CHINESE GEOGRAPHICAL SCIENCE
Volume 12, Number 4, pp. 366 – 372, 2002
Science Press, Beijing, China

ALTERNATIVE METHODS FOR CONDUCTING COMPARATIVE ANALYSES OF CADASTRAL SYSTEMS

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ABSTRACT: The conception of an efficient cadastral system is an important element in the development of each country. It is crucial for the efficient operation of the real estate market—the security and liberty of making transactions, registering a property, planning operations, the introduction of an *ad valorem* tax on property and more rational use of space. In Europe there are different types of cadastral systems, because the countries in Europe have different cultural backgrounds, different economical and social backgrounds. Through the centuries, many types of cadastral systems evolved and their differences often depend upon local cultural heritage, physical geography, land use, technology, etc. Comparative analyses of cadastral systems have been the subjects of many publications and studies in world literature. It was assessed that the useful tools in conducting comparative analyses of various cadastral systems include the procedures of statistical inference. This paper presents the results of a project to compare the performance of ten cadastral systems internationally by creating appropriate integrated indicators of a cadastral system using statistical technique. Such indicators will make it possible to compare different cadastral systems and present them hierarchically in relation to their quality, structure, as well as legal, organizational and technological solutions. From a good number of methods available, techniques originating from two spheres of statistic inference were selected: distribution free methods and multivariate analysis methods. For analyses with the distribution free methods, FRIEDMAN's test (FRIENDMAN's non-parametric variance analysis) as well as KENDALL's test (KENDALL's compatibility ratio) were selected. For analyses with the multivariate analysis methods, factor analysis was selected.

KEY WORDS: cadastral system; comparative analyses; statistical techniques; indicators; property

CLC Number: P283.5 Document Code: A Article ID: 1002-0063(2002)04-0366-07

1 INTRODUCTION

The comparative analyses of cadastral systems have been the subjects of many publications and studies in world literatures (LARSSON, 1991; GAŹDZICKI, 1995; STEUDLER *et al.*, 1998; MOLA, 1998; BOGAERTS, 1998).

One of the less complex methods in comparative analyses of cadastral systems consists of comparing two or three principal cadastral systems by providing accurate characteristics of those systems. Subsequently, on this basis, in the form of either verbal or table-illustrated description, conclusions related to similarities and differences between the systems are presented. The principles of this method were used by HESSE and WILLIAMSON (1990), who analyzed cadastral solutions in use in Australia and New Zealand, DALE(1995), in Bulgaria, Hungary and Romania, while ZEVENBERGEN(1998), in the following four countries: Austria, Ghana, Holland, and Indonesia.

Another technique in use requires gathering appropriate information, and presenting it in the form of consolidated sheets, which normally determine the percentage share of each element, phenomenon, or trend, compared to the general population. This technique was used in such exemplary publications as 'Inventory of Land Administration Systems in Europe and North America' by MOLA (1998), as well as 'Cadastre 2014, a Vision for a Future Cadastral System' by International Federation of Land Surveyors (KAUFMANN and STEUDLER, 1998), both of which,

Received date: 2002-04-05
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on the basis of information obtained from 40 and 31 countries respectively, arrived at the following results: all the countries have a system of property registration; 45% of countries register transactional prices of real estate; 69% of countries have either computerised or semi-computerised real-estate registers; 59% of countries keep real-estate registers on the central level; 69% of countries have either totally computerised or semi-computerised registers; 56% of countries administer the registers centrally, and 44% regionally; 95% of countries have their entire territories covered by land surveying networks; and 23% of countries have their territories entirely covered by digital maps.

In some works, information about cadastral systems is processed into suitable indicators and only as such are they subject to further comparative analyses. "Benchmarking Cadastral Systems", the publication of the International Federation of Land Surveyors (STEUDLER *et al.*, 1998) determines, among others, the following types of indicators: the ratio of population to the number of plots for a given country; the ratio of the number of transactions to the number of plots for a given country; the ratio of the number of disputes over plot borders to the number of plots for a given country; the ratio of the extent to which the territory of a given country is covered by maps to the number of maps in digital form; the ratio of the number of land surveyors to the population of a given country; the ratio of the number of notaries to the population of a given country.

