Criteria for evaluating the significance of transport infrastructure in precedence analysis

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Abstract. The precedence analysis enables to find new links and relationships in the evaluation of selected variables. The most important finding is the impact of changes in the values on the surroundings. The basis for precedence analysis is the definition of system objects, elements and relationships. The system is then transformed into incidence matrices. Because of examining the changes that have occurred in the selected variables in a certain time interval, we analyze the mutual influence of the relative and absolute changes in the values of the selected element to the neighboring elements. Based on relative and absolute values of these changes, we can determine the increases or decreases directions of these variables in the system. Then we are able to examine antecedents (precedences), consequents (successions) and multiple precedences and successions. The problem in assessing the transport infrastructure is the choice of criteria and their weights to determine the significance of transport infrastructure in the region and the subsequent search of the significance of changes in the time interval. In this paper we deal with changes in road infrastructure, increase or decrease of highways, expressways and I, II., and III. class roads. The search of weights for these transport structures is also presented in the paper.

Keywords: precedence, sukcedence, cities with extended authority, infrastructure.

JEL **Classification**: O18, C65
AMS **Classification**: 65C20

1 The method and tools

In the frame of dissertation and few projects there is the analysis of traffic infrastructure impact on a region development. Precedence analysis was used as a method. Relations of selected quantities between the cities with extended authority (CEAs) in Moravian – Silesian region are being analyzed.

If we are working in the system with relations, it is if there is a mutual effect on each other, we can describe structural and time precedences and subsequences of effects. The matrix for precedence description is commonly called the precedence matrix, for capturing subsequences the succedence matrix. Matrices can be binary, and these are being used in non evaluated graphs. In evaluated graphs is either being used transcription into numerical matrices or into combination of a binary matrix and a numerical vector, describing flows. The special case is the flow matrix, in which a write using values of „1“, „0“ and „-1“ is being used.

In precedence matrix (resp. succedence matrix) is value „1“, if a row element is a direct precedence (resp. subsequence) of a column element. In other cases we write nothing into the matrix (in some cases, we write value „0“, if it is necessary for mathematical processing)[3].

Precedence matrices are used s a tool, allowing effective work with heterogeneous quantities. Matrices serve for identification and record of relations and their orientation in the system. The basis for the analysis is a finding of direct relations between analyzed subjects, then the basic unitary flows of tracked quantities are determined on the basis of uneven progress of these subjects in time. The defining of flows was done by comparison of tracked data of elements with a relation (adjacent CEA) in selected times. Data growths or falls were expressed for the data in percent and by comparison of these quantities the course of particular quantity flow was determined. From the identification of growth and fall between CEA the precedences and succedences are determined.

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[3] Own principles and mathematical apparatus are more closely described in [1], [3] , [5] a [7].

1.1 Data basis

Calculations were performed upon the data, available in the databases of Directorate of Roads and Highways and Department of Transportation. For model construction, map materials from the portal of public administration of MSR were used. Data come out from planned changes in infrastructure between 2004 to 2013.

As default standards for weight (rate) of CEA infrastructure change determination was used specification of road network to highways, speed roadways, 1st, 2nd, and 3rd roadways, their increase (or decrease) in a region. It was evaluated, if there is a connection of particular roadway and other parts of infrastructure inside and outside CEA, whether there is a connection to an infrastructure with higher significance rank (European, TEN-T[4], transeuropean networks, corridors, etc.). Next factor was the number and placement of slip roads, new roadways integration into regional and local structures (bypasses, through roads, etc.) and creating of particular infrastructure types. Also the negative traffic impacts of transitive character were assessed. A coefficient of region significance was used for determination of flows (density and quality of infrastructure and connection onto other structures)[5] in case that particular CEAs had not construction at disposal in selected period.

A weight table of infrastructure growth for particular CEAs was created on the basis of selected group of standards. The region significance coefficient (density and quality of infrastructure and connection to other structures) was used in case that relevant CEAs did not have construction in selected time period.

