuals the formula (9) is modified as follows:

$$F_T^*(\lambda_1, \dots, \lambda_k; q) = \left(\frac{T-(k+1)q-p}{kq}\right)\frac{\hat{\delta}'R'(R\hat{V}(\hat{\delta})R')^{-1}R\hat{\delta}}{SSR_k} \quad (11)$$

where:

$\hat{V}(\hat{\delta})$- variance covariance matrix of $\hat{\delta}$ that is robust to serial correlation and heteroskedasticity. Matrix $\hat{V}(\hat{\delta})$ is given by the equation (12):

$$\hat{V}(\hat{\delta}) = plimT(\bar{Z}'M_X\bar{Z})^{-1}\bar{Z}'M_X\Omega M_X\bar{Z}(\bar{Z}'M_X\bar{Z})^{-1} \quad (12)$$

The statistical data concerning tourist departures and arrivals used in the study comes from the World Bank database. These are annual data from 1995-2018 and concern the European Union. Two time series are considered: tourist departures - variable $Dep_t$and tourist arrivals - variable Arr_t. The data are presented in millions of people. The time series are presented in figure 1.

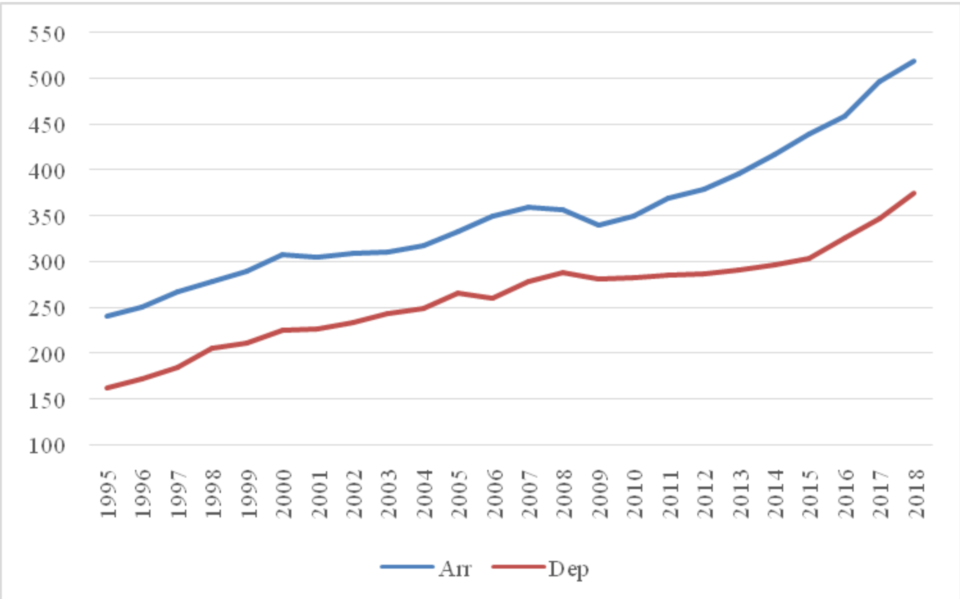

Fig. 1Tourist arrivals and departures in UE in 1995-2018
Source: Author's own elaboration basing on https://data.worldbank.org.

The time series observed in figure 1 indicate instability in both variables in several periods of time that may be the result of structural breaks. Structural breaks are the subject of testing in the next section. It is reasonable to ask a question whether structural breaks in tourist movements coincide with structural changes that are observed in the GDP series in the EU. The GDP series is presented in figure 2.