Comparative analyses were carried out separately for each of the ratios determined in this manner. As a result, analysts were able to produce graphs showing values of the relevant indicators specified for each of the 53 countries under analysis, and located in the graphs in ascending order, from the lowest to the highest value.

In view of the existing methods and techniques used by various scientific and professional organisations as well as individual surveyors in the process of comparative analyses of cadastral systems, the following conclusions may be drawn:

1) Comparative analyses constitute a significant element of examining cadastral systems; 2) the methods and techniques currently in use allow for a detailed comparative analysis of cadastral systems only in the aspect of single attribute or indicator; 3) there are no indicators which would characterise the cadastral system as a whole.

The conclusions mentioned above impose the necessity of conducting research in order to make comparative analyses of cadastral systems, which would allow for determination of integrated indicators to characterise the entire system. Such indicators will make it possible to compare different cadastral systems and present them hierarchically in relation to their quality, structure, as well as legal, organisational and technological solutions. They also make it possible to determine the position of Polish cadastral solutions in relation to those of other countries. Thus, if the proposed analyses results in a number of leading countries implementing cadastral reforms, all the experiences and all the original solutions applied in cadastral systems of those countries should be used for the purpose of introducing the best possible cadastral solutions in Poland.

2 APPLIED RESRARCH METHODS

It was assessed that the useful tools in conducting comparative analyses of various cadastral systems include the procedures of statistical inference. From a good number of methods available, techniques originating from two spheres of statistic inference were selected: distribution free methods and multivariate analysis methods.

The distribution free methods were examined in order to find those allowing simple and adequate methods of conducting tests to establish the significance of differences between the specific cadastral systems in question. The basic criterion for selection of the suitable test was the algorithm for selection of difference significance test, as illustrated in Fig. 1.

For analyses within the distribution free methods, FRIEDMAN's test (FRIEDMAN's non-parametric variance analysis) and KENDALL's test (KENDALL's compatibility ratio) were selected. That choice resulted from the fact that the number of countries under analysis (comparative groups) meet the condition > 2, and that the scale used for describing the data characterising cadastral systems is of a hierarchical nature.

What constitutes the foundation of FRIEDMAN's variance analysis is the ranking system. The least significant observation within each attribute is ranked 1, the second in ascending order is ranked 2, and the greatest is ranked k (ACZEL, 2000). The number of ranks for each attribute is further summed up, and the sums are marked R_1, R_2 ... R_k respectively. The differences between the ranks are measured with the use of FRIEDMAN's test statistics, marked as X^2, according to the following formula:

