A C T A U N I V E R S I T A T I S L O D Z I E N S I S
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ANALYSIS OF TURNING POINTS ON THE EXAMPLE OF ARRIVALS OF TOURISTS FROM SLOVAKIA TO POLAND

Abstract. The purpose of this paper is to determine the turning points, their horizontal left- and right-side contiguity together with giving their various properties. They are illustrated on the numerical data concerning the arrivals of tourists from Slovakia to Poland in successive months in the years 1999 – 2006.

Key words: Turning points, times series, tourism.

I. INTRODUCTION

Many phenomena in tourism are characterised by different quantities, monotonicity and dynamics in the time where after the periods of increase there occur decreases and vice versa. For their description there are used the methods of analysis of time series. The places of changes of the general tendency of the tested phenomenon are called turning points. They are of the character of peak or valley points. For each of them there is singled out a horizontal contiguity of preceding and following time periods of various lengths.

At testing the turning points the analysis is possible: on the original data (this variant is applied in the paper), on the transformed data (e.g. logarithmically) and on the first, second, ... differences.

The purpose of this paper is to determine the turning points, their horizontal left- and right-side contiguity together with giving their various properties. They are illustrated on the numerical data concerning the arrivals of tourists from Slovakia to Poland in successive months in the years 1999 – 2006.

II. ARRIVALS OF TOURISTS FROM SLOVAKIA TO POLAND

Now we will assume that the data concerning the analysis of the time series are listed in the form of a two-dimensional table (matrix) **X** of the type *periods* × *years*. It is assumed that in the set matrix there are singled out K rows referring

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to the singled out periods in years (e.g. K = 4 – quarters, K = 12 - months) and L columns for years. Further, we will permanently assume K = 12. The typical element of the given matrix x_{ij} expresses here the quantity of the

tested phenomenon for the i-th month in j-th year, at $i = 1, 2, ..., 12;$ $j = 1, 2, ..., L.$

The basis for the analysis of turning points are the numerical data concerning the number of arrivals of tourists from Slovakia to (SLO→POL) in the years 1999-2006 (tab. 1).

Table 1. Arrivals of tourists from Slovakia (in thousands)

Months	1999	2000	2001	2002	2003	2004	2005	2006
I	145,0	105,2	113,3	69,8	81,1	138,3	108,4	97,5
II	119,2	163,9	123,0	100,2	89,2	183,5	121,2	95,5
III	375,0	296,4	228,5	152,7	139,9	308,0	172,5	171,6
IV	330,3	418,7	194,0	139,9	182,1	401,3	249,9	237,7
V	378,5	329,1	259,9	182,0	232,3	294,0	293,7	249,8
VI	313,0	293,4	222,0	158,5	200,5	363,8	264,7	256,0
VII	394,9	363,5	252,2	198,0	277,0	434,0	418,3	355,2
VIII	408,8	429,6	312,1	225,7	290,0	405,3	437,6	435,5
IX	407,6	317,4	223,6	192,2	244,7	377,5	343,3	317,1
X	615,1	463,3	314,0	307,9	423,3	497,4	413,8	407,4
XI	396,0	363,5	240,1	236,5	414,0	346,7	299,3	270,6
XII	350,9	295,9	159,5	162,6	322,2	297,1	251,6	193,2

Source: Author's elaboration on the basis of Institute of Tourism, www.intur.com.pl

For the data in table 1 there have been determined the basic numerical characteristics:

n	Min	Max	Average	Median	Standard deviation	Average – standard deviation	Average + standard deviation	Number of time moments	%
96	69,8	615,1	273,4	273,8	113,15	160,25	433,66	72	75,0

The data in the matrix **X** are transformed by the operation columns string (cs) to the column row vector **y**, writing successively the columns of the matrix **X** one under another, which is expressed as $csX = x$. The vector **x** contains n = 12 L elements, referring to n time moments. The data of the vector **x** containing $n = 96$ elements are presented in fig. 1.