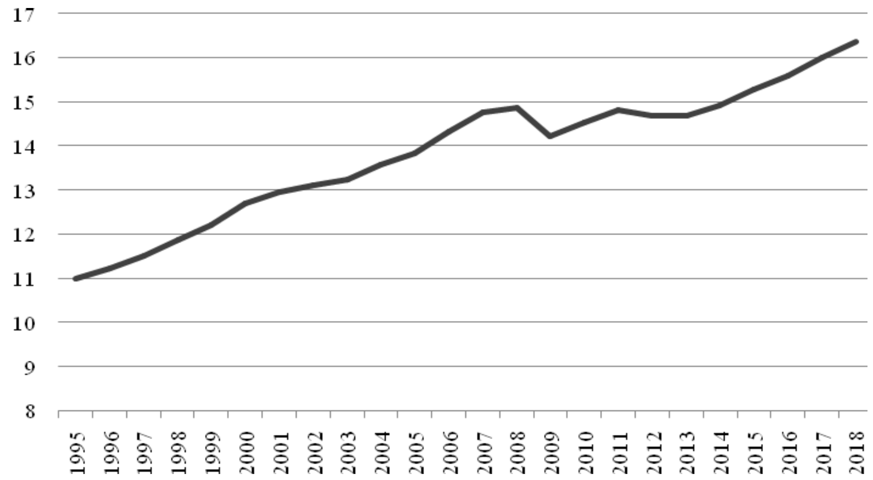

Fig. 2GDP in the UE in 1995-2018 (in bln. euro)
Source: Author's own elaboration basing on https://data.worldbank.org.

One can easy observe that two structural breaks dominate in the GDP series. These are in 2009 during the financial recession as well as in 2013 during the European debt crisis often also referred to as the eurozone crisis.These two crises are fully identified and widely described in the literature (comp. Kahler and Lake, 2013). Having structural breaks identified the next step is to forecast tourists' departures from the EU and arrivals to the EU. To do so a simple autoregressive model with a deterministic part including structural breaks'variables was assumed (Greene, 2011). The model has the following form:

$$\Delta y_t = \alpha_0 + \alpha_1 DU_t + \alpha_2 DT_t + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \qquad (12)$$

For comparison a 3-step moving average was applied which ensures a flexible form of forecasting.

Results

The first step of the empirical research started with demonstrating the results of Perron tests for stationarity and the presence of a single structural break (Tab 1.). The time series are examined for structural breaks in levels and in the first differences denoted with Δ symbol. Due to a small number of observations, the tables also include critical values at 5% and 10% significance levels.

Tab.1 Results of the Perron test for a single structural break

Variable	Trend specification	Break specification	Break date	t-Statistic	c.v. 5%	c.v. 10%
Arr_t	C	C	2014	-2,136	-4,443	-4,194
Arr_t	C, T	C	2008	-3,642	-4,86	-4,607
Arr_t	C, T	T	2013	-4,124	-4,525	-4,261
Arr_t	C, T	C, T	2013	-3,718	-5,176	-4,894
ΔArr_t	C	C	2009	-4,288	-4,443	-4,194
ΔArr_t	C, T	C	2009	-4,019	-4,86	-4,607
ΔArr_t	C, T	T	2013	-4,354	-4,525	-4,261
ΔArr_t	C, T	C, T	2008	-3,883	-5,176	-4,894
Dep_t	C	C	2014	-2,541	-4,443	-4,194
Dep_t	C, T	C	2006	-3,867	-4,86	-4,607
Dep_t	C, T	T	2009	-5,367	-4,525	-4,261
Dep_t	C, T	C, T	2006	-5,883	-5,176	-4,894
ΔDep_t	C	C	2008	-6,336	-4,443	-4,194
ΔDep_t	C, T	C	2008	-6,181	-4,86	-4,607
ΔDep_t	C, T	T	Dep ~ I(0)	Dep ~ I(0)	-4,525	-4,261
ΔDep_t	C, T	C, T	Dep ~ I(0)	Dep ~ I(0)	-5,176	-4,894

C – constant, T – linear trend
Source: Own elaboration.

The results of Perron test (1989, 1990, and 1997) for single structural break show that both tourist departures Dep_t and tourist arrivals Arr_t are non-stationary variables with structural breaks in both constant and trend. At least once in any group of tests for each variable there are years 2007-2010, related to the financial crisis in the EU. Also years 2013 and 2014 are indicated as those in which tourist movements fell down. It proves both a relationship of tourist industry with economic situation measured by GDP as well as it shows that a stable home budget is crucial for planning tourist trips.

In Tab 2.the results of Bai and Perron test for multiple structural breaks are presented.

Tab.2 Results of the Bai and Perron test for a multiple structural break

Variable	Breaking variables	Estimated break dates for T = 24
Arr_t	C	1999, 2005, 2013, 2016
Arr_t	T	1998, 2001, 2004, 2009
Arr_t	C, T	2000, 2004, 2007, 2010, 2015
Dep_t	C	1998, 2003, 2007, 2016
Dep_t	T	1998, 2001, 2006, 2010
Dep_t	C, T	1998, 2006, 2009, 2015

Source: Own elaboration.

