Estimation of the Number of Rights on Properties at the Community, Regional and National Levels in Greece and Their Use in Planning and Decision-making for the Development of the Hellenic Cadastre

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Key words: Cadastre, Hellenic Cadastre, Planning, Decision-making, Statistical Estimation

SUMMARY

This paper presents a statistical model that estimates the number of rights on properties that will be registered in each municipality in Greece at the end of the cadastral survey procedure. Specifically, the paper defines the problem that must be solved, describes the data that are used in the calibration and estimation procedures, presents the results of the calibration, assesses the internal and external validity of the model, and implements the model to compute the number of rights that are expected to be registered nationwide. The results showed that the model is parsimonious, simple, well calibrated, and accurate. The total portion of the observed variance that could be explained by the model was high (it exceeded the 95% level) and the expected accuracy of the results at the national level was satisfactory (approximately ±3,5%). The results of the model have been used to develop the corporate plans of Ktimatologio S.A. (Hellenic Cadastre) for the past two (2) years and to estimate the costs of establishing the Hellenic National Cadastre.

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1. INTRODUCTION

Knowledge of the number of rights to be registered in a legal cadastral system, which is under development, is one of the most important factors in planning and developing such a system. Indeed, the number of rights that exist in an area and must be registered constitutes a major cost driver that influences greatly the strategy adopted and the choices made during the planning and implementation processes. This is particularly true for the case of the Hellenic Cadastre (Potsiou *et al*., 2001) where the objective is to establish a cadastral system that would, eventually, guarantee property rights and provide legal certainty on land transactions. The influence of that factor in the data collection and validation processes, as well as, in the cost of the development of the cadastre was realized during the implementation phase of the pilot projects that were launched in the mid-1990's in order to explore the various dimensions of the development of the Hellenic Cadastre. Since that time, a major effort has been placed on estimating, as accurately as possible, the number of rights for each given area, both at a disaggregate and aggregate geographical levels. Such a task would enable planners and decision-makers to determine the volume of data collection work involved, the validation work required, and the total amount of funds needed to complete the Project.

In this paper, the data and methods used to estimate the number of rights to be registered in the Hellenic Cadastre for each municipality in Greece, as well as, for the whole country is presented. Specifically, the paper describes the spatial data that have been used to calibrate multivariate regression models and estimate their parameters. The properties of those models, as well as, their accuracy is examined and analyzed in order to determine the most reliable results. Particular emphasis was placed on the internal and external validity tests and on other factors that affect the values of the parameters of these models. The calibrated model is used to estimate the total number of rights that would be registered in the Hellenic Cadastre.

The paper is structured in twelve (12) sections. The next discusses the background of the problem. The third section defines the problem and provides the necessary definitions. The fourth section, discusses the data that are available to develop and calibrate the model. The fifth section outlines the approach that will be used to solve the problem. The sixth section describes the specification and the calibration of the model. The seventh section presents the analyses that were made to validate the model and assess its accuracy. The eighth section describes the use of the model in estimating the total number of rights at an intermediate stage: the stage of "1st Publication" of the collected cadastral data. The ninth section, presents the estimates that result from the model for the final stage of the of the cadastral survey procedure. The tenth section describes the use of the results in the planning and decision-making processes of the Hellenic Cadastre. The eleventh section discusses

certain aspects of the model and suggests certain directions for further improvements. Finally, the last section summarizes the conclusions.

2. BACKGROUND

2.1 The Hellenic Cadastre Project

The Hellenic Cadastral Project aims at the development of a legal cadastral system in Greece. The Project was launched in 1994 and was co-financed by the Greek Government and the European Union. So far, there have been three major cadastral survey Programs that cover a total area of 8,400 Km^2 (approximately 6,3% of the country) and include 341 municipalities (6% of the country) (Table 1). These municipalities are quite dispersed all over Greece. All three Programs are at the stage of completion. In fact, in several municipalities, the data collection and validation procedure has been completed and the cadastre is in operation.