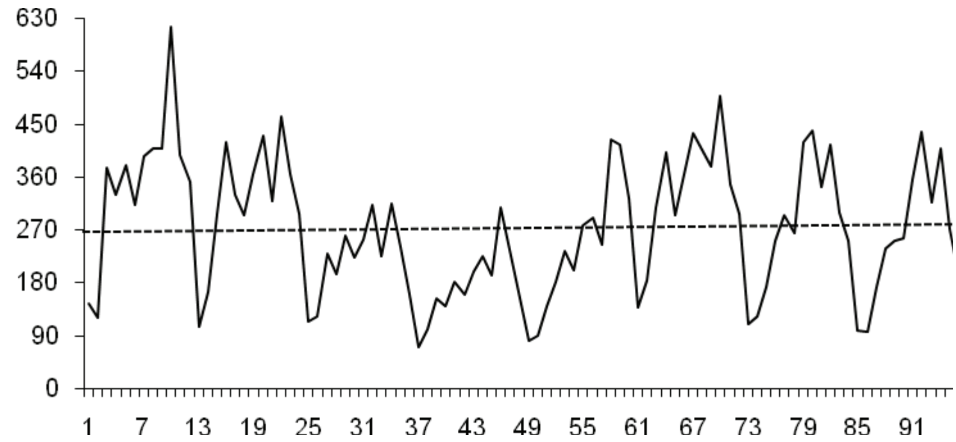


Fig. 1. Arrivals of tourists from Slovakia to Poland (in thousands) in the years 1999–2006
Source: Author's elaboration

The data in table 1 and the graphs 1 and 2 for SLO→POL lead to general conclusions:

- the lowest arrivals fall mainly in the months I and II, and the highest in X,
- the quantities of arrivals show some symmetry, which is indicated by almost identical values of the average and the median, and also by high concentration of data in the interval of one standard deviation (75,0 % of size of sample),
- fluctuation of quantities of arrivals in individual years are substantial, which is shown by the determined ranges, from 200,7 thousand in 2001 to 495,9 thousand in 1999.

The dynamics of border crossings SLO→POL shows the seasonal character in next years with high changes of decreasing of quantities of arrivals between the months X (max) and XI, XII, I (or II) (min). The changes in X in reference to IX are not high except 1999.

Assuming some characteristics of position x_0 (e.g. mean, quantile of α-th order) the matrix **X** transforms into the binary matrix **B** = (b_{ij}), where $b_{ij} = 0, x_{ij} < x_0;\ b_{ij} = 1, x_{ij} \geq x_0$. For the examined matrix **X**, we obtain the matrix **B** (shaded field) in the form:

Months	1999	2000	2001	2002	2003	2004	2005	2006	Suma
I	0	0	0	0	0	0	0	0	0
II	0	0	0	0	0	0	0	0	0
III	1	1	0	0	0	1	0	0	3
IV	1	1	0	0	0	1	0	0	3
V	1	1	0	0	0	1	1	0	4
VI	1	1	0	0	0	1	0	0	3
VII	1	1	0	0	1	1	1	1	6
VIII	1	1	1	0	1	1	1	1	7
IX	1	1	0	0	0	1	1	1	5
X	1	1	1	1	1	1	1	1	8
XI	1	1	0	0	1	1	1	0	5
XII	1	1	0	0	1	1	0	0	4
Total	10	10	2	1	5	10	6	4	48

Below the average level are the arrivals for I, II through all years and for III and IV for the years 2001-06, and in the month X through all years the arrivals are higher than the average. Below the average were the arrivals in the years 2001-02 except two and one months. The mentioned tendencies of the dynamics of arrivals are shown also in fig. 1.

III. DETERMINING THE TURNING POINTS AND THEIR TYPES

We introduce the following denotations:

- X – qualitative feature expressing the dynamics of the tested phenomenon,
- n – number of singled out time periods (moments) of the tested phenomenon,
- $x_1, x_2, ..., x_n$ – time series expressing the quantity of the tested phenomenon in successive time periods,
- i – number turning points (TP),
- *k, m* – numbers of expressions of the time series of preceding and following TP, i.e. left- and right-side horizontal lengths,
- $i-k, ..., i-1, i, i+1, ..., i+m$ – singled out time moments of the left- and right-side horizontal contiguity for *i*-th TP,
- *TP*(*k, m*) – TP with the set horizontal lengths.

