IMMOVABLE PROPERTY TAXATION AND THE DEVELOPMENT OF AN ARTIFICIAL NEURAL NETWORK VALUATION SYSTEM FOR RESIDENTIAL PROPERTIES FOR TAX PURPOSES IN CYPRUS

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DECLARATION

This is to certify that neither this thesis, nor any part of it, has been presented or is being concurrently submitted in candidature for any other University degrees.

A list of publications arising from the research is presented in Appendix IX.

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Candidate

CERTIFICATE OF RESEARCH

This is to certify that, except where specific reference is made, the work described in this thesis is the result of the investigation of the candidate.

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Candidate

Immovable Property Taxation and the Development of an Artificial Neural Network Valuation System of Residential Properties for Tax Purposes in Cyprus

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ABSTRACT

The last General Valuation in Cyprus, in 1980, took about twelve years to be completed by the Lands and Surveys Department. The comparison method was adopted and no computerised (mass appraisal) method or tool was used to assist the whole process. Although the issue of mass appraisal was raised by Sagric International, who had been invited to Cyprus as consultants, and recently by DataCentralen A/S with the development of a mass appraisal system based on regression analysis, there has been little literature and no research directly undertaken on the problems and the analysis of immovable property taxation in Cyprus and the development of an artificial neural networks valuation system for houses and apartments.

The research project approached the issue of property taxation and mass appraisal through an investigation into Cyprus's needs for an up-dated tax base for equitabileness and for an assessment system capable of performing an effective revaluation at a certain date, with minimum acceptable mean error, minimum data and minimum cost.

Investigation within Cyprus and world-wide indicated that this research project is a unique study in relation to Cyprus's property taxation and the development of a computer assisted mass appraisal system based on modular artificial neural networks. An empirical study was carried out, including prototyping and testing.

The system results satisfy IAAO criteria for mass appraisal techniques, compare favourably with other studies and established a framework upon which future research into computer assisted mass appraisal for taxation purposes can be developed.

In conclusion, the project has contributed significantly to the available literature on the immovable property taxation in Cyprus and the development of a computer assisted mass appraisal system for houses and apartments based on modular artificial neural network method. The proposed approach is novel not only in the context of Cyprus but also world-wide.

ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

A	Apartment
ANN	Artificial Neural Network
Beta	Standardized Regression Coefficients
BP	Back-propagation
CAMA	Computer Assisted Mass Appraisal
CAV	Computer Assisted Valuation
CILIS	Cyprus Integrated Land Information System
COD	Coefficient of Dispersion
COV	Coefficient of Variation
CYP	Cyprus pound
DCDB	Digital Cadastral Data Base
DF	Degrees of Freedom
DLS	Lands and Surveys Department
DVC	Direct Value Comparison
GIS	Geographical Information System
H	House
HA	House and Apartment
IAAO	International Association of Assessing Officers
MANN	Modular Artificial Neural Network Valuation
MAPE	Mean Absolute Percent Error
MLS	Multiple Listing Service
MRA	Multiple Regression Analysis
NIPMAP	Northern Ireland Property Market Analysis Project
NLIS	National Land Information System
pdf	Probability Density Function
PNN	Probabilistic Network
RFT	Request For Tenders
SE	Standard Error
Sig *T*	Significance of *t* statistic
SMG	Sub Market Group
SOFM	Self-organising feature map
SS	Sum of Squares
SSE	Sum of Square of Errors
Std. Dev	Standard Deviation
VLA	Valuation and Lands Agency

IMPORTANT SYMBOLS

$\mathbf{A}$	Assessment vector
A_i	Assessed value
AR^2	Adjusted *R square*
$\arg\min f(\mathbf{w})$	Minimum of the function $f(\mathbf{w})$ with respect to the argument vector **w**.
$\overline{A/S}$	Mean of Assessment Sale ratio
b	Regression Coefficients
$\mathbf{B}$	Matrix of Regression Coefficients
$b_j^l(n)$	Bias applied to neuron j
$\mathbf{d}(n)$	Desired response vector presented to the output layer of an ANN.
$d_j(n)$	The jth element of the desired response vector $\mathbf{d}(n)$
e	Error Term
$\mathbf{e}$	Matrix of Error terms
$e_j(n)$	Error signal
F	F Statistic
$f_a(\mathbf{X})$	The value of the pdf of class A at point $\mathbf{X}$
h_t	Error Tolerance (%)
$h_{j,i(\mathbf{x})}(n)$	Neighborhood function
i	Training vector number
$i(\mathbf{x})$	Best matching (winning) neuron
$\mathbf{J}$	Jacobian matrix
k	Number of independent variables
KS	Kolmogorov-Smirnov statistic
l	Layer
L	*Depth* of the network
n	Iteration
n_a	Number of training vectors in class A
N_e	Effective number of data points
n_r	Required sample size
n_s	Sample size
N_1	Number of data points in the first distribution
N_2	Number of data points in the second distribution
$o_j(n)$	Output signal of neuron j in layer L
p	Number of components in the training vector
$P_{(x)}$	Known (Normal) cumulative distribution function
$P^A(\mathbf{X})$	Polynomial approximation for vectors from category A
r	Coefficient of Correlation

R	Multiple R, Correlation coefficient between the dependent and independent
R^2	Coefficient of Determination
$\mathbf{S}$	Sale Price vector
S_c	Output of each summation
S_i	Sale Price
$S_{n(x)}$	Distribution function of data set
t	Vector transpose
t_s	The t statistic
$u_j^{(l)}(n)$	Induced local field
$\mathbf{w}_j(n)$	Weight vector
w_{ij}	Synaptic weight of synapse j belonging to neuron i
win_i	Winning output node
X	Independent Variable (observation)
$\mathbf{X}$	Matrix of Independents
$\overline{X}$	Mean of an independent variable (observation)
$\mathbf{x}(n)$	Input vector
$x_j(n)$	The jth element of the input vector $\mathbf{x}(n)$.
$X'X$	Coefficient matrix
$X'Y$	Matrix of constants
Y	Dependent (Output) Variable
$\mathbf{Y}$	Matrix of (Output) Dependent
$\overline{Y}$	Mean of Dependent Variable
$\widetilde{Y}$	Predicted value of the Dependent Variable
$\mathbf{Y}_{ai}$	The ith training vector from class A
Z	Standard Score
$\mathbf{Z}_{ci}$	Layer output of vector class (c) of pattern layer neuron (i)
a	Momentum
$\delta_j(n)$	Local gradient of neuron j at time n
η	Learning-rate parameter
μ	Scalar
σ	Smoothing variable
σ_s	Standard deviation of the dependent sale price
σ_{sd}	Standard deviation
σ_x	Standard deviation of the independent
$\varphi_j(.)$	Nonlinear activation function of neuron j
$\varphi'_j(.)$	Differentiation with respect to the argument

1. INTRODUCTION

The Republic of Cyprus (Kypros) is the third largest island in the Mediterranean, with an area of 9,251 square kilometres (3,572 square miles) and with a population of approximately 700,000. (Refer Appendix I). Its open-based economy is relatively poor in natural resources and is thus highly dependent on the import and export of goods and services. The Cypriot Employers and Industrialists Federation (1996) explain that since its independence in 1960, Cyprus's development has been acknowledged internationally as a success story in both the economic and social fields. Despite the acute political problems which emerged in 1974 when Turkey invaded the island, occupying about 38 per cent of its territory, the economy quickly recovered as a result of the concerted efforts of both the public and the private sector.

After the establishment of the Republic in 1960, agriculture continued to be the backbone of the economy of the island. However, with the post-independence days came the boom of an expanding tourist industry, coupled with an unprecedented residential, commercial and industrial expansion. All this exerted a tremendous pressure on the limited available land resources and the competition of uses became more acute (Kotsonis, 1990).

Taxation of landed property has always been a significant financial resource for the socio-economic development of the island and because such resources have been extensively used for local authority services, education, sewerage, construction of roads and generally for the improvement of areas.

Inspired by this progress in Cyprus, this research set out to identify the major problems of the existing property taxation system and make appropriate recommendations for their remediation. The research identified and focussed on a modular artificial neural network method and the development of multiple regression analysis (MRA) and artificial neural networks (ANNs) systems for the introduction of a new general valuation. The Republic may require these systems to support its further improvement and evolution, with particular reference to property valuation and landed property taxation. The specific aims are set out in 1.2.

This Chapter provides a brief account of the background to the research theme, i.e. the immovable property taxation and rating systems in Cyprus, the need for a revaluation, and the Sagric International consultancy and the DataCentralen A/S development in Cyprus.

The methodology adopted for the research is then outlined. Methods employed in the research are given in coherent sequence which reflects the hypothesis, based on the initial research, that MRA and ANNs systems, using modular artificial neural networks method, could be suitable approaches for the general valuation in Cyprus in the light of the fact that the Republic needs an up-to-date ad valorem tax base to support its landed property taxation. Limitations and constraints to the research and methodology are also described.

1.1 The Problem

According to the Cyprus Immovable Property (Tenure, Registration and Valuation) Law, Cap. 224, 1946, Cyprus's Lands and Surveys Department (Refer Appendix II) is authorised to produce valuations of all taxable landed property for taxation purposes. This is called a General Valuation and takes place whenever required by the Council of Ministers. So far this has occurred only in 1909 and 1980. The bases of tax assessments used in Cyprus today are "market" value and "assessed" value. "Market" value was used to produce the capital value as at the first of January 1980 of immovable property based on sales evidence of open market transactions and this is the latest general valuation. "Assessed" value is the 1909 value, based on the experience of Lands and Surveys Department's employees, who at the time had no sales records on which to produce any open market valuations. It can be argued that the "assessed" value was only an approximation of the 1909 open market value because it was produced by non-qualified valuers based on their professional experience alone and that the evidence of open market sales at that time was non-existent. Both values are currently used as a basis for the various taxes on landed properties. It can be concluded that immovable property taxation system in Cyprus is inequitable because the assessment of taxes are based on old values and that the resulting capital values do not reflect all the valuable characteristics of existing property at current values.

The implementation of a revaluation should take advantage of the benefits which information technology can offer. The introduction of Computer Assisted Mass Appraisal (CAMA) systems will assist in estimating property values at a certain date, based on limited sales data, using different techniques for the prediction of a property value e.g. MRA and ANNs. The best technique will predict values at a certain date, with minimum acceptable mean error, minimum data, minimum cost, a fast response, minimum staff and minimum human skill and effort. Consequently, the time taken for a revaluation will be extremely reduced, considering that the 1980 revaluation took twelve years to be completed. The long time taken over that revaluation and its high cost are the main reasons why a new revaluation has not taken place in Cyprus since 1980. Additionally, a prediction method can also be a useful tool for discouraging a purchaser and vendor from declaring a lower sale price and thereby avoiding the payment of appropriate levels of Capital Gains tax and transfer fees. Furthermore, these prediction methods can be useful tools in valuations for other specific purposes e.g. compulsory acquisitions.

Sagric International (Refer 3.4.1) was commissioned by the Lands and Surveys Department to carry out all the prepatory work for tenders' documents in 1991, for the introduction of information technology, including a CAMA system. In 1995

DataCentralen A/S (Refer 3.4.2) succeeded in an international "request for tenders" (RFT) competition for the design and development of the Cyprus Integrated Land Information System (CILIS). The development and testing of the software were completed in June 1999. In July 1999 CILIS was deployed in Strovolos Municipality and Kokkinotrimithia Improvement Board, located in the District of Lefkosia, and progressively will cover the whole Republic. The biggest issue for CILIS is data collection.

1.2 Aims

The aim of this research work is to identify the major problems of the existing system, make appropriate recommendations for remedying them and focus on the development of MRA and ANN systems for the introduction of a new general valuation using the modular artificial neural network method.

The objectives of the research are as follows:

1. to investigate, analyse and determine the major problems of the immovable property taxation system in Cyprus and make recommendations for their remediation;
2. to analyse the Sagric International's consultancy and DataCentralen's proposals for the introduction of Computer Assisted Mass Appraisal Systems in the Department of Lands and Surveys, Cyprus;

3. to utilise ANNs and MRA techniques using modular artificial neural networks method for the development of a CAMA system for tax purposes;
4. to design and develop a CAMA prototype system which will be capable of producing an individual market valuation for residential property areas for tax purposes; and
5. to test and evaluate the system.

In order to achieve the above aims, the research work has been carried out in two major stages.

In the first stage, the research analysed the Cypriot general valuation, taxation and rating laws as well as analysing the valuation problems in order to make recommendations to the Central Government in Cyprus and the local authorities so that they could improve the quality, efficiency and equity of their taxation and rating systems (Refer Chapter Two). Refer also, in Appendix IX for copies of published work and papers presented based on this research are included. The results of the first stage of the research showed that there are problems with the existing tax base which comprises valuations as at both 1909 and 1980. An updated tax base would improve both the efficacy and the perceived equity of the tax, and will assist uniformity. Furthermore, the Sagric International's consultancy, DataCentralen's proposals for the introduction of a CAMA system in Cyprus for tax purposes, as well as the application of MRA and ANN in real estate world-wide, were analysed (Refer Chapter Three).

The building and evaluation of MRA and ANN systems using modular artificial neural networks method for a revaluation in Cyprus are the focus of the second stage of the research which involved the methodology followed (Refer Chapters Four and Five), and the development and testing (Refer Chapter Six).

1.3 Research Methodology

Any landed property taxation system should be equitable, cost-effective, economical, convenient and certain, whether the tax is for current or future requirements. With the existing system in Cyprus, these principles are violated and it is necessary to identify the resulting problems, which must be solved for the success of any new system of landed property taxation.

The current status of the landed property taxation system in Cyprus was investigated by studying Cyprus Laws, available books and papers (Refer Chapter Two). The investigation was mainly concerned with the legal position and the valuation problems, which included the problems experienced by both Lands and Surveys Department's employees, irate taxpayers and local authorities, all of whom felt that the system could work more efficiently, equitably and produce more revenue. Having investigated property taxation theory (Refer 2.9), recommendations were made for revaluation and reforming of Cyprus taxation laws.

This research work investigates the recent proposals and current development of CAMA systems in Cyprus. It analyses the Sagric International's proposal (Refer 3.4.1) as well as DataCentralen's proposal (Refer 3.4.2). Based on these and on the characteristics of the local market of landed properties, the specific needs of Cyprus are determined in the CAMA systems.

An in-depth examination of British and international experience in CAMA systems, which includes MRA and ANNs was also carried out in order to investigate the relevance of important issues relating to the general valuation in Cyprus, such as homogeneity of residential areas and availability of sales evidence (Refer 3.3 and 3.5). Shiffler and Adams (1995) commented that MRA is probably the most popular statistical technique in the business world. This is another reason for the examination of CAMA systems including MRA. The main reasons for the examination of CAMA systems, including ANNs are:

1. the existence of studies which have reported a high level of success in predicting landed property values using such systems e.g. Borst (1991) and Evans et al. (1992);
2. the advantages of ANNs (Haykin, 1994; Maren et al., 1990; Michie et al., 1994), (Refer also Chapter Five).

An empirical study in Strovolos Municipality was performed in order to examine and apply MRA and ANNs. Data were collected for 211 houses and 492 apartments sold in the period from 20 October 1994 to 31 October 1997, and were used for evaluating the performance of MRA and ANNs separately. Because of MRA's popularity and the suitability of this method in the assessment of property values as demonstrated by some researchers e.g. Pendleton (1965), Hinshaw (1969), Fraser and Blackwell (1988), the results derived from this method were used as a base for testing new systems, such as ANNs.

The evaluation of each method (MRA and ANNs) together with benefits presented by Haykin (1994) and Gallinary (1995) established the hypothesis that a Modular Artificial Neural Network Valuation (MANN) system will be more robust and reliable than the individual methods of MRA and ANNs. In the light of these an appropriate CAMA system was proposed.

A bootstrapping procedure was used for evaluating the MANN system.

The literature search and review have been focused on the above outlined framework.