$$X^2 = \frac{12}{nk(k+1)} \sum_{j=1}^{k} R_j^2 - 3n(k+1) \qquad (1)$$

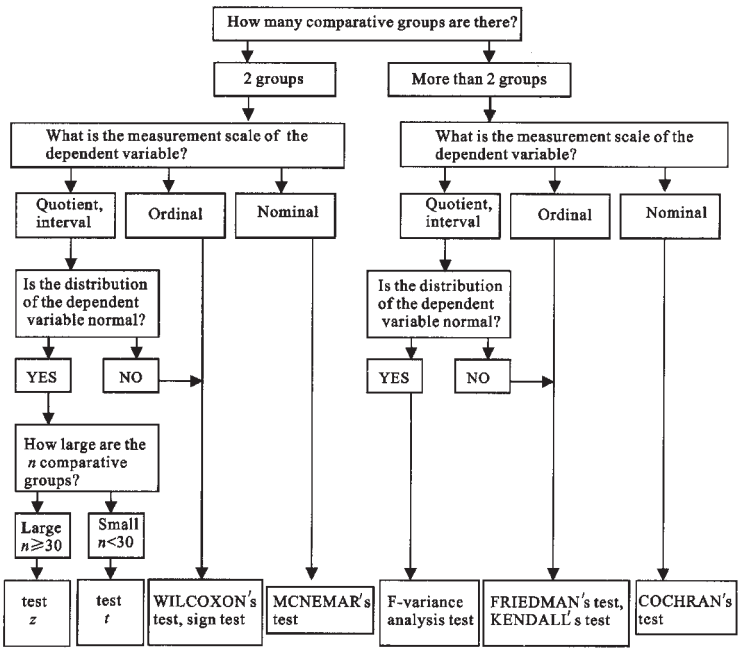


Fig. 1 The algorithm for selection of difference significance test

Source: Private study based on WALIGÓRA, 1985

where n — number of phenomena in question; k — number of variables describing the phenomena; R_j — sum of ranks in this measurement of the variable.

KENDALL's test includes the so-called KENDALL's compatibility ratio, which measures the similarities between the tested phenomena. Mathematically, this ratio is an arithmetic average of all ratios of SPEARMAN's rank correlation, marked as r_s, and determined from the following formula:

$$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(k^2 - 1)} \qquad (2)$$

where n — number of observations; d_i ($i = 1, 2 \ldots n$) — difference between ranks of the tested variables x_i and y_i.

Further stages of comparative analyses involved statistic algorithms from the multivariate analysis methods, which include the following techniques of statistic inference: 1) multivariate analysis of variance; 2) discriminate analysis; 3) factor analysis; 4) cluster analysis; 5) conjoint analysis; 6) canonical correlation analysis; 7) multi-dimensional scaling.

Comparative analyses, designed principally to determine integrated indicators which would characterise the entire cadastral system, were assessed to require factor analysis, as it "... constitutes a set of statistic methods and procedures allowing for conversion of a large number of variables, tested to a significantly smaller number of independent factors or main components which preserve a considerable amount of information conveyed in the primary variables." (MYNARSKI, 1999; WALESIAK, 1996). The fundamental objectives of the classic factor analysis include: identification of common factors hidden in a set of variables; reduction of the spatial dimensions of variables; ortogonalisation of the space in which the tested objects are considered; identification of the character of variables; transformation of the set of variables into a new set of main components with respect to quality; graphic presentation of the set of multidimensional observations.

Factor analysis enables such a conversion of a given mutually correlated set of variables that will result in a new set of variables (main factors or components), which would not be mutually correlated, but comparable to the initial set (SOKOLOWSKI and SAGAN, 1999). If this statistic method is applied, it is possible to reduce the number of attributes describing cadastral systems down to a few integrated indicators, which preserve their descriptive qualities, despite the reduction of variables that has taken place. In the process of such statistic analysis, what are formed are arithmetic models (in the form of linear formulas) describing the structure of multi-dimensional arrangements.

Comparative analyses of cadastral systems with the use of FRIEDMAN's variance analysis, KENDALL's compatibility ratio and factor analysis were conducted according to the following procedure, consisting of three

basic tasks: determination of the set of attributes characterising cadastral systems; preparation of a set of indicators characterising cadastral systems; calculations.

2.1 Determination of a Set of Attributes Characterising Cadastral Systems

The first stage of analyses of various cadastral systems required determination of attributes rendering the essence of those systems most effectively. One of the sources of data for conducting comparative analyses was a publication of MOLA (1998), which contained responses from 40 countries related to their cadastral systems. By courtesy of Mr. STEUDLER, secretary of Group 7.1 within Commission 7 the International Federation of Land Surveyors, as well as Mr. KAUFMANN and Mr. WILLIAMSON, it was possible to access the data of two collections of information regarding cadastral systems. The first "Summary of Questionnaire Responses" constituted the basis for the publication of the International Federation of Land Surveyors (KAUFMANN and STEUDLER, 1998), while the other "Cost Recovery and Privatisation" was the basis for the publication of STEUDLER, WILLIAMSON, KAUFMANN, and GRANT (1998).