Depending on the set *k, m* there are determined various types of TP. Among them there are singled out peak PZ (TPP) and valley TP (TPV) which are given by the set conditions of conjunctions on the quantities of the time series. For

TPP and PZV there are determined the ranges for left- and right-side horizontal time moments, applying for them the uniform notation by absolute values. We determine the following types of TP:

- ♦ *TP(1, 1)* – *1*-two-side horizontal TP (fig. 2):
- ❑ time moments: $i-1,\ i,\ i+1$
- ❑ *TPP*: $(x_{i-1} < x_i) \wedge (x_i > x_{i+1})$, *TPV*: $(x_{i-1} > x_i) \wedge (x_i < x_{i+1})$,
- ❑ $L = |x_{i-1} - x_i|$, $P = |x_i - x_{i+1}|$,

In the examined case the maximum number of TP is *n – 2*, and the numbers of TPV and TPP differ by 1 depending on what type of TP the time series begins with, and also on even parity or odd parity of the number of terms in the series. In this case it is enough to perform the operation *n* modulo *2,* which gives the remainder *0* for even numbers and *1* for odd numbers. The adequate numbers TPV and TPP are presented in table 2.

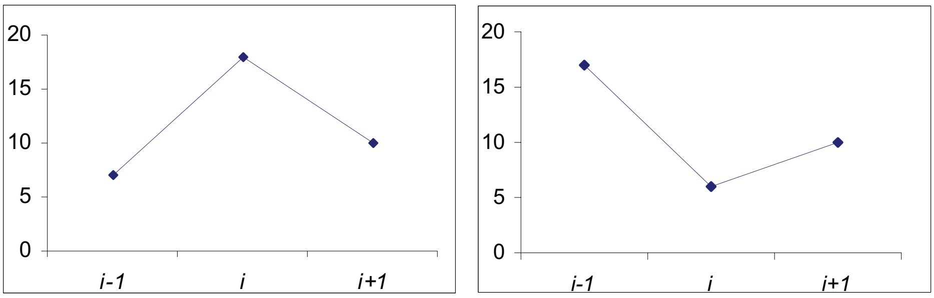


Fig. 2. TPP and TPV for TP(1, 1)

Source: Author's elaboration.

Table 2. Numbers of TPV(1,1) and TPP(1,1) at full randomness of the time series

Type of first turning point	Type of turning point	Quantity of time series	
		even	odd
TPP	TPV	$\frac{n}{2}-1$	$\frac{n-1}{2}-1$
	TPP	$\frac{n}{2}-1$	$\frac{n+1}{2}-1$
TPV	TPV	$\frac{n}{2}-1$	$\frac{n+1}{2}-1$
	TPP	$\frac{n}{2}-1$	$\frac{n-1}{2}-1$

Source: Author's elaboration.

- ♦ *TP*(*2, 1*) – *2*-horizontally left-side and *1*-horizontally right-side TP (fig. 3),
- ❑ time moments: $i-2,\ i-1,\ i,\ i+1$
- ❑ *TPP*: $(x_{i-2} < x_{i-1}) \wedge (x_{i-1} < x_i) \wedge (x_i > x_{i+1})$,
- ❑ *TPV*: $(x_{i-2} > x_{i-1}) \wedge (x_{i-1} > x_i) \wedge (x_i < x_{i+1})$,
- ❑ $L = | x_{i-2} - x_i |,\quad P = | x_i - x_{i+1} |$,

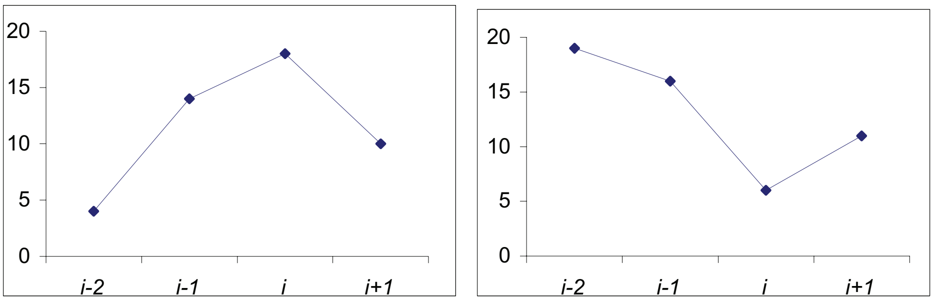


Fig. 3. TPP and TPV for PZ(2, 1)

Source: Author's elaboration.