1.4 Other Studies

There has been little literature and no research directly on the problems of immovable property taxation in Cyprus and the development of a suitable artificial neural networks valuation system for its property taxation problems. Ioannou's (1990) and Markides' (1991) books both include a summary of current property taxation laws but they neither identify nor analyse the problems. Sagric International (1991) described a simple regression analysis which was used in a pilot study of property valuations in Aglangia Municipality in the District of Lefkosia. Sagric International (ibid.) explained that a standard error of estimate slightly higher than 10% of the mean 1990 value was produced but the objective was to prove the concept of predicting landed property values by regression analysis rather than to obtain perfect results. In 1991, Sagric International developed the "Cyprus Land Information Project, Request for Tenders Documents" (Refer 3.4.1) and in the area of valuation, it suggested computer assisted mass appraisal systems using statistical (simple and multiple regression) models, summation (rating) methods and simple transformation algorithms for the prediction of the properties values. However Sagric International did not investigate or analyse the immovable property taxation problems nor apply its proposed solution to the problems nor did it recommend the use of artificial neural networks.

In 1995, the DataCentralen A/S company from Denmark succeeded in an international "Request For Tenders (RFT)" competition for the development of a Cyprus Integrated Land Information System. Because of its experience in the CAMA system in Denmark, DataCentralen A/S initially offered the development of that same system, adjusted for the Cypriot situation and general valuation problems which, presumably, they had investigated. After negotiations between the Lands and Surveys Department and DataCentralen A/S, it was agreed to include not only the adjusted Denmark CAMA system but also Sagric International's (1991) and additional Lands and Surveys Department's proposals on computerising other valuation methods e.g. cost approach, income approach, the direct sale comparison method and the development of a system for monitoring the progress of compulsory acquisitions/requisitions. The purpose of the Department's proposals have been not only to solve the general valuation problems but also existing identified problems for other valuations for other specific purposes (e.g. compulsory acquisitions). Such problems have not been investigated in the course of this research.

The Danish valuation system, known as the "Total Value System" or as a "base home approach" relies on property characteristics and sale transaction evidence. It makes extensive use of multiple regression analysis. Morch-Lassen and Pedersen (1994, at p. 24) explained that the statistical technique used is a one-step-multiregressional analysis and that the programming is done by the SAS commercial software package.

It is essential to identify problems inherent in the existing system of taxing immovable property in Cyprus in order to make suitable recommendations to assess the appropriate testing of the proposed CAMA solution. There is a variety of books, studies and a large volume of papers existing on the British and other international immovable property taxation systems e.g. Harvey (1989) which analyses property taxation bases and the advantages and disadvantages of local taxes. Youngman (1994) too analyses property taxation, valuation methods and problems, and her work is vital to understanding the principles of property taxation and specifically relevant valuation issues for the development of systems which resolve problems e.g. availability of appropriate sales evidences. Eckert (1995) and Beardshaw (1986) are also useful in understanding the principles of the ideal taxation system and to make appropriate recommendations. There is a variety of studies on the application of MRA in property valuation (e.g. Pendleton, 1965; Hinshaw, 1969; Lessinger, 1969; Shenkel, 1978; Adair and McGreal, 1986, 1987; Fraser and Blackwell, 1988; and Donnelly, 1989;) (Refer also 3.3). Furthermore there are studies on the application of artificial neural networks for property valuation (e.g. Tay and Ho, 1991; Borst, 1991, 1995; Evans et al., 1992; Do and Grudnitski, 1992; Worzala et al., 1995; Lam, 1996; Lewis et al., 1996; Lenk et al., 1997; McCluskey et al., 1998; Connellan and James, 1998a,b), (Refer also 3.5).

There have been research studies and papers into related areas of study, for example Scott's (1988) and Jenkins' (1992) research into expert systems for property valuation. Both studies are useful in understanding expert systems in property valuation. Furthermore, Scott's (1988) work is also useful in understanding multiple regression analysis in residential properties. None of these have focused on the problems of the immovable property taxation and the development of an ANN valuation system of residential properties for tax purposes in Cyprus, using modular artificial neural network method and none of these developed a MANN system incorporating MRA. This work is, therefore, unique in its aims and subject matter.

1.5 Limitations

This research has a number of limitations which need to be explained. The limitations are grouped into the following two aspects:

- access to information and constraints to the intended analysis; and
- limitations to testing.

1.5.1 Access to information and constraints to the analysis

The research intended to conduct a thorough investigation, local inspection and analysis of all the houses and apartments sold between 20 October 1994 and 31 October 1997 in Strovolos Municipality and recorded in the Lands and Surveys Department. In addition the research interviewed Mr Antonakis Panayi, the Valuation Officer of the Lemesos District Land Office (Refer Appendix IV), so that the information gathered from such an investigation could enable the research to make an appropriate analysis of the sales in order to assess market value and its determinants. This could have informed the design, development and the testing of the MRA and the ANNs mass appraisal systems. The research intended to collect all the 67 variables for houses and apartments (Refer Appendix VI) derived from interviewing Mr Antonakis Panayi. However, data collection and local inspections are time-and cost-consuming procedures and because one of the objectives of this research is to develop a CAMA system with minimum cost of maintenance, it was decided to proceed to the development of MRA models on the basis of the thirty variables only (see Table 4.1) as a representative sample. Most of these variables exist in the Lands and Surveys Department and they were available to this research. If the developed models had not satisfied coefficient of dispersion (*COD*) criterion (IAAO, 1990a), then a further data collection would have taken place.

Thus, two factual problems have been encountered in this respect:

1. the impossibility of access to all the variables identified from interview for all the house and apartment transactions from 20 October 1994 to 31 October 1997 in Strovolos Municipality; and
2. the volume of such potential work being would be too great and beyond the capacity of this research to investigate thoroughly.

In view of the above, the candidate subsequently undertook an investigation in the Lands and Surveys Department's records and performed selected local inspections and interviews, where it was necessary in order to achieve representative samples for both houses and apartments in Strovolos Municipality. This method of collecting data provided the much needed information for the research about the house and apartments transactions, individual characteristics as well as the property market in general. At the end were collected data for twenty-five variables for 211 houses and eighteen variables for 492 apartments (see Table 4.1), corresponding to 64% and to 56% of the whole transactions respectively.

1.5.2 Limitations to testing

Firstly, MRA models were tested on the whole sample by comparing the market value (as evidenced by the sale price) with the assessment derived from models using the mean absolute percentage error (*MAPE*) and the *COD*. Furthermore an investigation of the normality of the assessment sale price ratio, the normality of the error term and the variance of the error term were performed. The objective was not to test the models on sales of all houses and apartments located in Strovolos Municipality but to test them on a representative sample, using internationally-accepted coefficients and standards i.e. *COD* (IAAO, 1990a) and *MAPE*.

Secondly, a "bootstrapping" procedure was used for evaluating the system. Ten different sets of houses and ten different sets of apartments were selected at random for training and evaluating the performance of the MANN system consisting of ANNs and the MRA assessors. The training set of houses consisted of 150 houses and the testing set consisted of 50 houses. The training set of apartments consisted of 350 apartments and the testing set consist of 120 apartments. Representativeness of the sample, in turn, is a function of several factors, particularly size. In general, the larger the sample, the more reliable the calculated statistics (IAAO, 1990a, p. 606). Training sets are chosen to be larger than testing sets to keep representativeness high.

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2. IMMOVABLE PROPERTY TAXATION AND RATING IN CYPRUS

2.1 Introduction to the property taxation system

According to the Cyprus Immovable Property (Tenure, Registration and Valuation) Law, Capital 224, 1946, Cyprus's Lands and Surveys Department is authorised to produce valuations of all taxable landed property for taxation purposes. This is called a General Valuation and takes place whenever required by the Council of Ministers. So far this has occurred only in 1909 and 1980. The bases of tax assessments used in Cyprus today are "market" value and "assessed" value. "Market" value was used to produce the capital value as at the first of January 1980 of immovable property based on sales evidence of open market transactions and this is the latest general valuation. "Assessed" value is the 1909 value, based on the experience of Lands and Surveys Department's employees, who at the time had no sales records on which to produce any open market valuations. It can be argued that the "assessed" value was only an approximation of the 1909 open market value because it was produced by non-qualified valuers based on their professional experience alone. The evidence of open market sales at that time was non-existent. Both values are currently used as a basis for the various taxes on landed properties.

2.2 Administration

The Republic of Cyprus, for administration purposes is divided into six districts (Lefkosia (or Nicosia), Ammochostos (or Famagusta), Larnaka, Lemesos (or Limassol), Keryneia (or Kyrenia) and Pafos) (Refer Appendix I). The island's capital and seat of Government is Lefkosia. Each district is headed by the District Officer who is essentially the local representative of the Central Government. The District Officer acts as the Chief co-ordinator and liaison officer for the activities of all Ministries. The administrative power in Cyprus is a two-tier system, but the structure is rather centralised, delegating limited power to the local authorities from central government. There are three types of local authorities: Municipalities, Improvement Board areas, and the Villages. Municipalities have more power and more population than the other local authorities. According to the Cyprus Municipalities Law (111/1985), one of the definitions of a Municipality is its population size, which must not be less than 5,000 inhabitants.

The Lands and Surveys Department for administration purposes is divided into six District Offices and a Headquarters. Because Turkish troops occupy Keryneia and part of Ammochostos, their District Offices are situated in Lefkosia and in Larnaka respectively.

2.3 Overview of taxes and rating

Cyprus Immovable Property Tax of 1980 (Law 24/1980 amended by the Laws 60/1980, 68/1980, 25/1981 and 10/1984).

This tax is levied by the State on the open market capital value as at the first of January 1980, on all of the owners' property. The owner may be either a legal body or private individual who is registered in the Lands and Surveys Department records or who is entitled to be registered, according to sections 9 and 10 of the Cyprus Immovable Property Law, Capital 224. According to section 9, no title to immovable property shall be acquired by any person by adverse possession against the Republic or a registered owner. According to section 10, subject to the provisions of section 9, if a person can provide proof of undisputed and uninterrupted adverse possession for a period of thirty years, that person shall be entitled to be registered as the owner. Properties belonging to the state, the municipalities and the communities (i.e. villages) are exempt, so are churches, places of worship, non-profit-making organisations, properties owned by farmers in rural areas and properties owned by foreign states for diplomatic purposes. Markides (1991) explained that the current Law replaced the old Laws 30/77, 38/78 and 93/79 under which the tax was levied on 1909 (assessed) values of properties. The tax is payable to the state on 30th of September each year.

The rates applied to the 1980 market value and based on the value of an owner's property are as follows:

Total value of an owner's properties in Cyprus	Rate of 1980 Market Value
up to £100,000	0.2% for legal bodies and 0% for individuals
from £100,001 to 250,000	0.2%
from £250,001 to 500,000	0.3%
from £500,001	0.35%

Delays on tax payment are penalized with 9% interest on the outstanding amount.

Cyprus Town Rate (Capital 240 and Laws 64/1964, 15/1966)

This is paid to the municipalities on all immovable property of legal bodies or individuals, according to the Municipality Law 111/85 (as amended), within the administrative limits of any municipal corporation. Properties belonging to the state and the municipalities are exempt, as are churches, places of worship, charitable institutions and properties owned by foreign states for diplomatic purposes. The rates are imposed by the municipalities subject to the approval by the government. The 1995 rate was 0.05% on the market value of such property as at the first of January 1980 as is registered or recorded in the books of the District Lands Office. The tax is payable to the municipality on the 30th June. A penalty of 5% is levied on payments made after the 30th of September.

Cyprus Improvement Rate (Capital 243 and the amendment Laws 46/1961, 58/1962, 4/1966, 31/1969, 7/1979, 49/1979, 65/1979, 7/1980, 27/1982, 42/1983, 72/1983, 38/1984, 72/1987 and 66/1989).

This tax is levied on all immovable properties within the geographical limits of any improvement area. According to the Cyprus Villages (Administration and Improvement) Law, Capital 243, an improvement area is any area declared by the Council of Ministers as an "improvement area", for improvement purposes (i.e. construction of roads, national parks).

Properties belonging to the state and the Improvement Boards are exempt, as are churches, charitable institutions and properties owned by foreign states for diplomatic purposes. The tax rate, decided by the Improvement Board, is subject to the approval of the government. The current rate is up to 1.5% on the 1909 assessed value of such property as registered or recorded in the books of the District Lands Offices. This tax is payable to the Improvement Boards by the owner on the 30 June each year and is used to support environmental improvements and local services. A penalty of 5% is levied on payments made after the 30th of September.

Cyprus Immovable Property (Towns) Tax (Laws 89/1962 and 73/1965)

This is levied on immovable property in towns or other areas defined by the Council of Ministers as "Towns", according to section 3. The tax rate is 1.5% on the 1909 assessed value of property as registered or recorded in the books of the District Lands Offices.

Properties belonging to the state, municipalities and communities are exempt, as are churches, charitable institutions and properties owned by foreign states for diplomatic purposes. Payments after the 30 of September are fined by 5% on the amount payable. This tax is collected by the state and is allocated to the Ministry of Education (note: it has replaced the Education Tax.).

Cyprus Estate Duty Taxation (Law 67/1962 and the amendment Laws 71/1968, 3/1976, 13/1985, 93/1986, 138/1986, 323/1987, 66(I)/1994, 6(I)/1996, 78(I)/1996, 17(I)/1997).

This is levied on immovable properties left by a deceased and is collected by the state. The properties are valued at their open market capital value as at the date of death. For deaths before the first of December 1942, Estate Duty is not levied. According to the amendment Law 138/86, inheritances due on deaths after 17 October 1986 incur the following level of relief:

£50,000	for husband or wife surviving;
£75,000	for every child under 21 years old at the date of death;
£75,000	for every disabled child surviving;
£50,000	for a 21 years old child;
£50,000	for all the children surviving.

Furthermore, there are rebates in some cases where the heir is a non-profit making organisation or religious organisation. These cases are examined by the state individually. Additionally, according to the 17(I)/97 amendment law, if the property left by the deceased is a residence used by the deceased or his/her family and the open market capital value at the date of death is less than £150,000, tax is not levied on the heirs. The rates of tax on evaluated immovable property are as follows:

up to	£20,000	0%
from	£20,001 to £25,000	10%
from	£25,001 to £35,000	13%
from	£35,001 to £55,000	15%
from	£55,001 to £80,000	17%
from	£80,001 to £105,000	20%
from	£105,001 to £150,000	23%
over	£150,000	30%

These rates are valid from March 1997.

Cyprus Capital Gains Tax Law (52/1980 and 135/1990)

Capital Gains Tax applies to both individuals and companies. Owners are charged at 20% on gains arising from the disposal of immovable property and shares in a company which owns immovable property. Gains are based on the open market capital values as at the first of January 1980 (or actual cost if acquired later) adjusted for the increase in the Consumer Price Index (CPI) up to the date of sale. Tax is paid to the state, and the main exemptions include:

1. Immovable properties left by a deceased (which is liable to Estate Duty);
2. Immovable properties given as a gift:
    - from parents to children;
    - from husband to wife and vice versa;

- from relatives up to second generation relatives (e.g. grandfather to grandchild).

Cyprus Betterment Charge Law (90/1972 Section 80)

The enforcement of the provisions of Cyprus Town and Country Planning Law, 90/1972 may cause an increase in value of immovable property. Such an increase may result either from a change to a more profitable use, or a higher density, or it may come about after the carrying out of development by a public authority in an area. Nicolaides et al. (1983a) commented that in the same way as it is "fair" to pay compensation to owners whose property rights are being materially adversely affected, it could be argued that it would also be fair to ask from those owners whose properties are being benefited by public activities to pay back at least some part of their gain. One way for the state to collect betterment is the levying of a Betterment Charge. Betterment Charge is levied on the increase in value to other property which is attributable to the scheme. The Betterment is ascertained by the carrying out of two open market capital valuations, one at the date prior to the scheme and a second one at a date falling within the period starting two years after the date of the decision and finishing two years after the date of completion of the scheme. The difference between the two valuations, after deducting any increase which is not attributable to the scheme, is the "Betterment" which is subject to the charge. Betterment Charge has been fixed up to a maximum of 30% on the betterment, and is payable to the state in 20 annual instalments. Betterment Charge has not yet been levied because of:

1. the difficulties in defining the area in which betterment has occurred and also in proving the quantum of the betterment;
2. limited number of staff of the Lands and Surveys Department;
3. the use of manual procedures by the Department; and
4. the political cost.