Table 1. Cadastral Survey Projects in Progress

Program	**No of contracts**	**Start year**	**Municipalities**	**Area (sq. kms)**
Pilot A'	30	1995	66	2.300
Pilot B'	25	1997	54	1.200
1st Main	38	1998	221	4.900
Total	**93**		**341**	**8.400**

2.2 Data Collection and Validation Procedure[1]

The procedure according to which cadastral data are collected and validated is quite comprehensive (Lolonis, 1997; Lolonis, 1999; Potsiou *et al.*, 2001). In brief, the procedure consists of the following major steps:

- Establish the geodetic network of the area under survey
- Compile the base topographic and aerial photography maps needed to locate properties and delineate their boundaries
- Collect declarations about properties and rights on properties. Those declarations are submitted by individuals (physical and legal persons)
- Process declarations and determine the properties on the maps, as well as, the rights that have been declared on those properties
- Publicize the results of the processing ("1st Publication")
- Collect petitions for corrections submitted by individuals
- Evaluate the petitions and modify the cadastral data according to the evidence provided
- Publicize the results ("2nd Publication")

- Collect objections submitted by individuals about the publicized data
- Process the objections and modify the data according to the available evidence
- Issue the "Initial Registrations".

The operation of the cadastre in an area (e.g. municipality) starts after the completion of the above procedure and the issuance of the "Initial Registrations".

The above described procedure, normally, is carried-out by private sector firms which sign contracts with Ktimatologio S.A. (Hellenic Cadastre), the State owned company that has undertaken the task to establish the Hellenic National Cadastre for Greece.

2.3 Issues of the Data Collection Procedure

At the initial steps of the Hellenic Cadastral Project, the area to be surveyed, classified as "urban", "sub-urban", "rural" and "other", was considered to be the primary factor that drives the cost of a cadastral survey (HEMCO, 1994). During the course of the Project, however, it was realized that the major cost driver was the collection, processing and validation of rights on properties. This realization, led to the need for developing a procedure that would enable the reliable estimation of the number of rights to be registered in an area and, subsequently, the computation of the total amount of work, as well as, the cost of the cadastral survey in that area. Both factors are essential in the planning process because they affect the number and size of the contracts that would be outsourced, as well as, cash flows of the Project.

3. THE PROBLEM

The problem addressed in this paper is to develop and validate a mathematical model that would enable the estimation, in advance, of the number of property rights to be registered as "Initial Registrations" during the cadastral survey procedure in a specified geographical area. This model, in order to be used in the planning procedure of the Hellenic Cadastre Project, should use, as an input, data that are available for all areas in the country and its results should be applicable to each of these areas.

For planning purposes, the smallest area that would be used as a "building block" of the model is the administrative area of a municipality, as defined by the Hellenic Ministry of Interior, Public Administration, and Decentralization. This decision was made because the geographical area of each municipality is well specified and there are statistical data available, at that level, for all municipalities in the country. In addition, municipality areas can be used, as flexible "building blocks" in the cadastral planning procedure, to form contract areas or produce estimates for other, more aggregate, geographical areas (e.g. prefectures, regions, the nation).

Within the context of this paper, the term "right" is defined to denote a distinct, non-decomposable, and well-defined set of legally acknowledged powers or authorities that a person, physical or legal, has on a property, which, depending on the type of right and the provisions of the Law, enable him/her to engage on certain actions within the property (e.g.

buy or sell the property, collect the yield of the property, build houses and other structures within the property, lease the property, pass through the property of another person etc). Within the Hellenic Cadastre framework, such rights are: ownership, usufruct, mortgage, servitude, leasing etc. Those rights, normally, are described in legal documents (deeds), which should be registered in the Registry Offices of the country in order to gain legal acknowledgement. This requirement to document rights on legal documents and register them in the appropriate Registry Offices, however, is not satisfied in a large number of cases in Greece. Thus, it is not possible to determine the number of rights on properties that exist in an area using the archives of the Registry System nor to do this task in any other feasible way before the cadastral survey procedure is completed in that area. The registration of those rights is the primary objective of the cadastral survey procedure in Greece.