- ♦ *TP*(*k m*) – *k*-left-side horizontal and *m*-right-side horizontal *TP*
- ❑ time moments: $i-k,\ldots,i-1,\ i,\ i+1,\ldots\ i+m,$,

$$TPS:\quad \left[\prod_{j=1}^{k}(x_{i-j} < x_{i+1-j})\right] \wedge \left[\prod_{j=1}^{m}(x_{i+1-k} > x_{i-j})\right],$$

$$TPP:\quad \left[\prod_{j=1}^{k}(x_{i-j} > x_{i+1-j})\right] \wedge \left[\prod_{j=1}^{m}(x_{i-1+j} < x_{i+j})\right],$$

- ❑ $L = | x_{i-k} - x_i |,\quad P =| x_i - x_{i+m} |$, where the symbol Π denotes the multiple conjunction.

Most often in the analyses of TP there are used equal horizontal lengths, i.e. at $k = m =1, 2,3, \ldots$.

IV. STATISTICAL ANALYSIS OF TURNING POINTS OF NUMERICAL DATA

We will carry out the analysis of TP together with their interpretation on the data presented in chapter 2. It will consist of determining the type of TP and giving the increases at the set horizontal lengths *k, m*. Calculations were made in the calculation sheet EXCEL according to Author's calculation formulas. The results were presented in the form of statements in order to reduce their excessive description.

TP(1,1) – *analysis of occurrences*

The data in table 1 are presented in the form of one time series (vector **x**) containing n =96 time moments, but: 1 – I,1999, 2 – II,1999, ..., 96 – XII, 2006. When comparing the sequences of values of three successive terms in the series there are localized TPV and TPP by inserting the element 1, when a given TP occurred or 0 in the opposite case, and TP is obtained by summation of the binary elements for TPV and TPP. Setting all TP ranges from II'1999 to XI'2006. The general calculation diagram is provided in the fragment of the statement:

Months	Nr	Data	TPV	TPP	TP	Series
I'99	1	145,0	0	0	0	
II'99	2	119,2	1	0	1	B
III'99	3	375,0	0	1	1	A
IV'99	4	330,3	1	0	1	B
…	…	…	…	…	…	…
IX'06	93	317,1	1	0	1	B
X'06	94	407,4	0	1	1	A
XI'06	95	270,6	0	0	0	B
XII'06	96	193,2				
Total		26 247	26	26	52	X

The given list shows singling out by 26 valley and peak TP and 52 TP in total. For each of the mentioned types of TP there are singled out the matrixes **D, S** and **P**. They are of the dimensions L × M, where $M \in \{1,2,...,12\}$. There is assumed for them the principle of omitting these months (columns) in which TP of a given type did not occur in all years:

Matrix **D**:

	I	II	IV	V	VI	IX	Total
1999	0	1	1	0	1	1	4
2000	1	0	0	0	1	1	3
2001	1	0	1	0	1	1	4
2002	1	0	1	0	1	1	4
2003	1	0	0	0	1	1	3
2004	1	0	0	1	0	1	3
2005	1	0	0	0	1	1	3
2006	0	1	0	0	0	1	2
Total	6	2	3	1	6	8	26

Matrix **S:**

	III	IV	V	VII	VIII	X	Total
1999	1	0	1	0	1	1	4
2000	0	1	0	0	1	1	3
2001	1	0	1	0	1	1	4
2002	1	0	1	0	1	1	4
2003	0	0	1	0	1	1	3
2004	0	1	0	1	0	1	3
2005	0	0	1	0	1	1	3
2006	0	0	0	0	1	1	2
Total	3	2	5	1	7	8	26

Matrix **P**:

	I	II	III	IV	V	VI	VII	VIII	IX	X	Total
1999	0	1	1	1	1	1	0	1	1	1	8
2000	1	0	0	1	0	1	0	1	1	1	6
2001	1	0	1	1	1	1	0	1	1	1	8
2002	1	0	1	1	1	1	0	1	1	1	8
2003	1	0	0	0	1	1	0	1	1	1	6
2004	1	0	0	1	1	0	1	0	1	1	6
2005	1	0	0	0	1	1	0	1	1	1	6
2006	0	1	0	0	0	0	0	1	1	1	4
Total	6	2	3	5	6	6	1	7	8	8	52