Cyprus Sewerage Charges Law (1/1971)

The aim of this Law is the establishment, construction, control and the administration of sewerage systems, including the processing and the disposal of waste. The Sewerage Council, according to section 30 of the Law, has the right to levy tax and fees. The tax is levied on the open market capital value as at the first of January 1980 and is payable on 30 September each year. Sewerage charges are levied on landed properties in areas where sewerage systems were constructed and are in use. The rates vary depending on the property type e.g. in Larnaka, in 1995, the rates on hotels, hotel apartments and industries was 0.932% and for all other types was 0.285%. Sewerage charges are also levied on properties in areas where sewerage systems are under construction, e.g. in Larnaka, in 1995, for all property types, where the rate was 0.07%. However, charges on landed properties in areas where systems are under-used, are likely to be replaced by charges levied on water consumption. The argument for this is that it is a "fairer" method for those areas, since the greater the water consumption, the greater the use of sewerage systems.

2.4 The place of the property tax within the general tax system

Taxation of landed property has always been a significant financial resource for the socio-economic development of the island because such resources have been extensively used for the provision of local authority services, e.g. education, sewerage, construction of roads and generally for the improvement of areas.

Tables 2.1 and 2.2 show statistics on the size of the tax base.

Year	Im. Pr. Tax 1980 £	Towns Tax £	Estate Duty £	Capital Gains Tax £	Betterment Charge
1991	4,754,000	449,000	1,433,000	5,001,000	-
1992	3,461,000	857,000	2,373,000	4,719,000	-
1993	2,997,000	505,000	2,203,000	5,181,000	-
1994	3,126,000	480,000	2,022,000	5,974,000	-
1995	5,949,000	488,000	2,318,000	9,336,000	-
1996	3,311,000	456,000	2,090,000	7,080,000	-
1997	3,861,000	470,000	2,871,000	6,251,000	-
1998	3,471,000	425,000	3,660,000	6,889,000	-
Total	30,930,000	4,130,000	18,970,000	50,431,000	-

Table 2.1. Government ordinary revenue raised by Immovable Property Tax (1980), Towns Tax, Estate Duty and Capital Gains Tax.

Year	Town Rate	Improvement Rate	Sewerage Charges
	£	£	£
1991	502,796	101,438	2,465,714
1992	761,319	104,502	4,050,446
1993	1,204,970	130,823	5,462,187
1994	1,835,115	114,889	6,520,881
1995	2,013,885	101,260	8,472,102
1996	1,957,787	108,589	7,877,822
1997	2,210,145	103,766	8,925,015
1998	2,449,951	107,430	8,708,821
TOTAL	12,935,968	872,697	52,482,988

Table 2.2. Calculated Town Rate and Improvement Rate by the Lands and Surveys Department and sewerage revenue from tax levied on landed properties.

Year	Total
	£
1991	11,637,000
1992	11,410,000
1993	10,886,000
1994	11,602,000
1995	18,091,000
1996	12,937,000
1997	13,453,000
1998	14,445,000
TOTAL	104,461,000

Table 2.3. Total government ordinary revenue raised by Immovable Property Tax (1980), Towns Tax, Estate Duty and Capital Gains Tax.

According to the Statistical Abstract 1994 and the Financial Report (1995) the most important sources of government revenue is the Income Tax, as a direct tax and Import Duties as an indirect tax (see Table 2.4).

Year	Income Tax (Direct Tax) £	Import Duties (Indirect Tax) £	Excise (Indirect Tax) £
1991	131,075,000	100,170,000	80,600,000
1992	154,390,000	108,402,000	96,670,000
1993	169,513,000	88,446,000	67,794,000
1994	217,075,000	88,167,000	98,900,000
1995	235,790,000	91,830,000	112,411,000
1996	236,888,000	90,088,000	111,564,000
1997	255,814,000	75,930,000	101,302,000
1998	298,084,000	56,263,000	108,968,000
Total	1,698,629,000	699,296,000	778,209,000

Table 2.4. Government ordinary revenue raised by Income Tax, Import Duties and Excise.

The total revenue raised by the Immovable Property Tax, Towns Tax, Estate Duty and Capital Gains Tax from 1991 to 1998 is 104,461,000 (see Tables 2.1 and 2.3). This means that their combined revenue is 1.57% of the total government income, (total revenue raised by taxes levied on landed properties divided by total government revenue). Furthermore, this revenue is 9.87% of the total government development expenditure, (total revenue raised by taxes levied on landed properties divided by total government development expenditure).

Both taxes in Table 2.1 and Lands and Surveys fees in Table 2.5 are government revenue. The total amount raised by those categories is 4.09% of the total government income and 25.78% of the total development expenditures.

Income tax provides the greatest contribution to the Government revenue. Immovable property tax is 1.82% of income tax (immovable property tax divided by income tax).

Year	Lands & Surveys Fees (Direct Tax) £	Lands & Surveys Fees (Indirect Tax) £	Lands & Surveys Fees (Sale of Goods & Services) £	Total £
1991	3,341,000	6,809,000	3,341,000	13,491,000
1992	4,083,000	8,276,000	4,084,000	16,443,000
1993	4,130,000	8,241,000	4,130,000	16,501,000
1994	5,277,000	10,504,000	5,277,000	21,058,000
1995	6,136,000	12,248,000	6,136,000	24,520,000
1996	6,566,000	13,019,000	6,556,000	26,141,000
1997	6,027,000	12,027,000	6,027,000	24,081,000
1998	6,512,000	13,036,000	6,512,000	26,060,000
Total	42,072,000	84,160,000	42,063,000	168,295,000

Table 2.5. Government ordinary revenue raised by Lands and Surveys Fees.

Year	Government Total Revenue £	Government Dev. Expenditure £	Government Ord. Expenditure £
1991	563,142,000	90,082,000	794,232,000
1992	635,219,000	104,807,000	803,603,000
1993	731,500,000	114,977,000	915,985,000
1994	847,530,000	120,948,000	1,011,048,000
1995	940,476,000	146,325,000	1,112,400,000
1996	941,808,000	136,000,000	1,282,300,000
1997	980,449,000	158,011,000	1,341,374,000
1998	1,033,959,000	186,900,000	1,458,900,000
Total	6,674,083,000	1,058,050,000	8,719,842,000

Table 2.6. Government total revenue raised, development and ordinary expenditures.

Antoniou (1999) (Finance Department, Union of Cyprus Municipalities) explained that for the last four years the average of the ratio of property tax (Town Rate) to Municipality total ordinary revenue is 4.5% approximately. Table 2.7 shows the ratio (%) from the 1995 to 1998.

Year	Ratio of Property Tax (Town Rate) and Municipality total ordinary revenue %
1995	4
1996	4
1997	5
1998	5

Table 2.7. Ratio (%) of Property Tax (Town Rate) and Municipality total ordinary revenue (Provided by the Finance Department, Union of Cyprus Municipalities)

It is worth noting that the two most important revenues for the municipalities are the professional fees with 20% contribution and the garbage charges with 17% contribution approximately (Antoniou, 1999). The Union of Cyprus Municipalities established in 1981 by the Cyprus Law for the establishment, functioning and dissolution of corporate bodies and institutions, and relative matters (57/1972). The Union is responsible for the development of the autonomy of the municipalities, provides mechanisms for the cooperation of the municipalities, provides assistantship for specialised problems, prepares laws, represents municipalities to the Central Government, and to international forum.

2.5 General Valuation

2.5.1 General Valuation Laws

According to the Cyprus Immovable Property (Tenure, Registration and Valuation) Law, Cap. 224, Section 69, the Lands and Surveys Department in Cyprus is required to produce a valuation of landed property for taxation purposes, called a General Valuation, whenever and wherever required by the Council of Ministers for the purposes of securing an up-to-date and uniform valuation of immovable property in any municipality, village or quarter.

According to Section 67, any immovable property can be revalued at the instance of the Director or on the application of the registered owner at any time after five years from the date of the last valuation, provided that the property has been materially changed, causing a substantial increase or decrease in value or if a general valuation has been ordered.

2.5.2 General Valuation Criteria

According to legal advice given by the Attorney General of the Republic of Cyprus (35/1969, dated 20 September 1969), the following legal principles must be applied in a general valuation:

1. equal treatment of the taxpayers by the state and the fixing of the taxpaying ability on the basis of objective criteria;
2. for general purposes, a revaluation must cover the whole state;
3. for specific purposes, the valuation must cover the whole area which is specifically affected; and
4. a valuation for specific purposes cannot be used as the tax base for general purposes.

Under the first principle, the Attorney-General requires not only equal treatment of taxpayers but also requires that the tax levied be an amount reasonably payable. Under the third principle, when the Council of Ministers of Cyprus decides to levy a new tax in order to develop a project in a specific area and for specific purpose e.g. construction and maintenance of a sewerage system in Lefkosia, the municipality requires a revaluation, known as a "general valuation for specific purposes". The last principle means that if a revaluation is made for a specific area for a specific purpose e.g. the sewerage system, it can not be used to levy the Town Rate which is for general purpose. If it is applied in this way, then it will be in conflict with the first criterion of equal treatment of taxpayers because each valuation is carried out using different criteria e.g. date of valuation.

2.5.3 General Valuation - Historical Review

The first General Valuation began in 1909 under the Cyprus Immovable Property Registration and Valuation Law 12/1907 by which a cadastral survey, registration and valuation to cover the whole island was authorised. The General Valuation was completed about 20 years after it started and the 1909 values adopted. Known as "assessed values", these were based on the experience of Lands and Surveys Department's employees after visiting the areas e.g. villages, and not always after an inspection of individual properties. The valuers were unable to use sale records because they did not exist. Nowadays, producing a 1909 assessment is a desk-based exercise and it can be argued that these assessed values are unreliable because of the lack of market evidence at the time and are unsuitable because of the extremely low values of properties in 1909 compared with today's values and the fact that it is not worth applying out-of-date valuation methods for such small return (see Towns Tax in Table 2.1 and Improvement Rate in Table 2.2). That General Valuation was used for property taxation as soon as it was completed and at present the 1909 assessment is used as the basis for the Towns Tax (previously the Education Tax) and Improvement Rate, since the application of the 1980 General Valuation is a tax basis which is used depending solely on central Government policy.

The second General Valuation was carried out for a specific purpose and only covered the Sewerage Areas of Lefkosia and Ammochostos at 1971 values in order to levy tax for the establishment of sewerage systems. This is a general valuation for specific purposes and could not be used as a basis for other taxation purposes. This tax was in fact levied only in Lefkosia because in 1974 Ammochostos was occupied by Turkish troops.

The third General Valuation was carried out for the whole of Cyprus (except the occupied area) at 1980 values and is known as the market (capital) value of the first of January 1980. It was completed in 1991 and its purpose was to create a record of uniform values all over the country for all purposes e.g. central government taxation and municipalities' rating. It is already in use for the Immovable Property Tax, Town Rate (previously the Municipal Tax), Sewerage Charges and Capital Gains Tax but not for the Towns Tax (previously the Education Tax) and Improvement Rate.

2.5.4 General Valuation Base

The basis of General Valuations in Cyprus has been Capital Value since the second General Valuation in 1971 in Lefkosia and Ammochostos and was also used in the third General Valuation in 1980 for the whole Cyprus (except the occupied area), and capital value was used after the enactment of the Immovable Property (Tenure, Registration and Valuation) Law in 1946 for other purposes e.g. compensation on compulsory acquisitions. A capital value basis satisfies general valuation criteria and it has fewer practical problems in Cyprus than an annual value, on account of the Cyprus Rent Control Law (23/1983 and the amending laws) which limits free market rentals which would otherwise be the market evidence for valuing residential and retail properties.

Landed properties are sold in an open market sale by a willing seller to a willing purchaser, and there is a volume of useful open market sales for evidence of comparable transactions. In Cyprus, sale evidence exists, but there is not a large volume of sales. However, what sales evidence exists provides strong and sufficient evidence for a capital value tax basis on the assumption that sales are reliable, genuine and not understated. The capital value basis or Direct Value Comparison is an approach based on the full open market capital value of immovable property in its existing condition, with all developments, improvements, and potentialities (considering the best use of property).

2.5.5 Capital Value Assessment

At present capital value assessments are achieved using comparisons made by Lands and Surveys Department based on open market transaction of similar properties for the last two general valuations because:

1. of the availability of a quantity of appropriate sales records of various kinds of immovable properties;
2. sales of immovable properties in the open market are the same as "capital value", with the provision that they are reliable and genuine and not understated. Furthermore, if a property sale is much higher than similar property sales in the same area, these may not be included as sales evidence in a general valuation because the sale price may include other assets e.g. goodwill; and
3. it is the simplest and most direct method of valuation (Britton et al., 1989).

Britton et al. (1989) explained that this method is based on comparing the property to be valued with similar properties and the prices achieved for them and allowing for differences between them, thereby determining the price likely to be achieved for the property in question. However each property is unique and valuers' judgement is essential to analyse transactions in order to reflect the inevitable differences which may affect price and value. The reasons for such differences are mainly:

1. location;
2. physical state of the property;

3. tenure and other legal characteristics of the property; and
4. market and economic conditions which vary over time.

The Lands and Surveys Department has developed both manual and computerised systems for keeping sales records. The manual system will be abandoned as soon as the Cyprus Land Information System is developed and an integration between the legal and fiscal data of properties and plans is provided for the whole of Cyprus. This will enable valuers to read sale information simultaneously with plan information. The present manual system offers only limited access to this facility. As soon as a contract of sale is deposited or a sale is accepted, Land Clerks write a file number, date and price at the back of a specific set of plans used by the valuation section. So whenever a valuer works on a specific property, sale information is available at the back of the plan. Property sales information (excluding the specific set of plans) are sold to the private sector, to valuers and to real estate agents in hardcopy and in digital forms.

2.5.6 Procedure of Valuation

According to the Section 70 of the Cyprus Immovable Property (Tenure, Registration and Valuation) Law (1946), Capital 224, when a general valuation has been ordered under section 69, the following provisions take effect:

1. the Director of the Lands and Surveys Department publishes a general valuation notice to inform the public that a general valuation will take place;

2. when the valuation is completed, the Director prepares a valuation list which is deposited by the Director and the Chairman of the town, village or quarter and is also published in the daily press and the official Gazette of the Republic. The valuation list is used to inform people about property values.

Within six months from the date of the notice, any person whose property is affected may object in writing to the Director. Nicolaides et al. (1983b) explained that an owner must deposit a fee equal to 1% of the difference between his own valuation and the valuation appearing in the valuation list. The purpose of this limitation is to discourage owners from supplying the Director with inadequate or false information. The Director examines any objections submitted to him with the required fee and notifies the person objecting of his decision. If the owner is not satisfied with the Director's decision, he has the right to appeal to the Court.

2.5.7 Procedure of Revaluation

According to Section 71 of the Cyprus Immovable Property (Tenure, Registration and Valuation) Law (1946), Capital 224, a revaluation of any individual property can be made at the instance of the Director for the purposes of securing an up-to-date and uniform valuation of immovable property in any municipality, village or quarter. The Director may give notice of the proposed valuation or revaluation to the person or persons affected, requiring the owner to supply the valuer with information about the immovable property and, if it is necessary, to give the valuer the opportunity to inspect the property. When a valuation or a revaluation has been made, the Director gives notice of the value to the owner of the affected property. The owner may object in writing to the Director within thirty days from the date of receipt of such notice. The Director may consider any objection made to him and notify the person objecting of his decision. If the owner is not satisfied with the Director's decision, there is a right of appeal to the court.

2.5.8 Appeals procedure

Owners are reminded by the mass information media of the dates of tax payments. In the case of sewerage charges, notices of property values are sent to taxpayers by mail. Owners may refuse to pay their tax because they have objected in writing to the Director. The Director considers any objection made to him and notifies the person objecting of his decision.

If an owner is not satisfied with the decision of the Director of the Lands and Surveys Department regarding the valuation of a certain property, he has the right to resort to the District Court. The District Court after having heard both parties (owner and the Department) will give the decision on the market value to be adopted. If either party feels that the decision of the District Court is not correct, an appeal may be made to the High Court. Individuals and legal bodies are represented by attorneys at all appeal cases and may hire expert property valuers and surveyors. An appeal does not postpone the deadline for payment and tax non-payments are fined with the pre-defined rate of interest on the payment amount. The number of appeals is generally quite small because owners are normally satisfied with the assessed property values. As values are estimated as at first of January 1980, owners have the illusion that the taxes are based on underestimated values. The constitution of Cyprus does not allow the use of valuation tribunals.