Deriving from the mentioned sources of data, 13 attributes were selected which characterised cadastral systems in the following twelve countries: Austria, England & Wales, Czech Republic, Denmark, Finland, Greece, Holland, Latvia, Germany, Switzerland, Sweden, and Poland. The countries in which cadastral systems were object of research were selected according to two criteria. Firstly, they had to be European countries, with representation of both western, central and eastern countries, and secondly, they had to be countries in which it was possible to gather information related to their cadastral systems.

2.2 Preparation of a Set of Indicators Characterising Cadastral Systems

The gathered attributes characterising cadastral systems in the selected 12 countries contained information referring to all sorts of problems related to:

(1) Real estate market in a given country: attribute No. 1—number of plots in a country in millions; attribute No. 2—annual number of transactions on the real estate market.

(2) Cadastral maps: attribute No. 3— percentage of maps kept in digital form; attribute No. 4—percentage of territory generally covered by maps.

(3) Descriptive data registers: attribute No. 5—percentage of descriptive data registers kept in digital form; attribute No. 6—percentage of completely registered descriptive data throughout the entire territory.

(4) Ways of financing cadastral systems: attribute No. 7—percentage of cadastral system financed by central organs; attribute No. 8—percentage of cadastral system financed by service fees.

(5) Methods of measuring borders of plots: attribute No. 9— borders of plots-method of registration.

a) Borders of plots registered in detail on the basis of geodetic measurement with the use of geodetic base points; b) borders of plots registered generally on the basis of topographic maps; c) borders of plots registered in both ways, urban areas—S, rural areas—T.

(6) The scope of data registered: attribute No. 10—registration of transactional price of real estate; attribute No. 11—registration of right to the real estate mandatory; attribute No. 12— registration of mortgage,

(7) Function of system: attribute No. 13— system functions for the following purposes:

a) fiscal; b) legal; c) required appraisal; d) spatial planning; e) environmental protection.

Once these seven problems were selected, and the relevant attributes for further analysis prepared, a set of seven indicators was designed to characterise cadastral systems in the selected countries. The indicators related to size of real estate market, maps, descriptive data registers, method of financing, precision of registration, gathered information, and multipurpose nature of a given cadastral system.

2.3 Calculations

(1) Distribution free methods. KENDALL's ratio tests similarities between n arrangements in k categories. This means that, in the discussed example, statistics may determine the extent of similarities between the rank arrangements in the seven indicators (n), characterising cadastral systems in the 12 countries (k). The ratio for the sample of the 12 countries was calculated as an arithmetic average of all indicators of SPEARMAN's correlation of ranks with the use of the formula(2). The value arrived at was $W = 0.229$, which gave a 23% mutual similarity between cadastral systems. The value of that statistic may be explained as follows. The statistic is a quotient of variance of the summed k ranks divided by the maximum possible variance of summed k ranks. If KENDALL's ratio in this analysis was close to the value of 1, this would mean that the cadastral systems are identical with re-

spect to the assumed attributes. Thus, further comparative analysis would be irrelevant. Now, since the result $W = 0.229$ is close to zero, the submitted thesis related to a multitude of solutions in cadastral systems as well as of economic and legal conditions in the countries under research is true. Little similarity between the cadastral systems tested requires research which would make it possible to find answers to the following questions: Which country has the best cadastral system? What is the position of the Polish system in comparison to those of the other 12 countries? Are there any groups of countries whose cadastral systems are very similar?

These questions may be answered by the results of FRIEDMAN's variance analysis (Table 1).