4. DATA

There are thee categories of data that are available for the modeling process that will be used in this paper: statistical data about the municipalities (1991 National Census), the number of rights that were collected by the contactors of Ktimatologio S.A. in each municipality up to the stage of the "1st Publication" of the data, and the number of rights that were collected by contractors each month in each municipality being surveyed.

4.1 Statistical Data

These are the data that the Hellenic National Statistical Service collects about each municipality every ten (10) years. The latest data available for the analyses of this paper were those collected during the 1991 Census. Particularly, for the analyses of this paper, the following variables for each municipality were included in the dataset: population, total area, urban area, rural area, grassland area, forest area, water-covered area, cultivated area, terrain type, population density, number of housing dwellings, number of households, number of agricultural land parcels, and number of agriculture related business operations. These variables were chosen because there are data for them for all municipalities in Greece and they are likely to be related to the number of property rights that exist in an area.

4.2 Number of Rights at the "1st Publication"

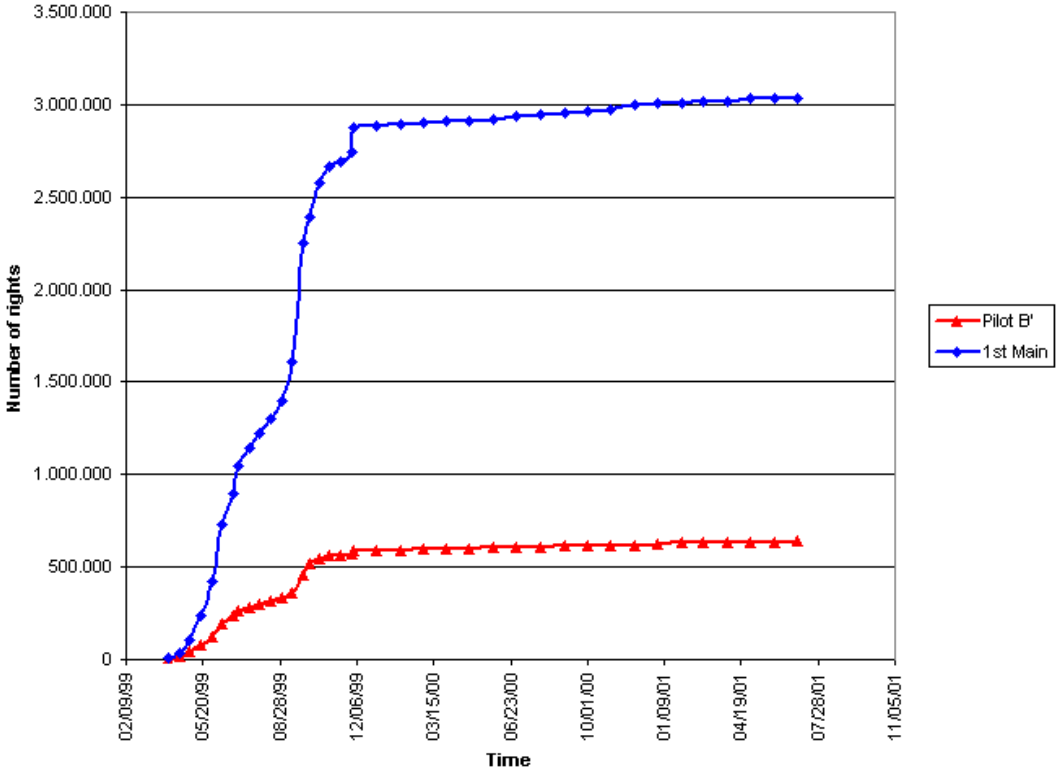
This data set includes the number of rights that had been collected up to the stage of the "1st Publication" of the cadastral data (please see section 2.2, point 5) for each municipality that has been under cadastral survey.

4.3 Monthly Counts of Rights Submitted for Registration

This data set consists of the number of rights that had been collected by Ktimatologio S.A. contractors each month in each municipality under survey. The general pattern of the data collection rate for Pilot B' and 1st Main Programs, aggregated at the Program level, is shown in Figure 1. Indeed, the rate of the number of collected rights was quite high during the data collection period (1999), while it slowed down after the deadline for submitting declarations

passed. From that point and then, the pattern is more regular and it reflects mainly the late registrations.