2.6 Exemptions, reliefs and concessions

Properties belonging to the state, the municipalities and the communities (i.e. villages) are exempt. Additionally churches, places of worship, non-profit-making organisations and properties owned by foreign states for diplomatic purposes are also exempt. It should also be noted that in Cyprus, central government taxes and local authorities' rates are mainly payable by those owners whose property is located within municipal, town and improvement board areas. Thus, properties in rural areas are not affected directly by taxation laws. Cyprus Immovable Property Tax of 1980 affects rural areas, provided that the owner is not a farmer and the total value of an owner's property exceeds £100,000. There are three main reasons for this:

1. to motivate people to develop agriculture and farming without the burden of taxes on the landed properties;
2. to discourage people from leaving rural areas and moving to towns, by reducing

the cost of living in the rural areas; and

3. to secure the reduction of administrative costs. Generally, land values in rural areas are much lower than values in towns, so an economic tax system in rural areas would have relatively high rates of tax, unless some form of complex equalisation of funds was introduced by the state.

The following properties are exempt from Towns Tax (S.9, Law 89 of 1962), Town Rate (S.92, Cap. 240) and Improvement Rate (S35 D, Cap. 243):

1. any public burial ground;
2. any church, chapel, mosque, meeting house or premises or such part thereof as shall be exclusively appropriated to public religious worship;
3. any premises used as public hospitals;
4. any immovable property:
    - held and registered in the books of the District Lands Office in trust for any school operating under any Law in force for the time being relating to Elementary or Secondary or Higher Education (this last for Towns Tax and Improvement Rate only);
    - belonging to the Republic;
    - owned or used exclusively for the purposes of any charitable institution of a public character supported mainly by endowments or voluntary contributions in so far as such immovable property is held for such purposes. (Such properties will not be exempt from taxation unless and until local enquiry is

held on the application by the institution concerned and on payment of fees for the purpose, and the Director to whom the report of the District Land Office, is referred signifies his approval for such exemption);

5. "Supply Lines" belonging to the Electricity Authority of Cyprus. "Supply Line" (S.2 Cap. 171) includes any building or apparatus connected with a conductor etc., for the purpose of transforming, etc., electricity (S.25, Cap. 171);
6. property owned by any foreign state and used by such state as an embassy or consulate or as an official residence of the diplomatic representative of that state, provided that such state has signed the 1961 Vienna Agreement on Diplomatic Privileges (Art. 23 of the Agreement, Law 40/1968).

The following properties are exempt from Towns Tax (S. 9, Law 89 of 1962) and Improvement Rate (S. 35D Cap. 243):

1. property owned by the Offices or any other body or Authority of any Communal Chamber of the Republic;
2. property registered or recorded in the books of the District Lands Office as common pasture ground;
3. property recorded or assigned *"abantiquo"* for the common use of the community. (This includes also all village domestic water supplies, whether issuing from wells or otherwise (DLS 314/1948 of 24.1.1951).

Property owned by a Municipality or a public utility body is exempt from Town Tax (S.9, Law 89/1962 as amended by S.2 of Law 73/1965). The Council of Ministers must decide on this after recommendations by the Minister of Finance and the Council of Ministers may impose on this such conditions as they may think fit. Property belonging to the Improvement Board of the area is exempt from Improvement Rate (Sec. 35D, Cap 243).

Reference should be made to the provisions of the Persons who sustained Losses (Exemption from Taxation) Cyprus Temporary Provisions Law, 62/1975. This is a temporary Law and it affects all immovable property which is situated in the area or is adjacent to the area occupied by the Turkish troops. Such properties are temporarily exempt from taxation. On the approval of the Director of Lands and Surveys Department, any tax paid for such properties for the year 1974, is refunded to the owners. (S. 2-3, Law 62/1975).

2.7 Collection Procedures

The central government tax collectors are located in each district and are responsible for the collection of Cyprus Immovable Property Tax of 1980, Towns Tax and Capital Gains Tax. Municipalities and Improvement Boards collect Town Rate and Improvement Rate respectively. Sewerage Boards collect the sewerage charges. Taxes are payable, in one payment, within a specified period of time applicable throughout Cyprus.

Generally the payment of taxes in Cyprus is the responsibility of the owner. Where legal ownership records are not updated, usually taxes are paid by those beneficiaries who are entitled to be registered as owners. Frequently leaseholders of government land are not asked to pay taxes.

The rates of Cyprus Immovable Property tax of 1980, Cyprus Immovable Property (Towns) Tax, Cyprus Estate Duty and Cyprus Capital Gains Tax are determined by the Ministry of Finance and are approved by the House of Representatives. Cyprus Town Rates and Cyprus Sewerage Charges are imposed by municipalities and the Sewerage Boards respectively subject to the approval by the government. Cyprus Improvement Rate is imposed by the government and collected by the respective Improvement Boards. There is no differential taxation on land and buildings since all taxes are levied on property as it stands.

2.8 Enforcement procedures

Enforcement procedures for the collection of taxes are provided by law. Late payments generally carry interest and in some cases, penalties. Delays on Immovable Property tax payment are liable to 9% interest on the payment amount and delays on Town Rate, Improvement Rate and Towns Tax are each fined with 5% interest. It is worth noting that in order for a property to be transferred to another person, the owner must present proof that he has paid all the taxes related to the property. As a consequence, the government and the local authorities can be sure that all taxes and interest will eventually be paid.

When the total amount of tax owed by an owner represents a substantial sum, the authority may decide to sue the owner. In that case, the owner may be liable to a fine or to imprisonment.

2.9 Principles of Ideal Tax System

Harvey (1989) explained that governments may themselves provide goods and services. Taxation is one method to raise money to finance public goods and services. Governments can expand aggregate demand (the sum total of all planned expenditures in the economy) through its purchases of goods and services. Similarly, it can reduce aggregate demand by decreasing its own spending or by increasing taxation or both. Further, taxation can be used as a measure of reducing the rate of inflation as real income falls and the money supply in the market is restricted. Moreover, Maunder et al. (1987, pp. 249-257) explained that taxes may be regarded as a leakage from the flow of income of the economy because they reduce the level of disposable income and therefore the level of personal consumption.

In order to achieve an equitable and efficient tax system, it is necessary to analyse the parameters that affect each individual tax system. The system is also influenced by the policies of the State relative to its objectives. Beardshaw (1986) explained that Adam Smith laid down four criteria for a good tax system which should have the following characteristics:

1. **Equitable** - a good tax should be based upon the ability to pay;
2. **Economical** - a good tax should not be expensive to administer and the greatest

possible proportion of it should accrue to the government as revenue;

3. **Convenient** - this means that the method and frequency of the payment should be convenient to the taxpayer;
4. **Certain** - the tax should be formulated so that the taxpayer is certain of how much has to be paid and when.

Maunder et al. (1987) explained (pp. 148-161) that there are three types of taxation systems:

1. In a *proportional tax system,* taxpayers at all income levels end up paying the same percentage of their income in taxes. Such taxes in Cyprus are the Town Rate and Capital Gains Tax.
2. A *progressive tax system* removes a larger percentage of peoples' incomes as income increases. Such a tax, it can be argued, is more equitable than a proportional tax because it produces a closer relationship to the ability to pay. Cyprus' Immovable Property Tax and Estate Duty are progressive taxes.
3. A *regressive tax system* removes a greater proportion of income as the amount of income decreases. Taxes of this type place a relatively greater burden on the lower income groups. VAT, it can be argued tends to be regressive in Cyprus. A low income family with many children pays more VAT than single adult living alone because it spends more for everyday living.

Eckert (1995, p4) explained that the general guideline for choosing the criteria for the tax base is that which will maximise equity at affordable administration and compliance costs. He also considered that international experience indicates that an ad valorem value-based, (usually either annual value or capital value or site value) property tax system which is based on real market transactions will improve taxpayer equity (ability to pay) and revenue buoyancy.

2.10 Critical Analysis

The 1909 and 1980 general valuations are used as the base for a number of taxes. The basis of assessment should ideally be a single valuation base, since uniformity of property values is one of the general valuation purposes and conforms to the legal principle of the Attorney-General, i.e. equal treatment of taxpayers. Furthermore, property taxes e.g. the Immovable Property Tax, the Town Rate, the Improvement Rate and the Towns Tax should be a single tax paid to a single authority because it would be easier for owners to pay one tax to one authority instead of paying several taxes to many authorities. Additionally, central government and local authorities' administration expenses would be reduced significantly.

If capital values for a general valuation are kept updated at regular intervals, for example every two or three years or whenever an assessment ratio study indicates that reassessment is needed (IAAO, 1990a, p. 540), the assessment of tax will be based on what actually exists on the land, including buildings, at the date of taxation. An assessment ratio study compares appraised values to market values (IAAO, 1990a, p. 515). It can be argued that this is an equitable system since the capital value as indicated by an open market sales price reflects all the valuable characteristics of the property (McCluskey, 1999, pp. 2-4). It increases the social equity of the tax because it reflects current values and up-to-date relativities of "wealth" (assuming "wealth" equates at least in part to capital values of immovable property and not to other financial indicators). Examples of an out-of-date assessment tax system are the Cyprus Immovable Property (Towns) Tax and the Cyprus Improvement Rate, because 1909 assessed values are used as a basis of taxation.

If an owner has the following properties located in the area of Strovolos Municipality which is affected by Towns Tax, and the following values apply:

	evaluated at 1980 Capital Values	evaluated at 1909 General Valuation
building site	£15,000	£50
house	£30,000	£250
apartment	£20,000	£200
Total	£65,000	£500

each year the owner would pay the following taxes:

1. Immovable Property Tax of 1980. As the total value of the owner's property is less than £100,000 and providing the owner is not a legal body, then he is exempt from paying this tax.
2. Town rate. The rate is 0.05% on the total value of the property in the Municipality, so at 1980 values, the owner will pay £32.50 (£65,000 multiplied by 0.05%).
3. Towns tax. The rate is 1.5% on the total value of the property in the Municipality, so at 1909 values, the owner will pays £7.50 (£500 multiplied by 1.5%).

The Town rate is £32.50 because the basis of assessment is 1980 values. An up-to-date valuation basis would ensure that taxpayers pay according to an up-to-date capital value and in proportion with their current relative liabilities i.e. if someone's property is now worth £30,000, he should pay half the tax of his neighbour, whose property is now worth £60,000, even if both properties were worth £15,000 in 1980.

In order to have an estimate of the effect of an updated revaluation on tax liability, an analysis of 90 apartment sales was carried out, (see Appendix III). The sales were carried out in the Strovolos Municipality from January 1995 to October 1995 and at the analysis stage, the sale (declared) price was compared with the 1980 values. This analysis demonstrates the existence of inequity because the assessment of taxes is based on old values and the capital value does not reflect all the valuable characteristics at current values. This sample does not include all the sales of apartments in Strovolos municipality but includes only the sales for which 1980 values were stored in computer records. The 1980 values are not stored immediately for every record because of the difficulties in finding them from the manual records.

The mean percentage increase is calculated as follows:

$$\sum_{i=1}^{i=90}(SALEPRICEi - 1980CAP.VALi) \times 100 \div 1980CAP.VALi \qquad (2.1)$$

the "SALEPRICE" is the sale price corresponding to the whole share, "1980CAP.VAL" is the 1980 capital value. The result of the equation (2.1), is divided by the number of samples, that is 90.

The mean percentage increase is estimated at 134.14%, so it can be argued that the above owner's apartment may roughly be valued for £46,800 at 1995 values and an estimate can be made of the owner's tax liability assuming a similar level of revenue is to be raised. Sale price is also called "declared price" because it is the price declared by the vendor and purchaser in the Lands and Surveys Department for transfer fees purposes. Sometimes the price declared is understated unlawfully in an attempt by the purchaser to pay to the Lands and Surveys Department lower transfer fees and the vendor to pay less Capital Gains Tax.

The ratio of the sum of 1980 open market capital value and the sum of the sale price (corresponding to the whole share) is 0.44. This is a strong indication that 1980 values do not represent today's values. The 87th and the 88th apartments in the sample were both sold in September and October 1995 for £40,000 each. However, the owner of the 88th pays 18% less Town rate and Towns tax compared with the owner of the 87th because their 1980 assessments differ by £3,600. This is a distinct example of inequity.

Furthermore, Figure 2.1 provides a descriptive summary of the ratio of 1980 capital values and sale prices over the month of sale. It can be observed that the points are away from the unit: that is, there is great difference between 1980 capital values and sale prices. Most of the values of ratios are found between the 0.4 and 0.5: that is, most of the 1995 sale prices of this set of apartments in Strovolos were sold for more than double their 1980 capital value.

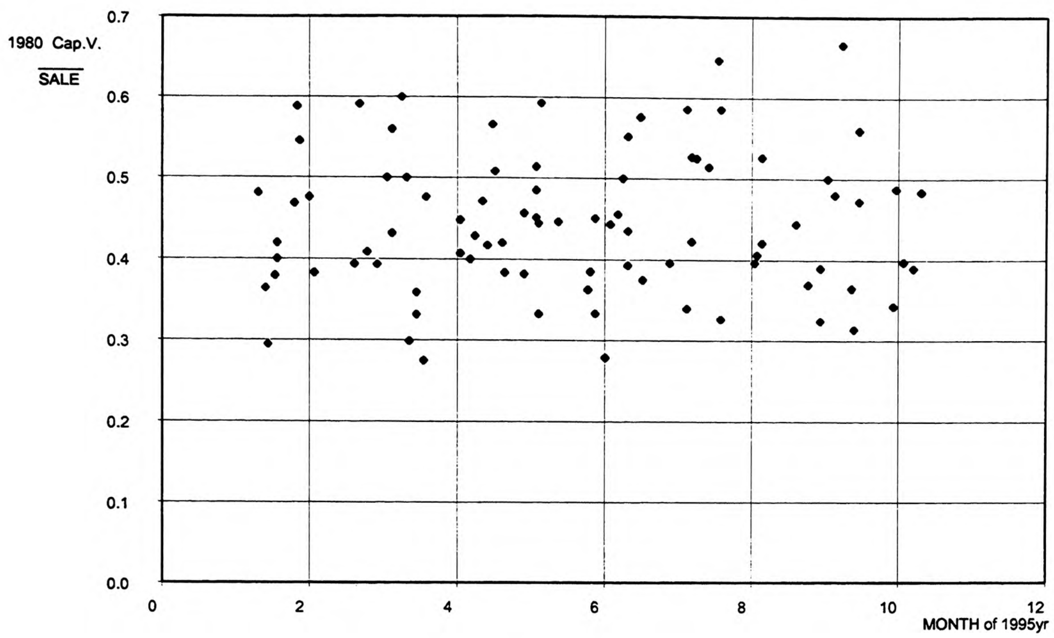

Figure 2.1 Capital Value and Sale Price ratio

It is also worth noting that land records are not updated immediately with landed property changes because manual systems are used at present for the interchange of information between the Lands and Surveys Department and the local authorities. The Lands and Surveys Department is supplied once a year with changes. Additionally, when there are deceased owners and the properties of the deceased have not been registered in the name of the heirs, taxes are paid by those heirs who are entitled to be registered according to sections 9 and 10 of Cyprus Immovable Property (Tenure, Registration and Valuation) Law, Capital 224, 1946. This is usually observed in rural areas where values are rather low compared to properties in the municipal areas.

2.11 Conclusions

It has been demonstrated that immovable property taxation system in Cyprus is:

1. *inequitable;* because the assessment of taxes is based on old values and the capital value does not reflect all the valuable characteristics at current values;
2. *inconvenient;* because tax payers pay various taxes to various authorities, especially when an owner's properties are located all over Cyprus;
3. *unfair;* because tax systems of the Town Rate, the Improvement Rate and the Towns Tax are proportional and because of this fact, people with high-valued immovable properties pay at the same rate as every other owner;
4. *unjust;* regarding the contribution between those owners within local authority areas and those outside; and
5. *inconsistent;* because properties located outside municipalities, towns and improvement boards are affected only by one direct tax, the Immovable Property Tax of 1980, and this only if they are not exempted under this Law.