TP did not occur in two months XI and XII. In IX and X TP occurred through all years. Only once TP occurred in VII, and two times in II. The matrix **P** is obtained from summation of the matrixes **D** and **S** mutually corresponding columns referring to the individual months. At carrying out the operation of such a summation only the months IV and V occurred simultaneously in the matrixes **D** and **S.** Creating the product **DD’**, we obtain the symmetrical matrix of the dimensions L×L:

	1999	2000	2001	2002	2003	2004	2005	2006
1999	4	2	3	3	2	1	2	2
2000	2	3	3	3	3	2	3	1
2001	3	3	4	4	3	2	3	1
2002	3	3	4	4	3	2	3	1
2003	2	3	3	3	3	2	3	1
2004	1	2	2	2	2	3	2	1
2005	2	3	3	3	3	2	3	1
2006	2	1	1	1	1	1	1	2

The diagonal, which expresses the number of months in year with occurrence of TPV, and the extra-diagonal elements indicate the common number of months in the compared two years of occurrence of TPV. The analogical properties are given for the matrixes **SS’** and PP’. Similar interpretations are given for the matrixes **D’D**, **S’S** and **P’P,** where adequate comments are shifted to months.

The qualitative changes of the increase (A) or decrease (B) of the quantity of SLO→POL between the successive months are given by the series of letters A and B:

1-24		B	A	B	A	B	A	A	B	A	B	B	B	A	A	A	B	B	A	A	B	A	B	B
25-48	B	A	A	B	A	B	A	A	B	A	B	B	B	A	A	B	A	B	A	A	B	A	B	B
49-72	B	A	A	A	A	B	A	A	B	A	B	B	B	A	A	A	B	A	A	B	B	A	B	B
72-96	B	A	A	A	A	B	A	A	B	A	B	B	B	B	A	A	A	A	A	A	B	A	B	

There were obtained 94 series in total, and the letter A occurred 50 (53,2 %) times, and the litter B – 44 times (46,8 %). The longest 6-character series A occurred for the period III –VIII’2006, and for B it was the 4-character series in the period XI’2005 - II’2006. The total number of series is 47, and for A – 26, and for B – 27. The numbers of series of various lengths of letters A and B are given by the statement:

Lengths of series	1	2	3	4	6	Total
A	12	9	2	2	1	26
B	18	2	6	1	0	27

Higher number of the single series for B indicates that there often occurred the decrease of SLO→POL, and it happened even 6 times when there was observed the decrease of arrivals in the successive 3 months. For SLO→POL we obtained 26 TPV, 26 TPP and 52 TP, which constitutes 54,2 % of all time moments. The given number of TP allows deciding if the examined time series is stationary or not stationary. For this purpose we determine the average and the variance for the number of PZ (Yule and Kendall 1966):

$$\bar{z} = \frac{2}{3}(n-3), \quad s_z^2 = \frac{16n-29}{90}.$$

Adequate quantities are given in the statement:

Average	Variance	Standard deviation	Average –standard deviation	Average + standard deviation
62	19,74	4,09	57,91	66,09

from which it appears that the empirical number of 52 TP is not contained in the determined interval of standard deviations, which means that the tested time series is not stationary. Knowing the numbers of occurrences of TP for individual months we determined the relative frequencies which may be treated as the probability of the event that in a given month there will occur TZ, i.e. it is the quotient of the sum of one's by the number of examined years:

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
PZD	0,750	0,250	0,000	0,375	0,125	0,750	0,000	0,000	1,000	0,000	0,000	0,000
PZS	0,000	0,000	0,375	0,250	0,625	0,000	0,125	0,875	0,000	1,000	0,000	0,000
PZ	0,750	0,250	0,375	0,625	0,750	0,750	0,125	0,875	1,000	1,000	0,000	0,000

To test how TP distribute for the differences of time moments of their occurrence, we acted in the following way:

a) for a given type of TP we determined the lengths of intervals of occurrence,

b) we ordered the length from a) non-decreasingly,

c) from the sample in b) we created the point distributive series of {Lengths of intervals | Quantity}.