Figure 1. Progress of collecting rights through time.
Pilot B' and 1st Main Programs



5. APROACH TO SOLVE THE PROBLEM

Based on the data that were available, the objective to develop a model for estimating the number of rights at the stage of the "Initial Registration" for each municipality in Greece is achieved in two major steps:

- Specify a model that estimates the number of rights at the stage of the "1st Publication" of the data
- Estimate the rate of change in the number of rights after the "1st Publication" of the cadastral data and, then, use it to compute the final number of rights at the completion of the cadastral survey ("Initial registrations").

5.1 Specification of the Model that Estimates the Number of Rights at the Stage of the "1st Publication"

The specification of the model will be made using multivariate regression analysis. Specifically, the number of rights of the municipalities of the 1st Main Program, as they had been recorded at the stage of the "1st Publication", will be regressed on the census data of those municipalities to estimate the parameters that relate the census data with the number

of rights. This approach is likely to produce useful results because the number of rights, which reflect human activities, should be related to variables such as population, area, dwellings etc. The resulting model would be used to estimate the number of rights at the stage of the "1st Publication" for all other municipalities in Greece which, currently, are not under survey.

In the regressions, we will use data only from the 1st Main Program because the number of observations that we have in that Program is larger that the corresponding numbers in the other two Programs. In addition, we will use the data of the Pilot A' and Pilot B' municipalities for testing the external validity of the model.

5.2 Estimation of the Number of Rights at the Stage of the Completion of the Cadastral Surveys

In this step, the rate of collecting late declarations after the "1st Publication" is computed using trend analysis. Given the fact that the number of rights at "1st Publication" is known from step 5.1 and that the time period until the completion of each cadastral survey is specified in the contracts, then it is feasible to estimate the number of rights at the completion of each cadastral survey.

It must be noted that the step described here would not be necessary, if we knew the total number of rights at the completion of the cadastral surveys of the current Programs. If that was the case, we could regress that number of rights on the Census data and we would get the model that we need. Unfortunately, this is not feasible yet, because the number of municipalities for which the cadastral surveys have been completed is small.

6. MODEL SPECIFICATION

6.1 Regression Analyses

The general equation of the regression models that were calibrated for the purposes of this paper is:

$$\Delta_i^A = \sum_{k=1}^{K} b_k * X_{ik} \qquad (1)$$

where:

Δ_i^A: The number of rights in municipality i at the time of "1st Publication"

b_k, $k = 1,\ldots,K$ Coefficient b_k of the linear regression

X_{ik}: Value of the independent variable k for municipality i. This variable may be the "Number of dwellings", "Urban area" etc.

K: The number of independent variables of the model.

The results of the regression analyses, after several trials, gave the following model:

$$\Delta_i^A = 2{,}00579 * R_i + 2{,}30756 * D_i + 1{,}2595 * U_i + 0{,}076389 * G_i - 2{,}44156 * O_i \qquad (2)$$

where:

Δ_i^A : The number of rights in municipality *i* at the time of "1st Publication"
R_i: The number of rural parcels in municipality *i*.
D_i: The number of dwelling units in municipality *i*.
U_i: Urban area (in 1000s of sq. meters)
G_i: The area of grassland (in 1000s of sq. meters)
O_i: Number of business operations using agricultural land.

The regression statistics of the above model are summarized on Table 2.