2.12 Recommendations

It is the recommendation of the research that all property-based taxes in Cyprus could be improved both from the tax payers' and the tax collectors' point of view addressing the needs of the spending authorities for regular, sufficient and stable sources of funding so that an equitable, convenient, certain, up-to-date system results and the operational and administrative costs decrease. The following recommendations would provide the means for practical improvement, thereby giving local authorities a strong and stable financial foundation on which to build the provision of quality services.

1. The central government of Cyprus should adopt an up-to-date capital value basis of assessment, so as to provide consistency throughout the country.
2. Current capital values will not only assist equity and uniformity but also can be a useful tool to discourage purchasers and vendors from declaring a lower price. Lands and Surveys Department could present capital values of similar properties in the area, as evidence to support estimated sale prices for transfer fee purposes. This would result in greater receipts of Capital Gains Tax and transfer fees.
3. Once a revaluation has been carried out and implemented, the new values should immediately be adopted for all taxes which should be merged (see 8).
4. In order to make revaluation regular and more frequent, say every two or three years, it is recommended that the benefits of new technology be utilised. The introduction of Computer Assisted Mass Appraisal (CAMA) systems would assist in estimating property values at a certain date, based on limited sales data, using different techniques for the prediction of a property value, e.g. multiple regression analysis and artificial intelligence systems. The best technique will predict values at a certain date, with minimum acceptable mean

error, minimum data, minimum cost, fast response, minimum human skill and effort.

5. The Lands and Surveys Department is able to provide digital information on ownership for a number of municipal areas and within five years for most of the country. Tax collectors, including central government, should use computer technology to send separate bills to each owner, where it is possible, as well as reminders, if necessary.
6. Even if all ownership records in Cyprus are computerised, it will not be possible to estimate an owner's total property market value, because Lands and Surveys Department has only started to record personal identity numbers and company registration numbers systematically since 1986. It will lead to erroneous results if Lands and Surveys digital records are used for the calculation of Immovable Property Tax 1980. The Department has to adopt methods to find the ID numbers of the owners where that is possible.
7. Rebates for the poor will make collection more acceptable i.e. recognition that a high property capital value does not mean a high income out of which taxes are paid.
8. The state should examine the likely effect of merging existing property taxes into a single one, including the resulting procedures of collecting revenues and appeal procedures against those who refuse to pay taxes. Revenues could be distributed to local authorities in those cases where collection is by central government. Since the administration of income is by local authorities, they

will not lose financial control. The procedural cost of property taxation will be minimised and as a result the system will be more efficient, cost-effective and flexible.

9. The state should examine the case for the inclusion of rural areas which are currently not affected directly by taxation laws, because of the continued rise of land values, the computerisation of Lands and Surveys Department, the need for local services and the environmental improvement of those areas. Rates can be regulated by local authorities, and specific rebates or cash-back schemes introduced where and when appropriate.

10. Government should clarify its position as to whether leaseholders should pay taxes as they enjoy services provided by local authorities and central government.

11. If based on the dated records held by the Lands and Surveys Department, the application of computer assisted mass appraisal techniques will not operate efficiently and will result in inaccurate assessments. The Lands and Surveys Department should re-examine the procedures for updating the land records with local authorities and the District Officers.

12. Furthermore, since the last general valuation was in 1980, a further revaluation should be implemented as soon as practicable.

This research work, including the following Chapters is focusing on recommendations from one to four and especially on the development and testing of a CAMA system using ANNs.

Never the less, the other recommendations are also important if Cyprus is to achieve an up-to-date, efficient and effective immovable property tax base from which to fund government spending programmes and achieve fairness to tax payers within that funding process.

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3. COMPUTER ASSISTED MASS APPRAISAL SYSTEMS

3.1 Introduction

The Department of Lands and Surveys of Cyprus, decided to introduce information technology in the late 1980s and for that reason commissioned consultants from the South Australian Lands Department to prepare a strategic plan for the development of a fully-integrated Land Information System (Sagric International Pty Ltd, 1989). In 1991 Sagric International Pty Ltd (see Appendix II) was commissioned to carry out all the preparatory work for tender documents (RFT). The main proposal in the area of Computer Assisted Mass Appraisal (CAMA) systems of residential areas was suggesting simple and multiple regression analysis.

More recently, DataCentralen A/S which developed the Danish CAMA system, has adjusted it for Cyprus' needs as a principal method for resolving valuation difficulties for Cyprus. The Danish Valuation system, known as the "Total Value System" or as a "base home approach", is also based on multiple regression analysis.

Multiple regression analysis (MRA) is the study of the relationship between a quantitative dependent variable Y and several independent variables. The goal of MRA is to analyse the relationship between the dependent variable and two or more independent variables (Shiffler and Adams, 1995). More specifically the objectives of

MRA are:

1. to identify the dependent variable and several potentially independent variables;
2. to propose a statistical model that relates the variables;
3. to fit the model;
4. to test the utility of the fitted model;
5. to use the fitted model for prediction, if applicable.

MRA technique measures statistically the relative influence of several factors. This fact is of considerable practical relevance to valuation where capital value may be modelled as the dependent variable and gross floor area, age of property, type of property and other property characteristics treated as independent variables. However Gronow and Scott (1986a) commented that while it might be hopeless to try to isolate all factors which buyers take into consideration when purchasing property, it is possible to establish a correlation between property values and a selected subset of characteristics which determine values. This can be achieved using stepwise method (Refer 4.5).

Artificial Neural Networks (ANNs) have the ability to learn from experience and are widely used in pattern recognition exercises e.g. classification problems. Attempts to apply ANNs to the valuation of residential property date from the early 1990's. Some researchers compared their results with MRA and contrasted their findings.

This Chapter consists of the following sections: the definition of mass appraisal; the multiple regression analysis in property valuation; the CAMA systems in Cyprus; the ANNs in property valuation; and the conclusions.

3.2 Defining Mass Appraisal

Mass appraisal is the systematic appraisal of groups of properties as at a given date using standardised procedures and statistical testing. This has become an important tool in the assessment for taxation purposes because it has the capability of assessing land properties in very short time (IAAO, 1990a).

3.3 Multiple regression analysis in property valuation

The first and the extensive use of MRA in property valuation, was to estimate the open market value of residential property. Pendleton (1965) demonstrated that a statistical model could be constructed to predict the average sales prices of a sample of houses in the District of Columbia within error limits of 6-7 per cent. He commented that it was possible to identify a group of independent variables that could account for approximately 90 per cent of the variations in the selling prices of houses. The principal independent variables used in Pendleton's regression analysis were house size, plot area, accommodation and equipment in the house, job accessibility index and the mean income of occupants. Another early application of the method was in the assessment of value for taxation purposes. Hinshaw (1969) as County Assessor of Orange County, California, demonstrated how MRA was used to predict the selling price for property using past sales of comparable properties as the basis for prediction. A major advantage was its objectivity and impartiality in arriving at value. Another advantage demonstrated was its low cost and accuracy in assessing the values of a large number of properties very quickly. These are major benefits for taxation and rating assessors. However a number of valuers remained unconvinced of the benefits of MRA. Lessinger (1969), criticised the way in which MRA was being applied, believing that fundamental assumptions of the method (see 4.2) were being violated by the characteristics of the property market. The point that MRA is highly dependent on the property market, makes impossible the avoiding of errors and omissions.

Adair and McGreal's (1987) analysis of the residential property market in the Northern Ireland Property Market Analysis Project (NIPMAP), 1985, indicated that if MRA is to be applied effectively by the valuer, then models need to be generated for a "homogeneous" group of properties in a well-defined geographical unit. Furthermore, they explained that in situations where variability is high and spatial location large, such as at the regional or city scale, it would appear that MRA has severe restrictions, unless good indicators of location can be generated. They concluded that MRA provided valuable assistance to the professional valuer by giving an objectively derived supporting opinion or highlighting circumstances where a re-appraisal of value is necessary.

In a similar study, Fraser and Blackwell (1988) commented that a serious consequence of the process of data collection was the absence of an internal inspection of the houses that prevented the use of about 50 per cent of the otherwise reliable sales data. In spite of this, the use of a smaller group of sales and the removal of some variables from the models used, produced a highly satisfactory conclusion (coefficient of dispersion, *COD*, 10.66).

Morch-Lassen and Pedersen (1994) explain that in Denmark a one-step-multi-regression analysis technique is used for estimating the value of immovable properties for taxation purposes and show that for single-family homes, the average error term for the 1986 and 1992 valuations was 2%.

Fibbens (1995, p. 68) comments that, at the date of his research, simple regression had been the main technique used to produce rating valuations in Australia. South Australia introduced computer-based valuation in 1979 and first used this system in the production of annual values in 1986. Fibbens (ibid.) explains that while the use of regression techniques has been favourably reported, the techniques may be subject to some practical problems. Firstly, in many cases in Australian valuation practice, all property within a valuation district is valued as at a single base date. However, this is not always the case and it is possible that valuers may be required to report at some other date e.g. the date of inspection of the individual property. Secondly, in cases where regression techniques are used effectively, these are underpinned by an up-to-date, accurate computerised data base. Thirdly, in the case of the use of index numbers (sale price/old value), if the original valuation is flawed, a simple linear regression will preserve the flaw throughout the computerised re-valuation cycle. Fourthly, even where an adequate database exists, problems may be encountered in the adoption of computer based valuation systems. It is possible that because of the diversity of housing types in cities such as Sydney, New South Wales that computer approaches developed elsewhere in Australia would be unable to deal effectively with this diversity. Fifthly, the quality of the existing database must be sufficient to support computer based mass appraisal. For example, it may be impossible to predict either annual value or capital value if data relating to improvements is unavailable (or even out of date).

Wayne et al. (1998) explains that in September 1997, in Alberta, Canada, MRA has been applied to examine and implement the re-appraisal of 4,000 apartment buildings using the income approach for the taxation year 1999 using 1998 as the base year. The *COD* of the estimated values was a useful 14.05 and they concluded that models should make appraisal sense, be statistically accurate and be stable.

The MRA models that are referred to above are linear. Non-linear models have also produced satisfactory results. In a similar study, Donnelly (1989) compared three alternatives:

1. the traditional valuation methodology;
2. the use of the linear model; and
3. the adoption of the Box-Cox model.

The reliance upon a linear formulation is evaluated using the Box-Cox (1964) modelling strategy. This is a non-linear transformation of the data that allows the data to indicate the most appropriate functional form. Comparisons among the formulations were based upon an analysis of the values of the log-likelihood functions of the various models. Donnelly (ibid.) concluded that, although the non-linear model formulation produces equation statistics superior to those obtained from the linear model, the latter might well be acceptable for the purposes of ensuring the consistency and equity that are intended. Still, as the state of the art in computers progresses, it is probable that even more complex non-linear models, e.g. the quadratic Box-Cox, will become the recommended modelling strategy. However, the linear formulation has proved to be robust and should not be rejected without due consideration (Donnelly, ibid.).

Clearly MRA has a long and respectable pedigree as a tool in residential valuation appraisal provided that it is properly applied.

3.4 Computer Assisted Mass Appraisal systems in Cyprus

3.4.1 Case 1: Sagric International consultancy

Computer Assisted Valuation (CAV) techniques can only be used if suitable data are available. The first and most important step is the creation of an appropriate data base. If a Legal/Fiscal Data Base is created for Cyprus, it should contain all of the relevant valuation data required to drive the CAV models. Sagric consultants suggested the following:

"2.2 LEGAL / FISCAL DATA BASE

The concept of the legal/fiscal data base will be to provide a fully integrated data base of both the legal and fiscal requirements of the Department of Lands and Survey. Data items that will be required the Valuation Branch are:

- Legal Description
  - Plots
  - Registration Block Number

- Registration Number
- Town/Village/Quarter

- Ownership
  - Vendor
  - Purchaser
  - Share of Property being transferred
  - Date of Contract (File number etc.)
  - Consideration (Price)

- Property Characteristic
  - Area of land
  - Frontage/Shape/Slope/Views
  - Improvement detail (including appropriate ROW & COL address)
  - Agricultural detail (including appropriate ROW & COL address)
  - Method of Valuation indicator
  - Land Use Code
  - Zoning
  - Planning Density
  - Sales Analysis Indicator
  - Address of Property.

- Assessed Values
  - Parcel Identifier
  - Value Type
  - Date Recorded
  - Value
  - Valuation Method
  - File Reference

- Special Valuations

  Special Valuation Project Details
  - Project file reference
  - Requesting authority code
  - Project type
  - Date initiated
  - Remarks

  Properties with Special Valuations
  - Parcel Identifier
  - Portion of plot indication
  - Date received
  - Special Valuation

- Date valuation applicable to
- Valuer assigned
- Date completed
- Checking authority
- Hours worked

The data base structures should allow for the addition of additional attributes should they be required at some time in the future." (Sagric International Pty Ltd, 1991, pp. 340-341)

"2.3 SALES HISTORY DATA

The important characteristics of this data are

- They provide an historical perspective to legal/fiscal data.
- It will provide access to the legal/fiscal data base at a particular point in time (i.e. the date of sale).
- Historical property definitions may not correspond with the current legal/fiscal data base. For example, due to land divisions many records on the current legal/fiscal data base may correspond to one historical record and vice versa. Old, non current records will have to be retained.
- There will be automatic update of historical data from the Registration system.
- Historical data for the whole country will be accessible in each district office.
- Corresponding historical spatial representation of land sold will be maintained on the Digital Cadastral Data Base (DCDB).

The function of the Historical data will be to provide up to date information regarding property sales. Market valuations are based on the evidence provided by such sales information and it will be used by both the Public and the Private Sectors for this purpose.

The Sales History System will have access to all the property details attributed to the property at the time of sale. For example:

- Legal Description
    - Plots
    - Registration Block Number
    - Registration Number
    - Town/Village/Quarter

- Ownership
    - Vendor
    - Purchaser
    - Share of Property being transferred

- Date of Contract (File number etc.)
- Consideration (Price)

- Property characteristic
  - Area of Land
  - Frontage/Shape/Slope/Views
  - Improvement detail (including appropriate ROW & COL address)
  - Agriculture detail (including appropriate ROW & COL address)
  - Land Use Code
  - Zoning
  - Planning Density
  - Sales Analysis Indicator.

Data Requirements are still to be finalised and it is a Department of Lands and Surveys (DLS) responsibility to finalise this detail.

There will be a requirement for each sale to be flagged by the valuer indicating whether or not it represents market value. This flag can then be used to select sales to be used in analysis of the property markets. (Sales Analysis Indicator)." (Sagric International Pty Ltd, 1991, pp. 341-343)

In 1992, a prototype legal/fiscal data base system was designed and developed jointly by the Information Technology Services Department, the LK Computer Systems Consultants Ltd and the Lands and Surveys Department. The objective of that system was data capturing of a pilot study area for the testing of the final Land Information System. Since there were delays in the approval of tenders of the Cyprus Land Information System, the data base system has been used for taxation, searching and reporting purposes. It has also been expanded and Certificate of Titles have been issued since 1994.

In 1994, the Lands and Surveys Department entrusted the candidate with the design and the development of a Sales History System. The System was designed according to the present manual system and the computerisation standards. It was developed using the Foxbase+ data management system. It does not provide access to the legal system, even though it is compatible, because each is an independent system. The main objectives of that Sales History System are the storage of data about sales and contracts of sale which are performed in the Lands and Surveys Department and also providing valuations/market reports for the needs of the Lands and Surveys Department valuers and the valuers in the private sector. It will not be extended but it will be replaced by the CILIS as soon this can support the transactions all over the Republic.

Primarily, the objective of CAV is to reduce the time and improve the level of accuracy involved in completing a valuation task without increasing the need for human resources or higher levels of technical skill. Historically, a large component of the mass appraisal function has been clerical, including filling in valuation sheets, searching for information etc. However, the philosophy of CAV is to change this historical role. CAV techniques would manage the clerical tasks, leaving the professional valuer free to perform the professional valuation function for which the valuer had been trained. This would maximise the use of scarce and valuable resources and allow for more of the professional valuer's time to be optimised without increasing the number of staff. The aim of CAMA systems is to produce an individual market valuation of all property as at a certain date in accordance with the Cyprus Immovable Property (Tenure, Registration and Valuation) Law, Capital 224, 1946 as a basis for the various property taxes levied by Government (refer 2.3).