1.2 Precedences and multiple precedences

On the basis of determined weights there was calculated the value determining the growth of traffic infrastructure for every CEA. After the calculation of relative changes between adjacent CEAs, the precedence matrix was created. The matrix has 23 rows and columns, rows and columns consist of a listing of 22 CEAs and their surroundings. In every matrix row was a value „1“ entered in the case, that row CEA precedes column CEA in the meaning of tracked quantity (has lower value of this quantity). By calculation of particular precedence matrix power were multiple precedences found. Multiple precedences show the range of tracked quantity changes in particular CEA onto the surrounding. The existence of precedence of particular length points to the existence of a track in the system. This track length is equal to power of particular precedence matrix. During transition between particular CEAs, there is always a growth of particular quantity.

Upon a binary multiplication[6] there are the existences of particular length precedences determined between particular CEAs. By classic multiplication of matrices we will obtain a frequency of these precedences between particular CEAs. For the analysis were powers calculated to the exponent of 8. Further powers of matrices contained only null values.

2 Weight adjustments of particular traffic roadway types

When determining the weights for particular traffic roadway types and their impact on the surrounding, four main variants were examined.

Variant 1

The variant allowed for spinal connections and an existence of roads of higher significance.
Basic weights of particular changes in CEAs were determined as follows: D = 5, R= 4, I. = 3, II. = 2, III. = 1, influence on the surrounding = 2. Changes in regions were points awarded according to their range and edited according to weights. To prevent casual concurrence in adjacent (MRP), the region significance coefficient was added in 0.2 to 1.5 interval, determined on the basis of CEAs inhabitants, location and size.

Variant 2

In next analysis there were adjusted the weights of slip roads. The aim was to allow for connecting of CEA onto spinal roadway. The variant allows for spinal connections and their connection onto existing infrastructure in given locality (number of slip roads). In this case was the weight of existing slip roads increased from a value „3“ to a value „6“.

[4] TEN-T / Transport infrastructure, available at: http://ec.europa.eu/transport/infrastructure/index_en.htm, online 20.10.2011

[5] In more detail for example in literature [6].

[6] In more detail for example in literature [1]

Variant 3

This variant includes the negative impact of a highway in the case, that it is only a transitive roadway. The weight of highway stretches without connection to traffic infrastructure of a region was decreased to „1“, highway stretches with connection to existing infrastructure have still a value of „6“.

Variant 4

Last variant determines the weights so that it concludes to advantage of regional traffic.

Connection of a highway to existing infrastructure = 6 without slip roads, R and I. = 4, II. And III. = 2.

Upon the growth of particular infrastructure type and particular weights it concluded in 2004-2013 period to quantification of traffic infrastructure growths. Values for tracked 4 variants of weights are in the table 1.

ORP	Bílovec	Bohumín	Bruntál	Český Těšín	Frenštát pod Radhoštěm	Frýdek-Místek	Frýdlant nad Ostravicí	Havířov	Hlučín	Jablunkov	Karviná
number ORP	1	2	3	4	5	6	7	8	9	10	11
analysis 1	54	76	0.3	24	0.2	55	0.2	7.2	0.2	14	6.2
analysis 2	60	91	0.3	24	0.2	55	0.2	7.2	0.2	14	6.2
analysis 3	28	59	0.3	24	0.2	55	0.2	7.2	0.2	14	6.2
analysis 4	28	64	0.3	26	0.2	58	0.2	10	0.2	18	8.2

ORP	Kopřivnice	Kravaře	Krnov	Nový Jičín	Odry	Opava	Orlová	Ostrava	Rýmařov	Třinec	Vítkov
number ORP	12	13	14	15	16	17	18	19	20	21	22
analysis 1	35	0.1	9.1	59	24	33	0.4	87	0.1	17	4
analysis 2	35	0.1	9.1	62	24	33	0.4	102	0.1	17	4
analysis 3	35	0.1	9.1	46	8	33	0.4	74	0.1	17	4
analysis 4	40	0.1	12	50	8	44	0.4	85	0.1	22	4