Table 2. Summary results of the regression analysis of the number of rights on the Census data

Regression Statistics	
Multiple R	0,98915296
R Square	0,978423578
Adjusted R Square	0,973299495
Standard Error	3517,055103
Observations	217

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1,18916E+11	23783277007	1922,708069	8,4676E-174
Residual	212	2622371439	12369676,6		
Total	217	1,21539E+11			

	Coefficients	*Standard Error*	*Standardized Coefficients*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
R (Rural parcels)	2,00579569	0,175783004	0,241	11,41063499	7,98766E-24	1,65928941	2,352301977
D (Dwellings)	2,30756330	0,058659852	0,714	39,33803470	2,2218E-99	2,191932061	2,42319455
U (Urban area)	1,25952324	0,128776441	0,190	9,78069615	6,97123E-19	1,005677049	1,513369431
G (Grassland)	0,07638860	0,02047937	0,036	3,73002724	0,000245788	0,036019344	0,116757869
O (Agric. Operations)	-2,44156585	0,868355264	-0,067	-2,81171307	0,005390145	-4,153281708	-0,72984999

Variance-covariance matrix

	R (Rural parcels)	D (Dwellings)	U (Urban area)	G (Grassland)	O (Agric. Operations)
R (Rural parcels)	0,030900	0,001374	-0,000085	-0,000303	-0,130112
D (Dwellings)	0,001374	0,003441	-0,005736	0,000266	-0,009799
U (Urban area)	-0,000085	-0,005736	0,016583	-0,000764	-0,017512
G (Grassland)	-0,000303	0,000266	-0,000764	0,000419	0,000099
O (Agric. Operations)	-0,130112	-0,009799	-0,017512	0,000099	0,754043

The results of the regression look plausible. Indeed, the regression coefficients of the variables included in the model have the appropriate signs and magnitude. Specifically, it is

plausible to expect that the number of rights in an area is positively related to the number of rural parcels, the number of dwellings, the size of the urban area, and the size of grassland area. Also, the regression results tell us that for every agricultural land parcel we would expect to register, on average, two (2) rights, for every dwelling unit 2,3 rights, and for every 10.000 sq. meters of grassland 0,8 rights.

It must be noted that other variables, such as forestland and terrain type proved to be insignificant during the statistical analysis process.

7. MODEL VALIDATION

The model that resulted from the above procedure was checked extensively for its statistical correctness and its external validity.

7.1 Internal Validity of the Model

The internal validity of the model was checked with respect to four (4) different aspects.

7.1.1 Check for Multicollinearity or near Multicollinearity

The independent variables of the model do not seem to have *multicollinearity* or *near multicollinearity* problems (*Besley-Kuh-Welsh Index= 6,3 <20*).

7.1.2 Check for Correctness of the Model Sspecification

Various alternative functional forms of the model were tried. Those forms included dummy variables that accounted for geographical specificities and polynomial expressions of the independent variables. However, no other model that had a significantly better fit than that of Equation (2) was determined.

7.1.3 Check for Model Specification at Various Geographical Aggregation evels

For this kind of test, the municipality data were aggregated at the contract and prefectural levels and, then, regression analyses were performed on the aggregated data. No significant difference in the regression coefficients was detected.

7.1.4 Check for Autocorrelation

Analyses of the distribution of errors did not reveal presence of any significant autocorrelation (spatial or other).

7.2 External Validity of the Model

The external validity of the model was checked in two (2) independent ways: against the data of the Pilot A' Program and against the data of the Pilot B' Program. In both cases, the

model (Equation 2) was applied at the municipal level for all municipalities of the Pilot A' and Pilot B' Programs, the estimates about the rights were computed, and the differences between computed and recorded values were compared. For Pilot A', the deviation of the results of the model from the recorded data was approximately 7% at the Program level. For Pilot B', the deviation was much smaller (1%). These magnitudes of deviations were expected given the aggregation level and the degree of fitness of the model.

8. ESTIMATION THE NUMBER OF RIGHTS AT THE STAGE OF THE "1ST PUBLICATION"

8.1 Estimation of the Expected Value of the Number of Rights at the Stage of the "1st Publication" for the Entire Country

Use of Equation (2) for each municipality in Greece yields the expected number of rights that would be collected in that municipality up to the point of the "1st Publication" of the data. A sum up of those values yields the corresponding total number of rights for the whole country. Indeed, if we perform the above steps, we obtain the total number of rights at the stage of "1st Publication". That number is:

$$\Delta^{A}_{Country} = 29.388.839 \qquad (3)$$

8.2 Estimation of the Standard Error of the Number of Rights at the Stage of the "1st Publication"

The standard error of the above estimate of the total number of rights at the stage of "1st Publication" is obtained using the appropriate formulae of the regression statistics (Jonhston, 1984, p. 195). Indeed, application of the formulae yields a standard error of:

$$s\Delta^{A} = \pm 997.231 \qquad (4)$$

The above error is approximately ±3,4% of the total number of rights.