Sagric consultants grouped the process of CAMA systems into three phases. These are:

" 4.2.1 The Monitoring Phase

Objective:
To compare the current assessment with the current market as indicated by comparable sales.

Data Source:
Sales History Data Base (Comparable Sales) Legal / Fiscal Data Base (Current Values).

Process
The statistic to be calculated for this comparison is called the Sales Ratio Statistic. This

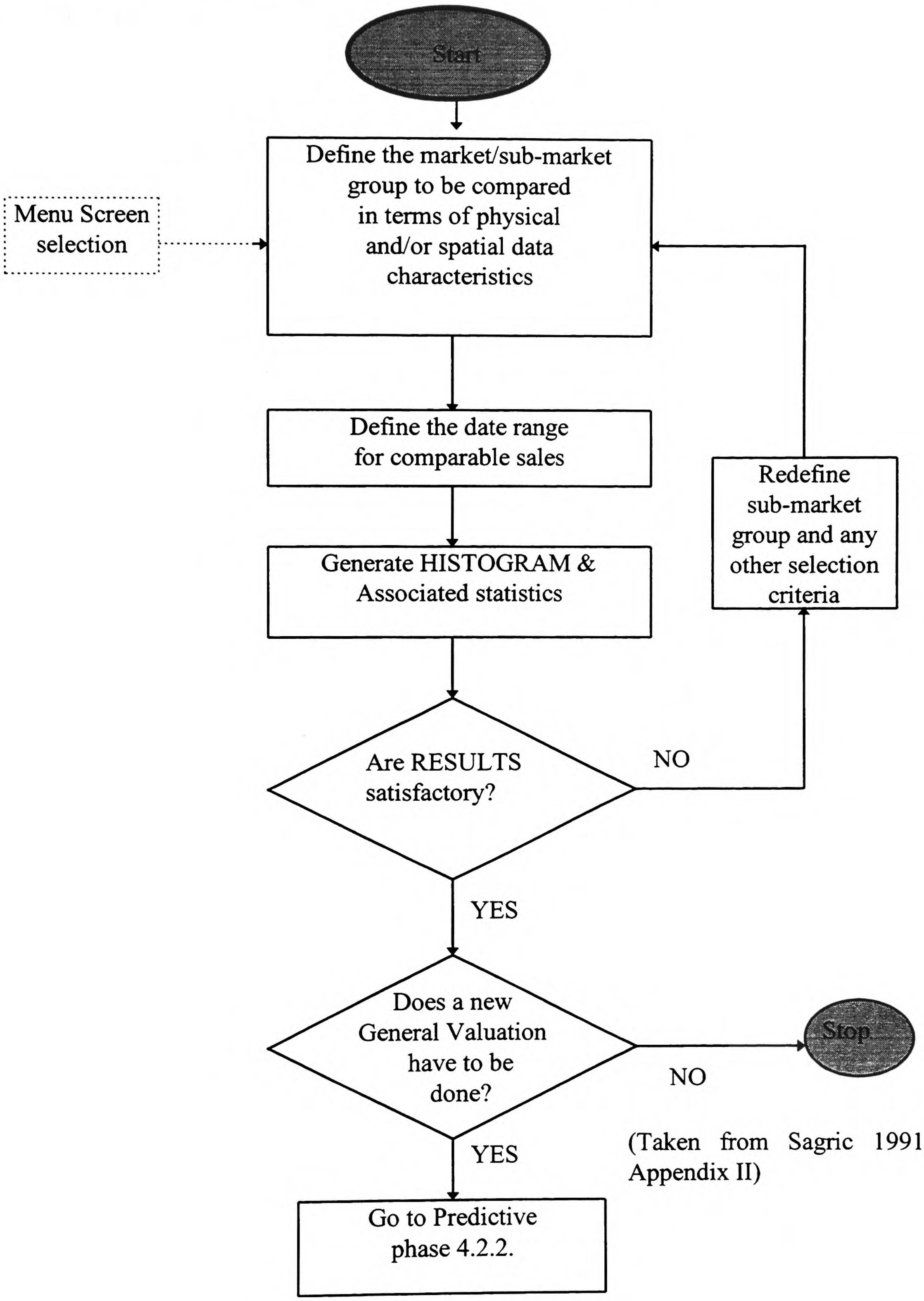
is defined as being =

$$\frac{\text{Current Capital Value}}{\text{Analysed Sale of Property}}$$

for all properties sold.

This ratio is calculated for each relevant (comparable) sale which has occurred in the area being monitored.
These ratios are visually presented to the user (hard copy format) in the form of a histogram (Frequency distribution for the ratios).
Statistics are also calculated giving various measures of central tendency and coefficients of dispersion.
Algorithms for these calculations are numerous, but a good reference is "Improving Real Property Assessment". International Association of Assessing Officers, 1978, Chapter 5.
The process may be broadly represented in flow chart form as shown in Appendix II."

(Sagric International Pty Ltd, 1991, pp. 348-349). Appendix II, Sagric International Pty Ltd (1991), is displayed in Figure 3.1.



(Taken from Sagric 1991, Appendix II)

Figure 3.1 The Monitoring Phase

"4.2.2 The Predictive Phase

Objective:
To produce a set of predicted market values at a level, and with a comparability, shown by the market through comparable sales.

Data Source:
Sale History Data (Comparable Sales)
Legal/Fiscal Data Base (Current property characteristics)

Process:
The Sub Market Group for which predicted values are required has already been established. It is the same as defined in the Monitoring Phase.
Establish the number and type of valuation methodologies (models) required.
The functional requirement will be for a many and varied number of valuation methodologies (models) to be used. A "method of valuation" indicator stored on the Legal/Fiscal data base will determine which model is to be used.

Broadly, they will fall into three main categories.

Firstly, statistical models. These will vary from multiple regression to single regression models. They will require the capability of statistically analysing sales history data and applying the resulting algorithms to the Legal/Fiscal data base. In the main they will be of the general form
$Y=A_0+A_1+A_2X_2+...+A_nX_n$
where A = Constant derived from statistical analysis
X= Variable stored on Legal / Fiscal data base
n= number of variables.
Although non-linear analysis and algorithms may be used, this will depend on results of future research. It should be possible, with the correct definition of Sub Market Groups, to maintain linear relationships."

(Sagric International Pty Ltd, 1991, pp. 349-350)

The multiple regression analysis technique measures statistically the relative influence of several factors and explains in an objective manner how value or price is dependent upon a particular set of independent variables. The fact that the combined influence and effect of several variables can be measured is of considerable practical relevance to valuation where capital value may be modelled as the dependent variable and gross floor area, age of property, type of property and other property characteristics treated as independent variables.

A pilot study was performed by A. J. M. Lockwood from Sagric International in 1990. For the residential model, 25 benchmarks were established at 1990 values. Simple regression against 1980 values produced strong correlation, with a standard error estimate slightly higher than 10% of the mean 1990 value. The objective was to demonstrate the concept of mass appraisal using a statistical method rather than to obtain perfect results.

"Secondly, the summation methodology. This will utilise a row and column address stored on the data base for each value component. This will be used by the algorithm to retrieve a user assigned value from a designated rate table and summing each component to establish a predicted value."

(Sagric International Pty Ltd, 1991, p. 350)

The summation methodology requires the existence of rate tables consisting of values which are derived from the statistical analysis of sales and property characteristics. Each property record keeps row and column addresses which are used to drive the selection of coefficients for the prediction of property assessment. The predicted values derived from this method depend on the good design of rate tables, well-calculated coefficients, well-described property characteristics and reliable and not understated sales in the open market. From time to time the rate tables must be updated by valuers because coefficients and values change.

An example of the summation methodology is the agricultural prototype developed by the Sagric expert, in 1990, in Cyprus. Each agricultural property record requires the following normalised coefficients:

1. Property type;
2. Irrigability;
3. Fertility;
4. Remoteness;
5. Accessibility;
6. Gradient;
7. Shape of Property;
8. Conditions of trees;
9. Obstacles; and
10. Lifecycle of trees.

The valuation branch gives ratings for various conditions. The assessment value is derived by an algorithm using the above factors and row and column addresses. This model was used in a pilot study area only. The accuracy of the results were mainly dependent on the ratings given by land clerks during local enquiry. Classification, as shown in the following example, of the above factors would had been more helpful for land clerks on deciding the best description, according to the local condition, instead of giving ratings.

Example of classification for obstacles:

1. holes;
2. wastes;
3. rocks;
4. bushes;
5. caves;
6. obsolete structures; and
7. stepped levels.

According to the Sagric International Pty Ltd (1991), the concept of row and column addresses was tested successfully using Lands and Surveys Department agricultural model. Based on these results it was also considered appropriate for other models.

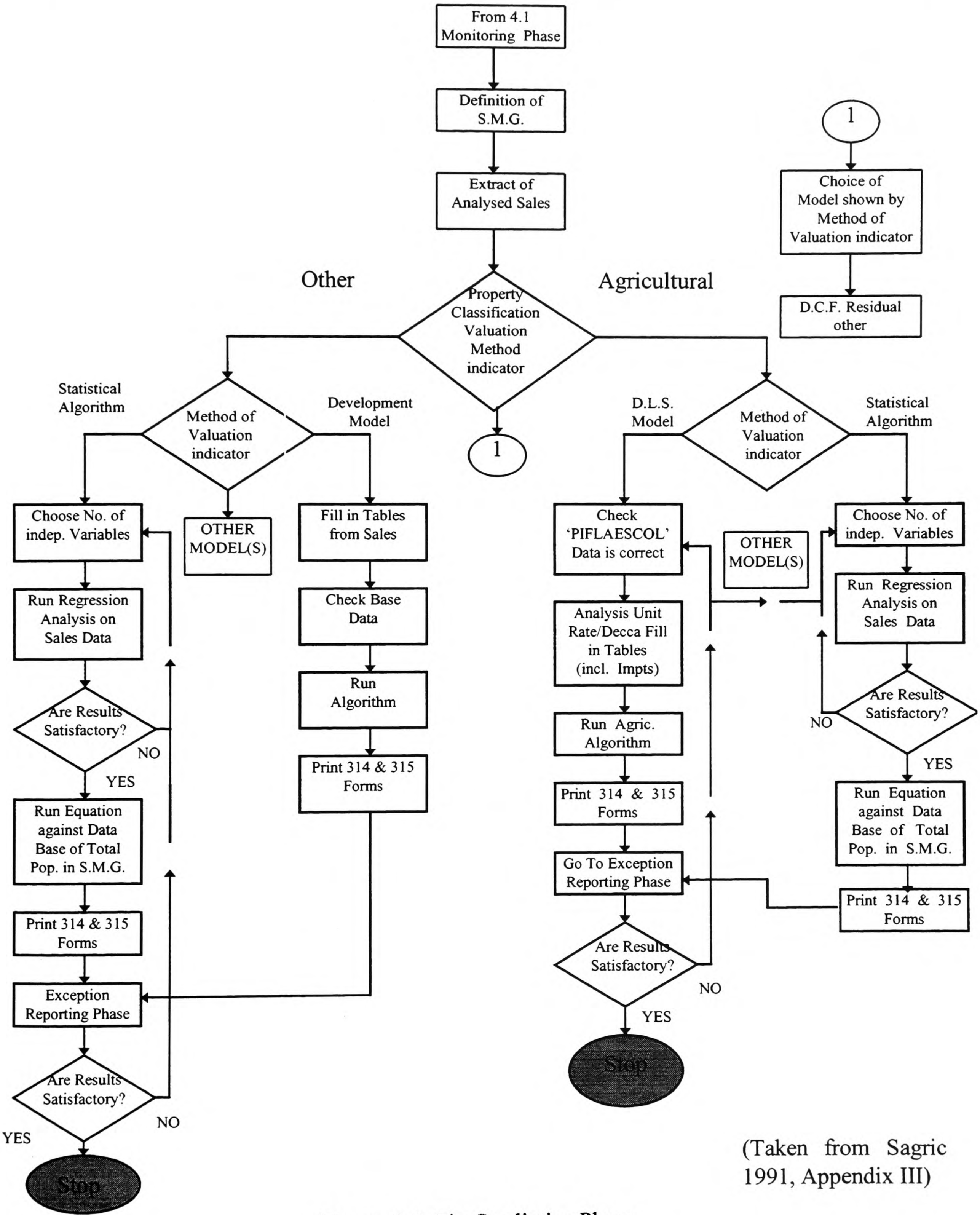
"Thirdly, simple transformation algorithms using data already stored on the data base.

- Apply the appropriate models to the appropriate groups of property.

This process may be broadly represented in flow chart form as shown in Appendix III."

(Sagric International Pty Ltd,1991, p. 350)

Appendix III, Sagric International Pty Ltd (1991), is displayed in Figure 3.2. This shows the Predictive phase of proposed CAMA system.



(Taken from Sagric 1991, Appendix III)

Figure 3.2. The Predictive Phase

"4.2.3 The Exception Reporting Phase

Objective

To produce a list of properties in a form which the responsible valuer can perform a field inspection check to determine the accuracy of the predicted value and the associated data. It is important both of these factors are checked.

This list contains properties which are statistically most likely to require the attention of the professional valuer.

Data Source

Legal/Fiscal Data Base (All property characteristics and predicted values).

Process

The responsible valuer defines GROUPINGS (by property characteristics) of properties which should have similar values and from which exceptions to this expectation are to be generated.

The total Valuation List is summarised in this form.

The exception report contains those properties by address, which deviate the most from the mean predicted value of these groupings.

This process may be broadly represented in flow chart form as shown in Appendix IV".

(Sagric International Pty Ltd, 1991, pp. 350-351)

Appendix IV, Sagric International Pty Ltd (1991), is displayed in Figure 3.3.

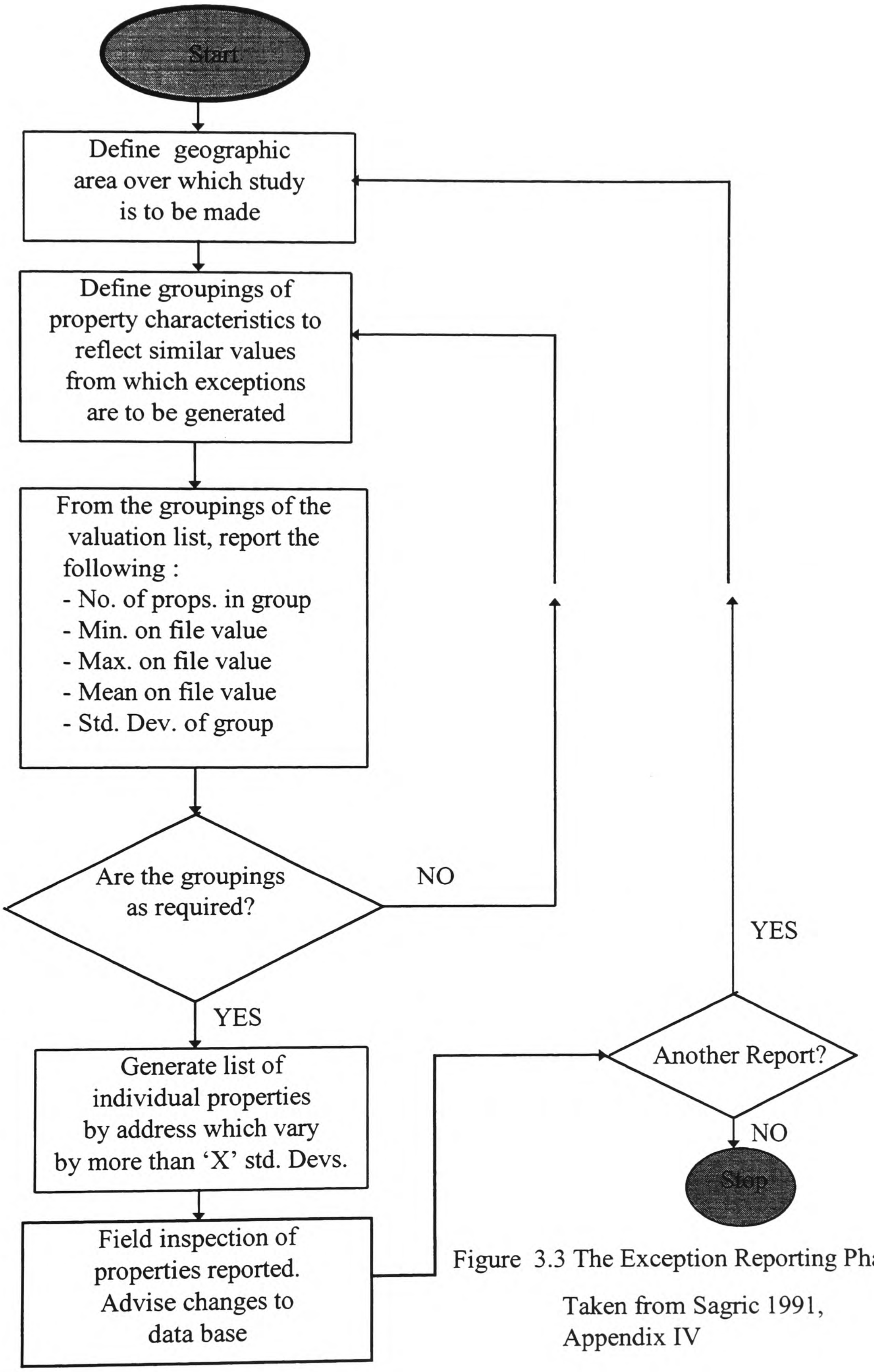


Figure 3.3 The Exception Reporting Phase

Taken from Sagric 1991, Appendix IV

Sagric International Pty Ltd (1989, p. 147), explained that in the long term, an optimum approach to the introduction of land information technology into the Department would be as follows:

1. establishment of a fully-integrated legal/fiscal data base for the whole of Cyprus, based on the findings of the pilot study;
2. establishment of CAV modelling techniques suitable for all property markets in Cyprus covering the three phases of CAV;
3. integration of legal/fiscal data with other land-related data so that the valuation function can take place as part of a fully integrated land information system.