Adequate intervals are given in the statement:

TPV		TPP		TP	
Intervals	Number	Intervals	Number	Intervals	Number
2	5	2	10	1	28
3	8	3	8	2	12
4	8	4	1	3	8
5	4	5	2	4	3
7	1	6	2	6	1
		7	2		
		10	1		
Total	26	Total	26	Total	52

The selected numerical characteristics for the mentioned series amounted to:

Characteristics	TPV	TPP	TP
Arithmetic average	3,58	3,62	1,81
Standard deviation	1,21	2,08	1,10
Average - standard deviation	2,37	1,54	0,70
Average + standard deviation	4,78	5,70	2,91
%	76,92	80,77	76,92

where % denotes the estimated number of occurrences in the interval of 1-standard deviation. On average, every 3 – 4 months there occur TPV or TPP and every 2 months TP. The highest variability characterises the lengths of intervals for TPP. High probability of shaping of the lengths of intervals occurs for TPV and TP.

PZ(1,1) – *analysis of increases of contiguity*

Now we will move to the analysis of increases of left- and right-side contiguity for PZ (1,1), i.e. the differences in the number of arriving persons between the preceding and following adjacent months and occurring from the month of localization of PZ. Adequate calculations of the differences are given in the fragment of the statement:

Nr	Arrivals	PZD	PZS	PZ	PZD		PZS		PZ	
					L	P	L	P	L	P
1	145,0									
2	119,2	1	0	1	25,8	255,8	0	0	25,8	255,8
3	375,0	0	1	1	0	0	255,8	44,7	255,8	44,7
4	330,3	1	0	1	44,7	48,2	0	0	44,7	48,2
…	…	…	…	…	…	…	…	…	…	…
93	317,1	1	0	1	118,4	90,3	0	0	118,4	90,3
94	407,4	0	1	1	0	0	90,3	136,8	90,3	136,8
95	270,6	0	0	0						
96	193,2									

There occur considerable differences for the particular types of TP. Beside the low values there occur also very high ones. These differences were analysed from the perspective of the type of distributions in the following way:

a) the values of the differences were ordered into the increasing sequence,

b) for this sequence there was constructed the distributive series together with the histogram of quantity, with the use of the procedure *Histogram* in the menu *Tools* | *Data Analysis* of the program EXCEL,

c) in the obtained time series, the class quantities were replaced with class frequencies, and then there were drawn the histograms of frequency (fig. 4).