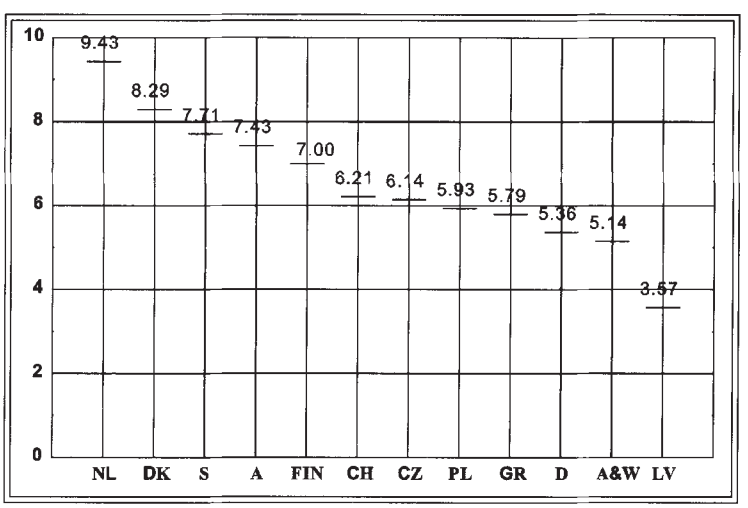
Table 1 Results of FRIEDMAN's variance analysis

Variable	Symbol	Average rank	Sum of ranks
Austria	A	7.43	52.00
England & Wales	A&W	5.14	36.00
Czech Republic	CZ	6.14	43.00
Denmark	DK	8.29	58.00
Finland	FIN	7.00	49.00
Greece	GR	5.79	40.50
Holland	NL	9.43	66.00
Latvia	LV	3.57	25.00
Germany	D	5.36	37.50
Switzerland	CH	6.21	43.50
Sweden	S	7.71	54.00
Poland	PL	5.93	41.50

The calculations established the highest average rank on the basis of seven indicators characterising cadastral systems in 12 countries: Holland's cadastral system reached the rank value of 9.43. That indicates that the Dutch system holds the greatest number of positive attributes, compared to the same selection of attributes in cadastral systems of the other countries. The lowest average rank belongs to Latvia's cadastral system (rank 3.57), while Poland with the average rank of 5.93 is in the 8th place. The results of FRIEDMAN's variance analysis and its graphic interpretation (Fig. 2) imply that the 12 systems may be divided into three groups Table 2. What determines the group to which a specific country is classified is the average rank value, consistent with the following principles, as laid down by the authors of this article: group I— average rank $\geqslant 7.0$; group II—$7.0 >$ average rank $\geqslant 5.5$; group III— average rank $\leqslant 5.5$.

(2) Multivariate analysis methods. As a result of using the factor analysis, two integrated indicators were extracted from the initial set of seven indicators characterising cadastral systems in the 12 countries. Those two integrated factors contained approximately 65% of the common variability. In Table 3, all factor values exceeding 0.7 are given in italics.

The first factor has the strongest link to the indicators numbered 2, 5 and 6; these include the indicator of maps, the indicator of precision of registration, and



A—Austria A&W— England & Wales CH— Switzerland CZ—Czech Republic D—Germany DK —Denmark FIN—Finland GR—Greece LV— Latvia NL— Holland PL—Poland S— Sweden

Fig. 2 The hierarchical set of cadastral systems

the indicator of gathered information. Thus, this factor may be called "the technical factor". The second factor is strongly linked to factors numbered 1, 3 and 7; these include the indicator of size of real estate market, the indicator of descriptive data registers and the indicator of the multi-purpose nature of the cadastral system. In-

Table 2 Classification of countries into groups based on the criteria of similarity of their cadastral systems

GROUP Ⅰ	GROUP Ⅱ	GROUP Ⅲ
Holland	Czech Republic	England & Wales
Denmark	Switzerland	Germany
Sweden	Poland	Latvia
Austria	Greece	
Finland		

dicator 4, related to methods of financing, adds little to the explanation of common variability, yet it is more strongly related to the second factor. Therefore, the second factor may be called "the organisational and economic factor". Table 4 shows the relevant factor values for each country.

Specific main factors may be interpreted as two-dimensional co-ordinates of the localisation of cadastral systems. Thus, based on the calculated values, Fig. 3 shows a two-dimensional configuration of cadastral systems in each country.