Sagric (1989, pp. 143-144) commented that the major benefits expected from CAV systems supported by an integrated legal/fiscal database are:

1. a significant reduction in the time taken to perform a general valuation;
2. a sharing of ownership and property details among land employees;
3. easier provision of valuation information to departmental clients e.g. municipalities, valuers from the private sector;
4. a potential for the government to gain a commercial return from its land information asset by selling them in digital or hardcopy form; and
5. a reduction of the necessary staff increases.

3.4.2 Case 2: DataCentralen A/S development

According to the DataCentralen A/S (1996a), the Lands and Surveys Department and the DataCentralen A/S identified and specified five different valuation methods during the requirement analysis stage and design stage. The valuation models are designed for use in connection with mass appraisal as well as valuations for other specific purposes (e.g. compulsory acquisitions) known as special valuations. The five methods are:

1. simple regression;
2. direct sale comparison;
3. base home approach;
4. income approach; and
5. cost approach.

The base home approach will be used principally for mass appraisal of residential areas. It is based on property characteristics and sale transaction evidence and it makes extensive use of multiple regression analysis.

The critical point for the use of these models is the capturing of appropriate data. If this is not achieved, the various valuation models will have been created but will have no applications.

Simple Regression method

According to DataCentralen A/S (1996a, p. 1.4.3.-6), this model is used to regulate property valuations during intervals of general valuations, that is, it generates a simple regression equation by comparing sales prices against the values determined in the last General Valuation. DataCentralen A/S (1996a), explains that the model relies heavily on an adequate number of sales to be used in the comparison process which is the vulnerable point in the Cypriot valuation area (ibid., p. 1.4.3-6). If an adequate number of sales does not exist, then results can be deduced from different benchmark valuations.

Direct Sale Comparison method

According to DataCentralen A/S (1996a, pp. 1.4.3.-6, 7), this model compares subject properties (properties that will be valued) with comparables (properties that have been sold) and the comparison is based on similar attributes for which adjustment takes place. Furthermore, DataCentralen A/S (ibid.) explains that this model, like the Simple Regression method, relies heavily on an adequate number of sales to be used in the comparison process. Therefore, it is equally vulnerable to a paucity of data. If an adequate number of sales does not exist, then results can be deduced from different benchmark valuations.

The Base Method

According to the DataCentralen A/S (1996a, p. 1.4.3.-7), the Base method comprises three sets of models:

1. Base Parcel (undeveloped, agricultural, residential and commercial/industrial land);
2. Base Home (residential units, hotels, hospitals, clinics and schools); and
3. Base Other Property (primary production, groves and boreholes and wells).

These models make adjustments to base values for different attributes. The adjustments will be based on multiple regression analyses that will result in parameter values for each of an attributes' different values. The Base method also relies on sale evidence. Furthermore, DataCentralen A/S (1996a) explains that a more accurate calculation basis also means many attributes, and the demands on the Lands and Surveys Department regarding data capture increase.

The Income Method

According to DataCentralen A/S (1996a, pp. 1.4.3.-7, 8), the Income Method has been deemed necessary in connection with certain income producing properties as shops, offices and industrials. This model uses the "Capitalisation of Net Income" valuation method as its basis and will be used for the mass appraisal of this type of property. It provides a mechanism for determining market values when inadequate numbers of sales are available.

The Cost Method

According to DataCentralen A/S (1996a, p. 1.4.3.-8), this method comprises three different models: shops, offices and industrials. The advantage of this method is that it operates without sale evidence. The disadvantage is the need for collecting appropriate data and the fact that there is no evidence that cost equates to value. The underlying principle of this method is flawed, as must be the results. The determination of the market value can be achieved by determining the replacement cost and by depreciating that cost to account for the age of the building.

The five valuation models are normally designed for an environment of a paucity of sales data. For that reason it has not been possible to build the models based entirely on the analysis of market evidence and it has been necessary to make assumptions partly derived from experience in other countries combined with knowledge about the Cyprus market (Morch-Lassen, 1997). However, the system is flexible, and allows for alternative approaches for each property type. For instance, if it turns out that one approach proves to be wrong or provide unsatisfactory results when applied, it is possible to exchange the approach for another. Furthermore, Morch-Lassen (1997, p. 4) identified that the base home approach for residential properties contains more than 20 variables, compared to 10 in the Danish system and that the cost of collecting and maintaining data must be considered.

It is worth noting that in an attempt to design a system which will actually perform regression analysis on homogenous areas, base home has been designed to select data for a specific property type from a specific geographical (land value) area, defined by administrative boundaries (district, town, village, quarter), planning zone and location (DataCentralen A/S, 1996b, 4.7.17-4). Location can be any area defined by the responsible valuer. This will cause some problems. Firstly, the system is designed without evidence that homogenous areas can be defined in Cyprus in the above way. This could cause the failure of the application of the method on homogenous areas. Secondly, this approach involves the creation of a huge number of separate land value areas and that requires the calculation of a enormous number of regression parameters. Thirdly, the creation of a vast number of land value areas will limit the application of sales data evidence. The identified problems will make the use of MRA difficult, its efficiency low and effectiveness poor.

3.5 Artificial neural networks in property valuation

ANNs systems are relatively new tools available to the appraiser or valuer, when compared to other more widely-used techniques, such as MRA. The discipline of property appraisal can also be viewed as a problem in pattern recognition. Each property has its peculiar extrinsic and intrinsic attributes that together furnish a pattern of the property. An ANN can learn from historical sales and then apply this knowledge to appraise other new properties.

The input neurons would be supplied with the various property and transaction features and one output neuron would be specified to represent the selling price. The neural network weights are used similarly to regression coefficients. The network includes a bias which is similar to Ao in regression.

Unlike traditional computing where programmers develop complex, application-specific algorithms, ANNs learn to solve specific problems without the need for specific algorithms. After example patterns are presented to an ANN, it captures the knowledge required for classifying or predicting the outcome of the input patterns. The ability of self-learning is considered to be one of the biggest features characterising the growing interest in this field. Many situations exist where it is difficult to identify, extract and represent the rules experts use to solve a problem. Tay and Ho (1991) commented that in property valuation, the sale prices are the consequence of many experts' and amateurs' judgements. The task of finding a unifying set of operational expert rules is not easy - given the conflicting opinions experts can have. Under such situations, the sales record can be presented to a network to capture the rules automatically without the need for human intervention.

ANNs were introduced firstly by Tay and Ho (1991), in the National University of Singapore, as a new tool for the task of prediction in the area of property valuation. ANN models can be developed based on data from historical sales and, once trained, such models can be applied for the prediction and appraisal of landed properties. One of the main characteristics of ANN is their learning ability to capture necessary information from the training data without making any assumption about the underlying probability density function.

ANNs have been applied successfully in property valuation by Tay and Ho (1991), Borst (1991), Evans et al. (1992), Do and Grudnitski (1992), Borst (1995), Worzala et al. (1995), Lam (1996), Lewis et al. (1996), Lenk et al. (1997), Connellan and James (1998a,b) and McCluskey et al. (1998). Some of these studies have concentrated on the comparison of ANNs with other parametric statistical techniques. Table 3.1 summarises the applications of ANNs in property valuation.

RESEARCHERS	NETWORK TYPE & LEARNING ALGORITHM	TRAIN / TEST	NETWORK ARCHITECT. IN:HID:OUT	ANN	MRA	PARAMETERS
Tay, D.P.H. and D.K.H. Ho (1991)	Multi-layer Perceptron Backpropagation	833 / 222	10: 21: 1	Mean Error % 3.9 -0.2	Mean Error % 7.5 0.0	Input : Floor Level, Postal District Code, Lot Number, Dummy 1, Dummy 2, Dummy 3, Dummy 4 (Plain Flat, Apartment with lift, Penthouse Apartment, Apartment above a shop, Walk-up Apartment), Floor Area, Years Remaining to expiry of Tenure, Sale Agreement Date. Output: Normalised sale price.
Borst, R.A. (1991)	Multi-layer Perceptron Backpropagation	a. 218 / 22 b. 217 / 22 c. 279 / 31 d. 217 / 22	a. 21: 42 :1 b. 18: 36: 1 c. 17: 36: 1 d. 18: 36: 16	Abs. Av. Error % 8.9 10.8 12.4 8.7	-	Case a input: Months to Valuation date, Number of dwelling units, Square root of total plumbing fixtures, Square root of number of fireplaces, Square root of basement garage area, Square root of attached garage area, Deck/open frame porch area, Enclosed porch area, Neighbourhood group, Recreation room area, Finished basement area, Grade factors, Square root of living area x Grade, Condition/desirability/usefulness (CDU) rating, Reverse date of sale x total living area, Total living area, Age x square root total living area, CDU x square root total living area, Air-conditioning factor x total living area, Other building and yard value, Pool area. Cases a,b & c Output : Sale Price.
Evans, A.H.J. et al (1992)	Multi-layer Perceptron Backpropagation	34 / 13	a. 9: 5: 1 b. 8: 5: 1 c. 7: 5: 1 d. 8: 5: 1	Average Error % 13.4 5.03 5.68 7.03	-	Input: Location, Valuation Office Coding Group, Type, Format, Year of construction, Floor area, Central heating, Garage, Car parking place. Output : Selling Price.
Do, Q. and G. Grudnitski (1992)	Multi-layer Perceptron Backpropagation	58 / 105	8: 3: 1	Mean Error % -1.31 Mean Abs. Error % 6.9	Mean Error % 2.73 Mean Abs. Error % 11.26	Input: Age, Number of bedrooms, Number of bathrooms, Total square footage, Number of garages, Number of fireplaces, Number of stories, Lot size. Output : Selling Price.

Table 3.1 Artificial Neural Network Research in Property Valuation

RESEARCHERS	NETWORK TYPE & LEARNING ALGORITHM	TRAIN/ TEST	NETWORK ARCHITECT. IN:HID:OUT	ANN	MRA	PARAMETERS
Borst, R.A. (1995)	Multi-layer Perceptron Backpropagation	302 / 33		Av. Abs. Error % 7.2 GIS influence 7.0	-	Input: Total Living Area, Year Built, Total Rooms, Bathroom Count, Bedroom Count, Rec room area, Finished Bsmnt area, Lot size, Grade Factor, Condition Factor. Output : Sale Price.
Worzala, E (1995)	Multi-layer Perceptron Feed-forward / Backpropagation	1. 217 / 71 2. 137 / 43 3. 83/ 29	Brain Neurosh. 7:8:1 7:5:1 8:3:1 8:3:1 7:9:1 7:5:1	Mean Abs.Error % Brain - Neur 13.2 - 14.4 10.0 - 13.1 11.7 - 11.6	Mean Abs.Error % 15.2 11.1 12.8	Case 1,3 input: Locate, Style, Number of Bathrooms, Lot size, Basement area, Total area, Size of Garage. Case 2 input: Age, Number of Bedrooms, Number of Bathrooms, Style, Lot Size, Total square footage of the house, Number of Fireplaces, Garage size. Output: Selling Price.
Lam, E.T.K. (1996)	Multi-layer Perceptron Backpropagation	337 / 169	13:5:1	Mean Sum Sq.Err 1. 3.89 2. 17.5 3. 12.4	Mean Sum Sq.Err 1. 23.4 2. 21.4 3. 23.7	Input: Average number of rooms / dwelling, Proportion of owner-occupied units built prior to 1940, Per capita crime rate by town, Proportion of residential land zoned for lots over 25,000 sq.ft., Proportion of non-retail business acres per town, Charles river dummy variable, Full-value property-tax rate per \$10,000, Pupil-teacher ratio by town, 1000 x square (BK-0.63) where BK is the proportion of black people by town, % lower status of the population, Weighted distances to five Boston employment centres, Index of accessibility to radial highways, Nitric Oxides concentration. Output: Median value of owner-occupied homes in \$1000's.
Lewis, O.M. et al (1996)	Feed-forward / Self-organizing feature maps	990 / 117	Grid Size 10 x 10	Mean Abs.Error % 8	-	Input: Street name, District or Village, Unit, Unit Type, Unit Size, Valuation Date, Main heating, Number of Bedrooms, Age in Years, Number of Garages. Output: Property Value.

Table 3.1 Continued. Artificial Neural Network Research in Property Valuation

RESEARCHERS	NETWORK TYPE & LEARNING ALGORITHM	TRAIN/ TEST	NETWORK ARCHITECT. IN:HID:OUT	ANN	MRA	PARAMETERS
Lenk et al. (1997)	Multi-layer Perceptron Feed-forward Backpropagation	204 / 67 204 / 17	7: 6: 1 7: 6: 1	Mean. Abs. Err % 10.3 11.1 10.2 40.2 56.0 36.1	Mean. Abs. Err % 9.7 40	Input: Num. of Bedrooms, Age of House, Lot Size, Basement area, Total area, Num. of fireplaces, Num. of Garages. Output : Sale Price.
Connellan & James (1998a)	Multi-layer Perceptron Backpropagation	850/5months head	12: 2: 1	0.6% mean divergence from Richard Ellis valuations.	-	Input: 12 proceedings valuations. Output : one most recent valuation.
Connellan & James (1998b)	Multi-layer Perceptron Backpropagation	110/8months head	8: 5: 1 16: 5: 1	ANNs gave better predictions than MRA.		Input: past valuations. Output : valuation of a property.

Table 3.1 Continued. Artificial Neural Network Research in Property Valuation

Tay and Ho (1991) illustrated how an ANN can be used in mass appraisal of residential properties. They compared the performance of the traditional MRA and the BackProbagated (BP) ANN in estimating sale prices of residential apartments in Singapore. A data set of 1,055 sale prices was used. This consisted of two sets comprising:

1. a training set of 833 transactions for building the BP and MRA models; and
2. a test set of 222 transactions for testing the estimation performances of the BP and MRA models.

The BP had ten input nodes/elements because there were ten property attributes and only one output node (i.e. estimated sale price).