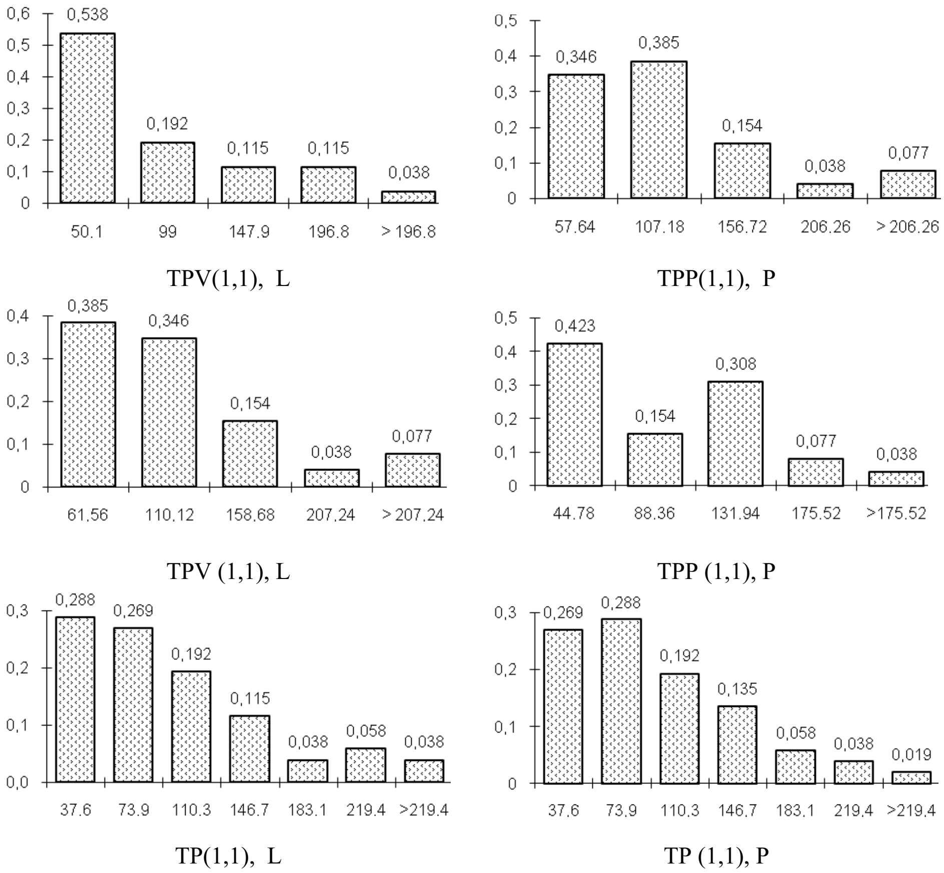
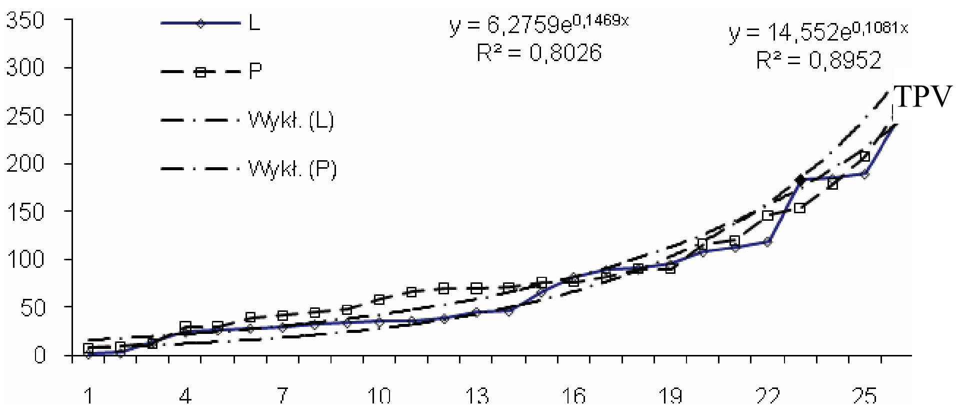


Fig. 4. Histograms of frequency for differences of quantities of arrivals of left- and right- side contiguity of PZ

Source: Author's elaboration

In fig. 4 there are given the histograms for PZD, PZS and PZ in general for the differences in SLO→POL arrivals on the left and right sides of PZ. The given histograms lead to the following findings:

- the distributions for the left and right contiguities of PZD and PZS are considerably diversified, and for PZ in general there occur high similarity,
- the class intervals for PZ are identical, and the corresponding to each other frequencies for the left and right contiguities of PZ differ slightly,
- the values of the successive differences for the left and right contiguities are well approximated with the exponential trends (fig. 5).



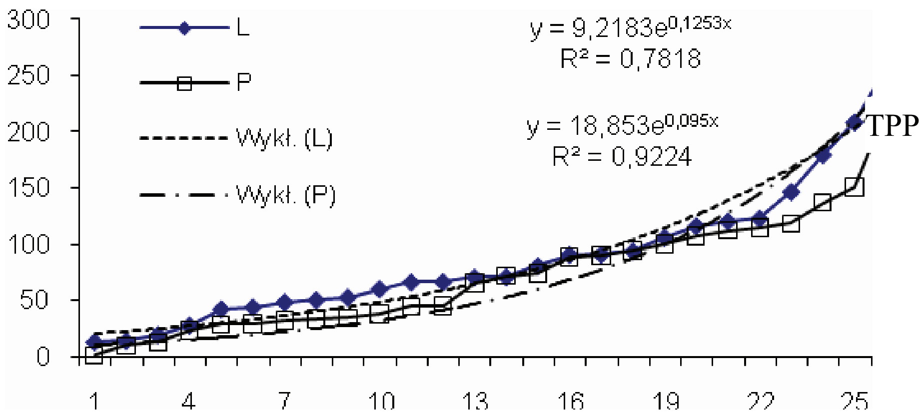


Fig. 5. Estimated exponential trend for differences in arrivals in neighbourhood of PZ
Source: Author's elaboration.