Table 1 Quantification of traffic infrastructure growths

2.1 Precedence changes for particular weight variants

Table 2 shows the numbers of precedences of available lengths. Numbers are stated upon binary and standard multiplication of matrices. In the left part of the table are changes of precedence number without multiplication between identical predecessors and successors. In this case, at the existence of particular length precedence without multiplication between two CEAs is their existence recorded. In the right part are the changes in multiple precedences. In this case is their number recorded at the existence of particular length precedence between two CEAs.

number of precedences given length								
lenght	1	2	3	4	5	6	7	8
analysis 1	62	114	85	53	32	13	2	0
analysis 2	62	102	82	56	31	12	4	0
analysis 3	62	100	63	32	15	4	1	0
analysis 4	62	108	71	43	26	10	3	1

number of multiple precedences given length								
lenght	1	2	3	4	5	6	7	8
analysis 1	62	146	199	184	100	30	4	0
analysis 2	62	130	161	132	69	24	4	0
analysis 3	62	131	135	83	36	12	2	0
analysis 4	62	139	159	120	68	27	7	1

Table 2 Numbers of precedences of different length

It is clear from the Figure 1 that many changes of traffic infrastructure in chosen time interval manifest mostly to distances of second precedences. Variant 3 with allowing for the negative impact of transitive roadways has the lowest number of precedences at all levels of precedence (at all track lengths) and affects the least surrounding CEAs. Largest impacts on direct surrounding have variants 1 and 4, variant 2 has larger influence (in comparison of all variants) on more distant CEAs. For next analysis there are equations of regression added, formed by 6^{th} order polynoms. These equations are used in further analysis for finding a similarity with other examined quantities.

The Figure 2 compares the numbers of multiple precedences. At this evaluation is the largest impact on surrounding at variant 1, smallest impact, again, at variant 3. It is clear from the graph, that largest numbers have precedences of length 3, at variant 1 and 2 even precedences of length 4. Consequently, between particular CEAs, more distant relations occur in larger number of combinations.