The results of Bai and Perron test for multiple structural breaks show that in a sample of 24 observations we usually have 4 structural breaks identified. Whether the structural meltdown is with a constant, in a trend, or both, the impact of the financial crisis on tourist arrivals and departures has been confirmed. In this test the Eurozone crisis in 2013 was not important for tourist movements. The year 2004 (and possibly 2005) identified as a structural break can be associated with the accession of 10 new countries to the EU. Similar results are presented in Table 3 with the results of Andrews and Zivot test.

Tab. 3 Results of the Andrews and Zivot test for a single structural break

Variable	Structural Break	Break point	t-Statistic	c.v. 5%	c.v.10%
Arr_t	C	2013	-3,619	-4,8	-4,58
Arr_t	T	2012	-4,124	-4,42	-4,11
Arr_t	C, T	2008	-3,802	-5,08	-4,82
ΔArr_t	C	2013	-3,852	-4,8	-4,58
ΔArr_t	T	2012	-4,354	-4,42	-4,11
ΔArr_t	C, T	2011	-4,268	-5,08	-4,82
Dep_t	C	2008	-3,468	-4,8	-4,58
Dep_t	T	2007	-3,337	-4,42	-4,11
Dep_t	C, T	2006	-3,163	-5,08	-4,82
ΔDep_t	C	2008	6,360	-4,8	-4,58
ΔDep_t	T	2012	-6,359	-4,42	-4,11
ΔDep_t	C, T	2008	-7,325	-5,08	-4,82

Source: Own elaboration.

The results of three tests indicate that tourist departures from the EU as well as tourist arrivals to the EU as time series are subject to structural changes. Focusing on structural breaks in a trend, or with a constant and in a trend at the same time, it was discovered that variables Dep_t and Arr_t demonstrate integration of order 1. Such a result of Bai and Perron and Andrews and Zivot tests directs econometric modeling towards threshold cointegration. Such a direction of modeling is also confirmed by Figure 1 and the result of Andrews and Zivot test for variable ECM_t, which also contains structural breaks with a constant and in a trend. Studying cointegration between Dep_t and Arr_t is not encouraged by the result of Perron test, (Table 1), according to which it is a non-stationary variable (Welfe 2013).

Structural breaks cause problems when one is going to forecast. In this case it was assumed that no structural break is going to occur in the forecasting horizon. That is why the time series have been shortened by 3 observations to leave them for forecasting. The stationary autoregressive models with structural breaks (AR_SB model, formula 12) were estimated using ordinary least squares method. They are presented in tables 4 (variable ΔDep_t) and 5 (variable ΔArr_t), respectively.

Tab. 4. Empirical autoregressive model for a variable ΔDep_t. Structural break – year: 2008

Variable	Coefficient	Standard error	t-Student	p-value
const	13,983	2,517	5,555	5,51E-05
DU_t	-17,883	5,103	-3,505	0,0032
DT_t	1,856	1,027	1,807	0,0908
ΔDep_{t-1}	-0,452	0,205	-2,201	0,0438

Source: Own elaboration.

Tab. 5. Empirical autoregressive model for a variable ΔArr_t. Structural break – year: 2012

Variable	Coefficient	Standard error	t-Student	p-value
const	10,629	2,849	3,731	0,0022
DT_t	6,757	2,559	2,64	0,0194
ΔArr_{t-3}	-0,443	0,240	-1,843	0,0866

Source: Own elaboration.

The results of forecasting are presented in tables 6, 7, 8 and 9. Tables 7 and 9 contain a summary of the relative ex post forecasting error (Wiśniewski, 2020), which shows the accuracy of the forecasts and the average absolute forecast percentage error (MAPE), typically used to compare forecasts made by two different methods (Hyndman and Athanasopoulos, 2018).

Tab. 6. Forecast $\Delta Dep_{T,P}$ and $Dep_{T,P}$

Year	Actual Dep_t	$\Delta Dep_{T,P}$ AR_SB model, tab.4	$Dep_{T,P}$	k=3 MA
2015	304,162			
2016	325,817	7,443	311,605	297,302
2017	346,751	9,440	321,045	299,291
2018	374,465	10,393	331,438	300,252

Source: Own elaboration.