8.3 Estimation of the 95% and 99% Confidence Intervals

Taking into consideration that the variable Δ^{A} follows the *t-distribution* with 217 degrees of freedom (the number of observations used in regression to calibrate the model), we determine that the 95% and 99% confidence intervals are:

Confidence Interval Δ^{A} at 95%: [27.434.266 – 31.343.411] (5)

and

Confidence Interval Δ^{A} at 99%: [26.819.972 – 31.957.705] (6)

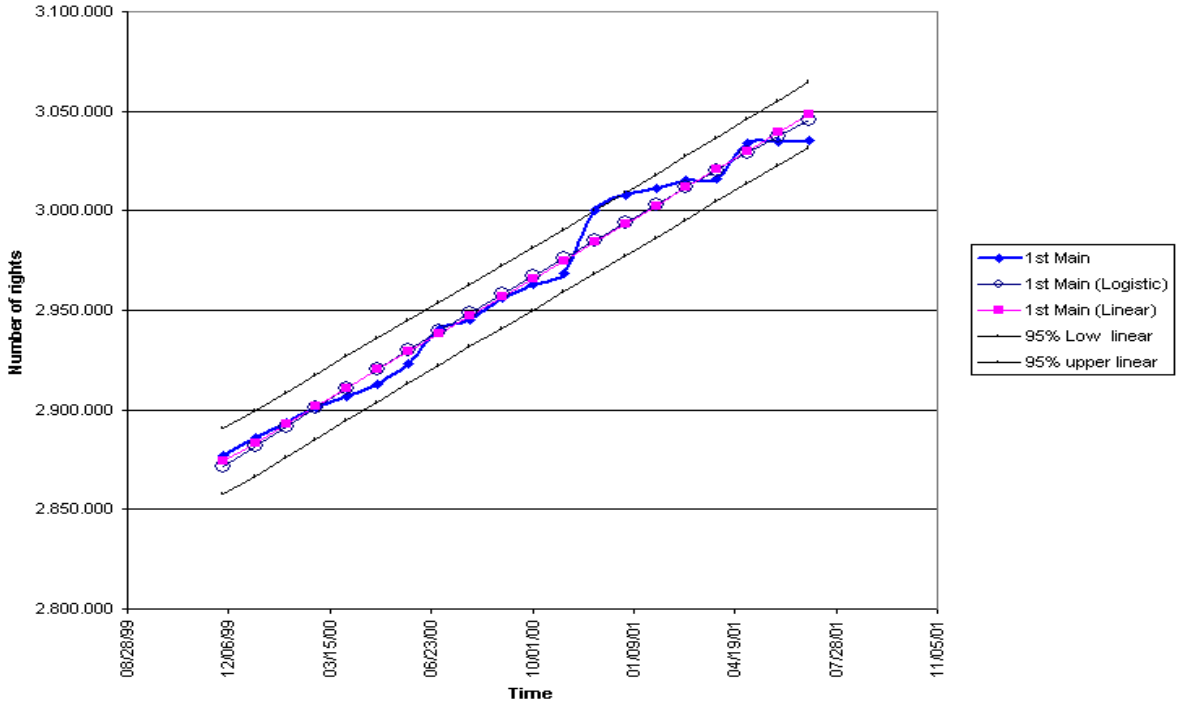
9. ESTIMATION OF THE TOTAL NUMBER OF RIGHTS AT THE COMPLETION OF CADASTRAL SURVEYS

Although estimation of the number of rights at the stage of "1st Publication" is an important step into the planning and decision-making process of the Hellenic Cadastre, however, it is not the final. The objective is to estimate the total number of rights that will be collected in an area through the entire cadastral survey procedure, that is, until the stage of the "Initial Registrations". This objective can be achieved if we observe that, after the end of the period of collection of declarations, the rate at which new rights are declared for registration in the Hellenic Cadastre (late declarations) is smooth (Figure 1, Period after December 1999). Therefore, if we estimate the rate of late declarations and we know the time of the completion of the cadastral surveys then we can make an extrapolation and compute the total number of rights at the time of the completion of the surveys ("Initial Registrations").