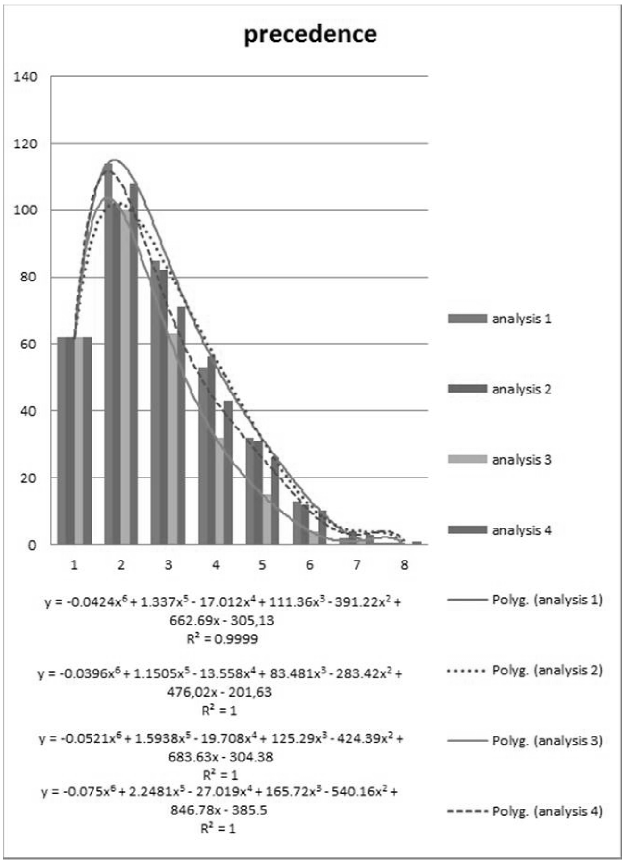

Figure 1 Number of different length precedences

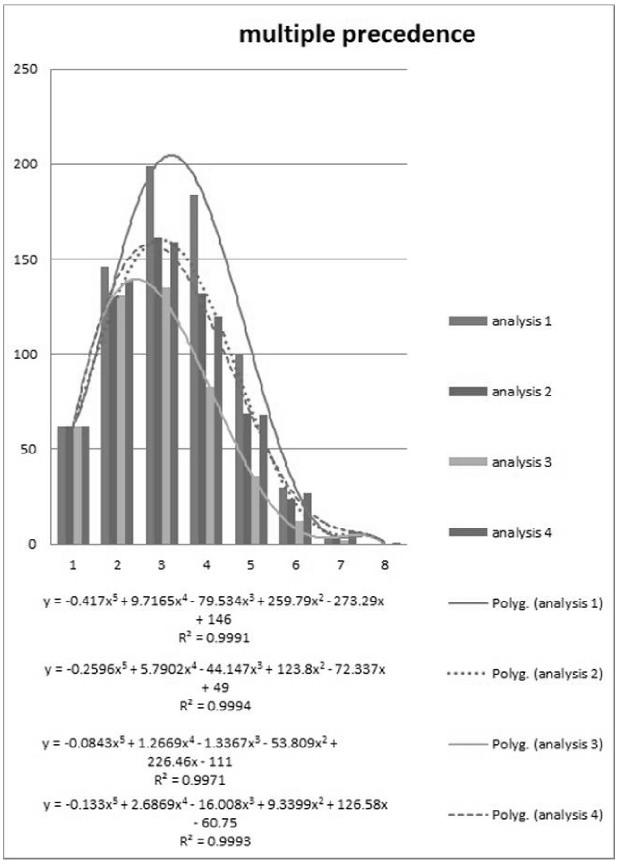

Figure 2 Number of different length multiple precedences

Following graphs represent gradually the changes of impacts according to particular CEAs. These graphs show the number of precedences and multiple precedences between the various CEAs. The first and third line shows the precedences, second and fourth line shows the multiple precedences.