The graphical interpretation of the grid may lead to the conclusion that the best cadastral systems—assuming that the quality of a system is determined only by the attributes of cadastral systems shown in Table 4—operate in Holland, Sweden, and Finland, and the least beneficial cadastral solutions are in England & Wales and in Latvia. Additionally, the countries under research were classified into four groups with respect to the criteria of similarity of cadastral systems. Table 5 shows this classification.

Table 3 Factor values extracted for the seven indicators

Type of indicator	Symbol	Factor 1	Factor 2
Indicator of size of real estate market	WSK-1	0.19572	0.71113
Indicator of maps	WSK-2	0.86274	0.22781
Indicator of *descriptive data registers*	WSK-3	0.25440	0.70775
Indicator of *method of financing*	WSK-4	-0.29971	0.40210
Indicator of *precision of registration*	WSK-5	0.80033	-0.42863
Indicator of *gathered information*	WSK-6	0.88470	0.15139
Indicator of *multipurpose nature of cadastral system*	WSK-7	0.19140	-0.83741
Common variability		2.39703	2.12811
In %		0.34243	0.30402

Table 4 Main factor values

Country	Factor 1 (*technical*)	Factor 2 (*organizational and economic*)
Austria	-0.1176	0.298828
England & Wales	-1.74844	1.402887
Czech Republic	-0.18309	-0.73044
Denmark	0.584525	0.310308
Finland	0.961468	0.622541
Greece	-0.91693	-0.87224
Holland	0.993293	0.897055
Latvia	-1.68753	0.352503
Germany	-0.15946	-1.62495
Switzerland	0.954413	-0.20891
Sweden	0.931415	1.089823
Poland	0.387936	-1.43742

Source: private study with the use of statistic package

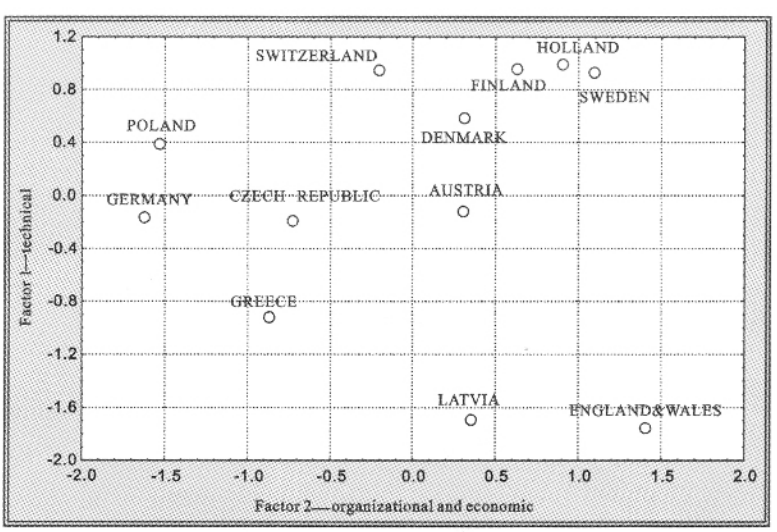


Fig. 3 Two dimensional configuration of cadastral systems

Source: private study with the use of statistic package

Table 5 Classification of countries with respect to similarity of their cadastral systems

GROUP Ⅰ	GROUP Ⅱ	GROUP Ⅲ	GROUP Ⅳ
Holland	Switzerland	Poland	England & Wales
Sweden	Denmark	Germany	Latvia
Finland	Austria	Czech Republic	
		Greece	

3 CONCLUSIONS

Research conducted with the use of two statistic methods within the range of distribution free methods and multivariate analysis methods (FRIEDMAN's variance analysis and KENDALL's comparability ratio) resulted in similar findings, both in establishing the system hierarchies and the classification of similar cadastral systems, which suggests that the analyses were conducted correctly in terms of methodology. The authors believe that the proposed methods may be useful in further, more in-depth research into the condition and assessment of cadastral systems in various countries, as well as in formulating the directions for their development.

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