9.1 Estimation of the Rate of Change in the Number of Collected Rights due to Late Declarations

A trend analysis in the data of the 1st Main Program showed that the rate of registering new rights in the cadastre, after the end of the period of collecting declarations, was 9.157 rights per month out of a total of 2.900.000 rights (Figure 2). The goodness of fit of the trend line is satisfactory, since the error bound is quite narrow and all observed values fall within the 95% confidence interval of the estimated trend line (Figure 2).

Figure 2. Collection of Rights after the 1st Publication
A Comparison of the Actual and Fitted Data. 1st Main Program



Given the above rate and the expected time of completion of the cadastral surveys, it is straightforward to determine the value of a coefficient that would convert the number of rights at the "1st Publication" into the number of rights at the "Initial Registrations". For the case of the 1st Main Program, which had an expected completion time the end of 2003, this coefficient is:

$$a = 1{,}12 \pm 0{,}01 \tag{6}$$

that is, we would expect to have 12% (± 1%) more rights at the end of the cadastral survey period than those that had been registered at the time of the " 1st Publication".

9.2 Estimation of the Total Number of Property Rights in Greece

Assuming that the conditions underlying the estimation of the coefficient *a* (Equation 6) are valid for the other areas of Greece, then, using the results of equations (3) and (6) we can compute the final total number of rights in Greece:

$$\Delta^F_{Country} = a * \Delta^A_{Country} = 1{,}12 * 29.388.839 = 32.915.500 \tag{7}$$

Similarly, using the results of equations (3), (4), and (6) and the Error Propagation Law in Equation (7), we can compute the standard error of the above variable:

$$s\Delta^F_{Country} = \sqrt{\left(\frac{\vartheta\Delta^F_{Country}}{\vartheta\alpha}\right)^2 s^2_\alpha + \left(\frac{\vartheta\Delta^F_{Country}}{\vartheta\Delta^A}\right)^2 (s\Delta^A)^2} = \sqrt{(\Delta^A)^2 s^2_\alpha + \alpha^2 (s\Delta^A)^2} \Rightarrow$$

$$s\Delta^F_{Country} = 1.154.917 \tag{8}$$

Thus, the total number of rights in Greece is estimated to be:

$$\Delta^F_{Country} = 32.915.500 \pm 1.154.917 \tag{9}$$

We observe that the above estimate has a ±3,5% error.

A "*2-sigma*" confidence interval is then: [30.605.666-35.225.334] (10)

10. USE OF THE RESULTS IN PROJECT PLANNING AND DECISION-MAKING

Knowledge of the number of rights at the municipal, regional and national levels is extremely important in planning and decision-making of the Hellenic Cadastre. Indeed, since the number of rights to be registered in an area is directly related to the amount of work (and, therefore, cost) required to collect and validate them, planners and decision-makers must have a clear idea about that number in order to develop effective plans and make sound

decisions. If that is not the case, then there is a risk that plans may fail to be implemented. This was the case in the initial steps of the Hellenic Cadastre development, where the number of rights of the areas involved had been underestimated. As a result, there were delays in the implementation of the plans and cost overruns. Having estimated the number of rights using sound statistical methods and knowing the uncertainties of the estimates, planners and decision-makers are able to develop effective and robust plans.

Another important characteristic of the developed model is that it enables analysts to decompose problems they deal with and analyze them at the appropriate level. For example, the model presented in this paper has such a structure and composition that it enables analysts to separate quantitatively the number of rights that are expected to be collected in urban areas from those that are expected to be collected in rural or mountainous areas. This characteristic is particularly important in planning and decision-making because the marginal cost of collecting and validating property rights in each of those categories of areas differs substantially.