PZ(2,2) – *analysis of occurrences*

In this analysis we will indicate only some results which are given in the statement in which there are marked all TP(2,2). There are 10 of them in total, including 8 TPVand 2 TPP:

No.	Date	x	TPV	TPP	TP	TPV		TPP	
						L	P	L	P
13	I'2000	105,2	1	0	1	290,8	191,2	0	0
16	IV'2000	418,7	0	1	1	0	0	254,8	292,4
18	VI'2000	293,4	1	0	1	125,3	136,2	0	0
25	I'2001	113,3	1	0	1	250,2	115,2	0	0
37	I'2002	69,8	1	0	1	170,3	82,9	0	0
49	I'2003	81,1	1	0	1	155,4	58,8	0	0
61	I'2004	138,3	1	0	1	275,7	169,7	0	0
67	VII'2004	434	0	1	1	0	0	140	376,5
73	I'2005	108,4	1	0	1	238,3	64,1	0	0
86	II'2006	95,5	1	0	1	156,1	142,2	0	0
Total	X	X	8	2	10	X	X	X	X

The given statement contains also the differences for left and right contiguities. Most often TP occur here as much as 6 times for the month I and they were only TPV. It is connected with the characteristic dynamics of SLO→POL from the month IX to the end of each year which we indicated earlier at the analysis of TP(1,1). In some cases (e.g. TPV for II'2006) they have almost equal horizontal lengths of left- and right-side contiguities, and in others (e.g. I'2005) there occur high differences in lengths of such horizons of contiguity.

SUMMARY

The analysis of turning points, which was carried out in the paper, on the empirical data concerning the number of arrivals of tourists from Slovakia to Poland indicated their high significance at interpretation of various characteristic changes which occur in months in individual years. High number of valley and peak turning points indicates various dynamics and tempo of changes of the tested phenomenon in time. It concerns in particular the changes which occur in months in individual years.

The analysis of the differences in the quantity of arrivals in the contiguity of turning points allows indicating orders of magnitude of changes, and also if they occur with equal power at both sides of turning points. Such differences for left and right sides of turning points indicate the exponential trend. Its matching to the mentioned empirical data turned out to be quite good.

To draw attention to how the turning points for arrivals of tourist from abroad behave we should take for comparison the tourist traffic of other countries neighbouring with Poland. Such an analysis will be carried out in other papers.

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ANALIZA PUNKTÓW ZWROTNYCH NA PRZYKŁADZIE PRZYJAZDÓW TURYSTÓW ZE SŁOWACJI DO POLSKI

Wiele zjawisk w turystyce charakteryzuje się różną wielkością, monotonicznością i dynamiką w czasie, gdzie po okresach wzrostu, następują spadki i vice versa. Do ich opisu stosuje się metody analizy szeregów czasowych. Miejsca zmian kierunków ogólnej tendencji badanego zjawiska nazywa się punktami zwrotnymi. Mają one charakter punktów szczytowych lub dolinowych. Dla każdego z nich wyróżnia się horyzontalne sąsiedztwo okresów czasowych poprzedzających i następujących o różnej długości.

Przy badaniu punktów zwrotnych możliwa jest analiza: a) na danych oryginalnych (ten wariant jest zastosowany w pracy), b) na danych przekształconych (np. logarytmicznie), c) na pierwszych, drugich, ... różnicach. W przypadkach a) i b) liczba punktów zwrotnych będzie jednakowa, ale będzie ona znacznie różnić się przy stosowaniu pierwszych różnic, czyli dla przypadku c).

Celem pracy jest określenie punktów zwrotnych, ich horyzontalnego lewo- i prawostronnego sąsiedztwa wraz z podaniem różnych ich własności. Zostały one zilustrowanie na danych liczbowych dotyczących przyjazdów turystów ze Słowacji do Polski w kolejnych miesiącach w latach 1999–2006.