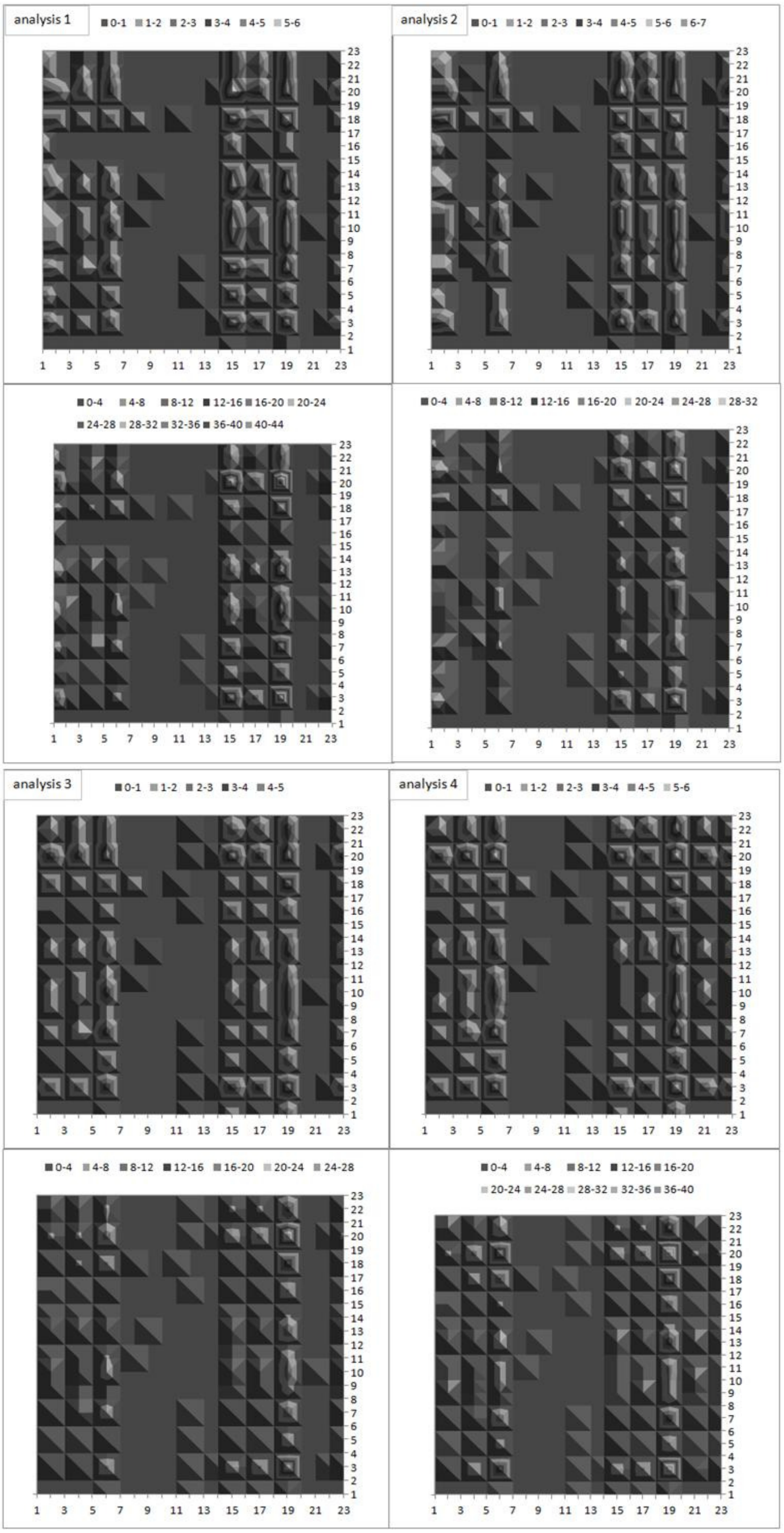

Figure 3 Influence of particular CEAs on different CEAs

3 Conclusion

It is clear from the graphs, that largest impact have the CEAs 1, 2, 6, 12, 15, 17, 19 and it is in all the variants of weights with minimal differences. Largest impact on the surrounding has, therefore, in MSR the construction of D1 and R48 highway.

What is for the whole precedence number, is that the largest impact is recorded at CEAs 6, 15 and 19. It is clear here, that changes of traffic infrastructure are concentrated to large cities.

The proposed method is based examination of change impacts on surrounding, its number and length. The results of analysis are possible to compare with analysis of different, seemingly heterogeneous quantities, at which we examine, again, the number and range of changes. The expression of impacts using the precedences will allow finding similarities in different quantities behavior on surrounding. In relation to investigation of changes in time interval we can analyze also the inertia of changes and time slips between changes at different quantities.

References

[1] Borje, L.: *Theoretical analysis of information systems*. Bratislava: Alfa, 1981.
[2] Botlík, J:. Opportunities of using analytical methods in logistic analysis of region . *Acta Academica* **1** (2011) Karviná: OPF Karviná, 2011, 25-36.
[3] Botlík, J.: Precedence, as a tool for analysis of a system using matrices. In: *Electronic conference E - CON Internactional Masaryk's Conference for doctorands and young scientific workers.* Hradec Králové: MAGNANIMITAS, Hradec Králové, 2010, 292-298.
[4] Botlík, J.: Precedence matrices and their analogy in bipartitionary graphs. In: *PEFnet 2010, 14. class - European Scientific conference of Doctors grade study listeners.* Brno: Mendels University, 2010,
[5] Botlík, J.: Specific analytical tools in logistics. In: *Compilation III. international scientific conference Conference for doctorands and young scientific workers of OPF Karviná.* Karviná, OPF: OPF Karviná, 2010, 65-77.
[6] Botlík, J., Botlíková, M.: Precedental regional analysis in caring economics. In: 7th International Symposium on Business Administration, Canakkale, Turkey, 2012, 206 - 224.
[7] Unčovský, L.: *Modely sieťovej analýzy,* Bratislava: Alfa 1991