Tab. 7. Ex post forecast relative error and MAPE for $Dep_{T,P}$ (values in %)

Year	AR_SB model	k=3 MA
2016	4,36	8,75
2017	7,41	13,69
2018	11,49	19,82
MAPE	7,76	14,09

Source: Own elaboration.

The results shown in table 7 indicate that ex post relative errors for AR_SB model are smaller than 10%, apart from the year 2018. On the other hand, the relative errors for moving average exceed 10% in the years 2017 and 2018. The MAPE for AR_SB is smaller than for MA, thus AR_SB model outperforms MA in the short run forecasting.

Tab. 8. Forecasted$\Delta Arr_{T,P}$ and $Arr_{T,P}$

Year	Actual Arr_t	$\Delta Arr_{T,P}$ AR_SB model, tab.5	$Arr_{T,P}$	k=3 MA
2015	438,992			
2016	459,146	29,95	468,942	417,663
2017	496,171	35,272	504,214	424,657
2018	519,571	41,568	545,782	427,104

Source: Own elaboration.

Tab. 9. Ex post forecast relative error and MAPE for $Arr_{T,P}$[in %]

Year	AR_SB model	k=3 MA
2016	2,134	9,035
2017	1,621	14,413
2018	5,045	17,797
MAPE	2,93	13,75

Source: Own elaboration.

The results shown in table 9 indicate that ex post relative errors for AR_SB model are smaller than 10%. On the other hand, the relative errors for moving average exceed 10% in the years 2017 and 2018. The MAPE for AR_SB is smaller than for MA, thus AR_SB model outperforms MA in the short run forecasting.

Discussion

Structural breaks are related with discontinuities which change the conditions of any activity. Also tourism industry is a subject of structural breaks. Their nature is both economic and non-economic. In the year 1995-2018 tourism industry in the European Union was on an increasing trend line however it was a subject of several structural breaks. According to the report presented by Eurostat nearly two out of three EU residents made tourism trips in 2018. Finland (91.0 %), the Netherlands (85.0 %), Sweden (84.9 %) and Luxembourg (81.1 %) were the leaders as concerns a share in participation in tourism in the EU. At the opposite end, less than half of the residents of Romania (27.0 %), Bulgaria (33.8 %), Greece (42.8 %), Portugal (44.8 %), Italy (44.9 %) and Croatia (46.5 %) participated in tourism (Tourism trips of Europeans, Eurostat 2019).

Applied tests for structural breaks indicated mainly the years of financial and economic recession 2008-2009 as well as the European debt crisis in 2013. Also year 1998 (Asian crisis) and 2004 (the EU enlargement) were indicated as statistically significant. It is worth noting that the date of EU enlargement in 2004 was known in advance and could be predicted. In general, structural breaks make forecasting difficult due to their unforeseen dates. However in the forecasting horizon which was since 2016 till 2018 no structural break was observed.

Thus forecasting was possible and brought reasonable results lover than 10% ex post relative forecasting error. A decision-maker can assume other level of acceptance the forecast, however maximum level of 20% cannot be exceeded. Forecasting of variables susceptible to structural breaks should not be done using the simplest methods.

There are many other non-linear models or linear models with cointegration which can be recommended and applied in future research. Also one-step ahead forecasting prepared systematically helps in monitoring forecasting accuracy. Proper construction of forecasts can to some extent prepare the tourism industry for structural breaks in future. Sometimes, particularly when the cause of discontinuity is external, it is however extremely difficult. Such a situation took place in the period of the COVID19 pandemic in 2020.

Conclusions

The study was focused on detection structural breaks and short term forecasting of tourist movements in the European Union. An important aspect of this study was to answer the question of what tools and forecasting methods to use to accurately predict future values of tourist departures and arrivals, which are highly susceptible to particularly negative shocks. In the years 1995-2018 the presence of structural breaks was confirmed by a set of statistical tests. These breaks were related with general economic conditions rather than with external phenomena. We can consider them as endogenous. The autoregressive model with structural breaks was proved as the acceptable tool for short run forecasting in the presence of structural breaks. However, the selection of tools and forecasting methods should be considered in the context of data availability and the length of available time series.

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