Within the Hellenic Cadastre Project framework, all these data and information was used into a GIS-based decision-making environment in order to develop and analyze scenarios and plans on how the cadastral surveying procedure would expand and cover the whole country. Various risk factors that would jeopardize the further implementation of the development of the Hellenic Cadastre were also quantified and assessed into this decision-making setting.

11. DISCUSSION

The model presented here, although it has certain very attractive characteristics such as, intuitiveness, parsimony, goodness of fit ($R^2=0,98$), and satisfactory accuracy (about 5-7% at the Program level), yet, has the potential to be improved even further. Indeed, its accuracy should improve if it could incorporate factors such as the existence or not of implemented consolidation projects in an area[2]. Also, it would be interesting to see, how the model parameters change if the 2001 Census data are used in the calibration procedure, instead of those of 1991. Finally, it would be important to analyze the structure of the model, its parameters, and its results by calibrating the model directly into the final data of the "Initial Registrations" and not on the data of the "1st Publication". All these possibilities, as well as others, will be pursued in the near future, as soon as the necessary data become available.

12. CONCLUSIONS

In this paper, a statistical model that enables analysts and planners to estimate the expected number of rights that will be registered in each municipality in Greece at the end of the cadastral survey procedure is presented. The model was developed taking into consideration the needs of the planning procedure and the available data. The results showed that the model is intuitively plausible, structurally sound, and effective. Indeed, it consists of independent variables that are expected to have an impact on the number of rights in an area, it is parsimonious since it achieves a high degree of fitness ($R^2=0,98$) using a very small number of independent variables, it requires data that are widely available (1991 Census

data), it provides information at various aggregation levels (municipal, regional national), and it has a satisfactory level of accuracy (approximately 3,5% at the national level). For all these characteristics, it has been used, for the past two (2) years, as a major analytical tool in the development of the corporate plans of Ktimatologio S.A.

DISCLAIMER

The views presented in this paper are personal and do not represent necessarily the official views of *Ktimatologio S.A.*

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BIOGRAPHICAL NOTES

Dr. Lolonis is the Head of the Project Planning Office of Ktimatologio S.A. (Hellenic Cadastre). He has a diploma in Rural and Surveying Engineering from the National Technical University of Athens, Greece (1986), a Master of Arts in Geography from the University of Iowa, U.S.A. (1990), and a Ph.D. in the same field from the same institution (1994). Dr. Lolonis specializes in cadastre, Geographic Information Systems (GIS), cartography, and spatial analysis. In the past, he has worked extensively in the areas of spatial decision support systems, spatial statistics, spatio-temporal database design, and spatial database accuracy. He has authored (or coauthored) more than 15 research articles in international journals and conference proceedings (e.g. *Cartography and GIS*, *Computers, Environment and Urban Systems*, *Statistics in Medicine*, *GIS/LIS*, *FIG)*. For his academic performance and work, Dr. Lolonis has received several awards by Greek and international organizations, such as the Hellenic Institute of Governmental Scholarships, The National Technical University of Athens, The University of Iowa, The Association of American Geographers, and the Iowa Department of Public Health. He is a member of the Technical Chamber of Greece, the Hellenic Association of Rural and Surveying Engineers, the Hellenic Society of Photogrammetry (member of the Auditing Committee since 2003), the Hellenic Association of Computer and Information Technology Scientists, and the Hellenic Geographic Information Systems Society (founding member and member of the Auditing Committee since 2002). For the past eight (8) years, Dr. Lolonis has been working for the Hellenic Cadastre on various technical and managerial topics, such as technical specifications, tenders, R&D, project monitoring, and corporate planning.

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[1] For simplicity reasons, certain stages of the procedure are either not mentioned here or incorporated on other stages. For a comprehensive desciption of the stages, the reader should consult the corresponding legislation (Law 2003/1995, Government Gazzette Issue 114A/June 15, 1995, pp. 3837-3844 and its subsequent Laws and guidelines) or the Hellenic Cadastre documents.

[2] This variable was not incorporated into the model because the necessary data are not available in usuable form for each municipality in the country.