The results of the MRA and ANN techniques in estimating the sales prices for both the complete and filtered test set were summarised:

	Complete test set		Filtered test set	
	MRA	Neural	MRA	Neural
No. of outliers removed	0	0	14	9
% error in excess of	-	-	60%	50%
Mean percentage error	7.5%	3.9%	0.0%	-0.2%
Standard deviation of percentage error	44.4%	31.9%	24.9%	16.3%

The results show that with or without the removal of outliers, the BP provided better estimates than the linear MRA. Tay and Ho (ibid.), explained that this highlights the extent of non-linearity existing in the "true" but unknown valuation function. Although the MRA technique performs very well, it is still a formidable task to prove that it is the "globally optimal" form, unless all other functional forms have been exhaustively tested; or if 100 per cent (i.e., globally optimal) of the variations are explained by that function. The BP requires no selection of a valuation function at any time. The latent function is discovered by the network in the course of its automatic self-learning from the training set of sales.

Tay and Ho (ibid.), explained that for the BP there are no guidelines on the exact size of a suitable training set, which is unfortunate, but they consider that research in this new technology should soon reveal more useful guidelines for its implementation. Statutory bodies which perform valuation for tax purposes, for instance, have a large database available and are immediate candidates for this technology.

Borst (1991) considered that the ultimate goal of neural network research is to build networks that can think like people. In his 1991 paper, he provides a fundamental exposition of artificial neural networks. Terms were defined and the design process for an "evaluator network" to predict selling prices of unsold real estate was documented. The underlying model structure assumptions and calibration mathematics of linear regression, feedback, and artificial neural networks were compared. The results indicated that ANNs deserve strong consideration by the valuation and taxation assessment community. Borst (ibid.) dealt exclusively with feed-forward networks, and in particular, with non-linear feed-forward networks. In Case 1, he used 218 sales within a twenty-one input neurons, forty-two hidden neurons and the sale price as an output. The main purpose of Case 1 was to find out if ANNs would work at all for estimating property sale prices. Finally, an average absolute error of 8.9% was found. In Case 2 there were eighteen input neurons, thirty six hidden neurons and the sale price as output neuron. The estimate of absolute average error was 10.8 percent, compared to 8.9 percent for Case 1, a modest difference. In Case 3, a test was made to see if neural networks can be used to screen sales from a "dirty" data set to yield a smaller group that will produce an effective set of weights. The training was performed on 279 sales and seventeen input neurons were used. An estimate of the average absolute percent error yields 12.4 %. Based on these results, Borst (ibid.) explained that it is a matter of judgement whether or not to use neural networks to screen sales. The safest approach was to follow proper appraisal validation and outlier examination procedures. In Case 4 he tested the efficacy of using multiple output neurons to represent sale price intervals rather than the single output neuron to represent sale price. The average absolute error was 8.7 %. However the single output neuron could do the same kind of prediction.

Evans et al. (1992) investigated whether the use of neural networks could provide a successful means of analysing residential property price data and of estimating values in England and Wales, taking into account the limited extent of market information which is normally available to practitioners. Furthermore they considered whether neural networks might offer useful assistance to practitioners, in terms of accuracy of valuation and/or ease of use. The data used was obtained from actual property and transaction details covered by the Official Secrets Act in England and Wales. The 34 data sets were used to train a neural network with nine inputs, five hidden layers and one output. The results of the first test with 13 sets of data, when compared with the actual sale prices, were found to have an average error of 13.48 per cent. In the second test, an eight input network was used, omitting central heating and outliers. After these changes, the average error was reduced to only 5.03 per cent. In the third test, the number of street was also omitted and as a result of this the network slightly increased average error to 5.68 per cent. In the last test, the 45 properties were randomly rearranged into a different training set of 33 and an independent validation set of 12. The average error was again relatively low, 7.03 per cent. Taking into account the limited range of parameters which were inputted, it was considered that this result was very satisfactory and significantly better than that which could have been expected by the use of traditional multivariate statistical techniques on such limited data. The average error of between 5 and 7 per cent would make the technique highly suitable for applications, such as taxation valuation, particularly the UK's capital-value based Council Tax, or for loan security purposes. Furthermore Evans et al. (ibid., p. 202), concluded that the trained network allowed not only the estimation of the value of unknown properties but also an analysis of the value effects of various attributes of the training set of properties. They explained that this can be achieved by repetitive testing with notional property, during which a single parameter is varied over the desired range while the remainder are fixed. For example, to investigate the relationship between floor area of the property and value, all parameters for the chosen property type are kept constant while a range of areas is input. The resulting values can be divided by the appropriate floor area to show the required relationship as value per square metre.

Do and Grudnitski (1992), investigated the feasibility of a neural network approach to residential property appraisal based on single-family housing market transactions from a large city. Their purpose was to demonstrate the superiority of a neural network over a multiple regression model in estimating values of residential properties which is a comparison it had demonstrated only once previously. The data used by Do and Grudnitski (ibid.) came from information provided by the San Diego Board of Realtors' Multiple Listing Service (MLS) to its member agents. Observations consisted of 163 single-family homes sold during the period January 1991 to June 1991 in the south-western part of San Diego County. The neural network model used consisted of an input layer of eight nodes, each of which represented an attribute of a property; a hidden layer of three nodes; and an output layer of one node; which represented the estimated value of the property. The network was trained using 58 residential properties sold during the first quarter of 1991, and was then used to predict 105 residential properties sold during the second quarter of 1991. The neural network resulted in a mean percentage error and a mean absolute percentage error of -1.31 percent and 6.9 percent, respectively. This corresponded to errors of 2.73 percent and 11.26 percent for the multiple regression model. The authors used market transactions to provide evidence that a neural network's estimates of residential property values are nearly twice as accurate as those of a multiple regression model.

Borst (1995) analysed and valued sales from a community in Massachusetts using a single-pass, three step methodology. In the first step an Artificial Neural Network was used to establish initial value estimates. The second step was the spatial analysis of "error" patterns (ratio of predicted value to actual value) in a Geographic Information

System (GIS) to develop neighbourhood value correction factors. The third step modified the initial value estimated by applying multiplicative factors derived from the neighbourhood analysis. The results showed that Artificial Neural Networks performed very well in establishing initial value estimates, achieving an average absolute error (prediction versus actual) of 7.5%. In a simulation trial, where neighbourhood influences were introduced into the data set, error was reduced from 10.3% to 7.0% by applying neighbourhood adjustment factors derived from the GIS. A process referred to as geo-coding was utilised to place the sales on the street map by Borst. Street addresses were matched between the graphic file and the CAMA database allowing for the placement of the sales on the street map. Another helpful approach was to form regions (neighbourhoods) which allowed for the aggregation of statistics within the area encompassed by the region. The eleven neighbourhoods were analysed and value ratios were computed graphically using the GIS. To illustrate the point that a GIS can be a valuable tool in neighbourhood analysis and valuation, a "neighbourhood effect" was introduced into the study data. Borst's study had two goals. First it was intended to demonstrate that an ANN can be a valuable and easy-to-use valuation tool. With an absolute error of 7.2% on the real life data, and without yielding to the temptation to eliminate one or two outliers to improve the statistics, it is submitted (ibid., p. 18) that this has been adequately demonstrated. The second goal was to show that a GIS can be useful in the valuation process. The original data did not exhibit a significant variation in neighbourhood valuation, but the simulation of such process, provided adequate evidence that if there were neighbourhood influences they could be detected and analysed and corrected by use of a GIS (ibid., p. 18).

Worzala et al. (1995) investigated the application of neural networks to real estate appraisal and compared the performance of two models in estimating the sale price of residential properties with a multiple regression model using two different neural network software packages. They concluded that the neural network models slightly outperformed the multiple regression models in some cases and that the results between the two neural network packages were not consistent. Furthermore, they encountered the following problems during the development and implementation of neural network models:

1. neural networks are not easy to use;
2. results are inconsistent between neural network packages;
3. results are inconsistent between runs of the same neural network software; and
4. neural networks can have very long run times.

Therefore, the results of this study indicate that extreme caution is necessary when applying the neural network technology to real estate appraisal.

Lam (1996) presented an analysis of Boston housing using six different mass appraisal modelling techniques. They were: 1. classical linear model; 2. generalised linear interactive model; 3. neural networks; 4. generalised additive model; 5. partial least square regression; and 6. M-estimate robust regression. He explained that neural networks and generalised additive model have the capability of identifying and representing general non-linear dependencies in the data without previously specifying which non-linear dependencies to look for. He performed cross-validation by splitting the data into the sample and the hold-out sample. Single split cross-validation is usually used in neural networks literature and the sample is used to assess the complexity of the neural network models. The hold-out sample is used to test the model. In terms of in-sample and cross-validation prediction, the neural network model was found to outperform the other parametric regression. In terms of a single out-of-sample prediction, neural networks and M-estimate robust regression models were found to perform better than the other models. Finally, he concluded that combining local and global fitting, neural network model and generalised additive model was found to have the best prediction performance among others.

Lewis et al. (1996) investigated the application of neural networks to residential property appraisal using a "kohonen" map and a series of back-propagation networks. The advantage of using the kohonen self-organising map for this application is that it can identify clusters within the parent data set that are difficult to achieve using simple sort procedures. The following are required for this methodology to be successful:

1. class boundaries must be identified around clusters formed by the kohonen feature map over the input mapping that exclude outliers and nodes from neighbouring clusters; and:
2. only "good" clusters should go on to form training data sets for subsequent back propagation models.

In order to implement this methodology, the authors decided to investigate a recently-published variance estimation routine known as a Gamma test with the expectation that this would address these two requirements. The Gamma test is a data analysis routine which aims to estimate the best Mean Square Error which can be achieved by any smooth data modelling technique using the data.

The authors concluded that an average increase in prediction accuracy of 10% was achieved using the new method over the conventional approach by modelling. Furthermore, it was concluded that the kohonen step can be applied to subsets of the data to create even more accurate sub-markets.

Lenk et al. (1997) examined critically the efficacy of hedonic pricing models and ANNs. They compared the predictive performance of an hedonic pricing model and three ANNs with respect to their ability to estimate the value of a random sample of "normal" residential properties and a sample of outlier properties. The data used consisted of 288 single-family residential properties that were sold in Fort Collins, Colorado, USA from November 1993 to January 1994 and contained the sale price and 12 variables for each property. Seven variables, which have been shown consistently in prior studies to be significant property attributes for determining value, were chosen as the independent, or input, variables. These variables were the number of bedrooms, the age of the house, the lot size, the finished interior square footage of the house, whether there was a basement, the number of fireplaces, and the size of the garage. Outlier properties were determined as properties that possessed a z-score greater than 2.0. Seventeen outlier properties were identified and separated into an "outlier" holdout sample leaving 271 properties in the "normal" holdout sample. The training set for both the hedonic model and ANNs consisted of 204 properties. They used three feedforward backpropagation networks with six nodes in the hidden layer. These are: the Neuroshell, the forced threshold (@Brain) and the best fit (@Brain). The mean absolute errors were 10.3, 11.1 and 10.2 for the "normal" holdout sample and 40.3, 31.9 and 45.4 for the "outlier" holdout sample. The hedonic results were 9.7 and 35.8 for the "normal" and the "outlier" hold out samples respectively. The hedonic model outperformed all three ANNs.

The results of this study conflict with the findings presented by Do and Grudnitski (1992) who reported results from an ANN model that exhibited half of the error level of their hedonic pricing model. The results corroborate the findings of Worzala et al. (1995) who concluded that data issues may mitigate the consistent success of the ANN models for real estate valuation.

Connellan and James (1998a) showed how time series methods can be applied effectively to the problem of analysing commercial property values and to prognosticate future valuation trends in a useful and applicable manner. They used past valuations from Richard Ellis International Property Consultants. The properties comprise a range of office investments in the City of London and the West End which are regularly re-valued on a monthly basis. These data includes over 90 separate valuations for each property but they used the last three or four years valuations because these revealed an over-renting situation running back this period. Connellan and James (ibid.) modelled the underlying patterns in back propagation neural networks, using a double time series (lagged) of capital valuations and 15 year gilts, and projected these values forward in time for a period of five months. The neural network consisted of 12 input nodes and one output node. The output was the most recent gilt value whilst the remaining gilt values for the proceeding months were the 12 inputs. The algorithm used for training was back propagation and the training set consisted of 850 cases. The predictive processes were carried out for each month from January to May 1996. At the end was achieved an overall mean 0.6 per cent divergence from Richard Ellis valuations. It can be argued that this could be accepted by most valuers and clients.

Connellan and James (1998b) developed a system for producing a time series of past valuations. The time series is combined with leading indicators such as gilts, to forecast the valuation series into the future for about eight months ahead. Two innovations were described in this work: the production of a simulated history of valuations using a method called "backtracking" and the use of a gilt index as a leading indicator for pre-empting changes in property valuations. The properties studied were standard shop units, small industrial units and a modern office block. The time series values were calculated from Hillier Parker data. Connellan and James (ibid.) projected valuation indices from the base date for several months into the future using MRA and ANN techniques. Each ANN model had eight inputs and one output in the case of a single series model, and 16 inputs with one output in the case of a double series. They used one hidden layer with five neurons and the networks were trained until the error on the training set dropped down to the square root of the Gamma value. In all cases, neural networks gave better predictions than regression, underlining the non-linear nature of capital time series.

McCluskey et al. (1998) used ANNs and genetic algorithms to test their applicability within an appraisal environment and to measure their performance against the traditionally-accepted standard of MRA analysis. The data used was supplied by the Valuation and Lands Agency (VLA). The VLA is the government agency charged with the statutory responsibility to assess all real property tax in Northern Ireland. The data set consisted of 657 sales which occurred over the period September 1995 to December 1997. The produced ranges of COD were all within acceptable standards (IAAO, 1990a), but the produced COD from MRA has the lowest value.

McGreal et al. (1998) evaluated the ability of a neural network model to predict the value of properties in a test sample within a range acceptable for valuation purposes. The sample for the 1992 data contained 1,026 transactions covering the entire 12 month period. The training set contained 912 properties and the testing set 114. A multi-layered back propagation model was used. McGreal et al. (ibid.) explained that the evidence presented adopts a more sceptical approach to the potential merits of neural networks within the valuation process and in this respect agrees with Worzala et al (1995) results. The best models show that only 80% of properties achieved a predicted value within 15% of sale price. The study suggested that more research, testing and evaluation of ANNs on larger data-sets are necessary before any decision is taken to utilise them in valuation practice. Furthermore, McGreal et al. (ibid.) concluded that whilst some very close predictions are possible, other can deviate appreciably from the sale price and the use of ANNs in mass appraisal purposes remain problematic.

3.6 Conclusions

MRA was introduced in 1965 in property valuations and it can be argued that is the most popular method for mass appraisal. Many countries in the world e.g. Australia and Denmark, use MRA for the assessment of properties for taxation purposes. However, a number of researchers conclude that the validity of an MRA model depends on the degree that certain assumptions (see 4.2) are satisfied, although generally it might well be acceptable for the purposes of ensuring the consistency and equity that are intended.

The Sagric consultants pointed out that the use of computer systems in the valuation of immovable properties in Cyprus will improve dramatically the overall cycle of the work and the services provided by the valuation branch. However they did not report on how the problem of inconsistency because of the heterogeneity of residential properties is resolved, nor how a lack of data for any particular submarket is covered. These are critical for the accuracy and reliability of regression analysis models. As Morch-Lassen (1997) explained, the critical point for the use of these models is the capturing of appropriate data. If this is not achieved, the various valuation models that have been created will have no useful application.

ANNs seem particularly well suited to finding accurate solutions in an environment, such as residential appraisal, characterised by complex information or imprecisely-defined functional models. Problems associated with the incomplete or inexact predetermination of the appraisal model's functional form are eliminated because the neural network itself determines a functional form and tunes its estimation parameters based on the criterion of "best fit" to the data. One potential benefit of the network model is that it may be easier to use than either MRA or feedback because less time is required for data transformations (linear) or model specifications (feedback), or both. Furthermore, there is little cost impediment to initiating research in artificial neural networks because of the availability of relatively low-cost (less than £500) PC-based software. Additionally, ANNs have the ability to learn linear and, more interestingly, non-linear functions. In MRA, there has to be *a priori* knowledge of the form of the non-linear function to be tested (noting that there are thousands or millions non-linear functions e.g. polynomials, splines and exponential). ANNs, however, do not require such *a priori* information. They learn by inducing the latent rules inherent in the training set of input and output patterns. The induced rules exist in a distributed form as interconnectioning weights in the network. These rules, because of their numeric and distributed nature, are unintelligible to humans.

The network could be used in one of at least four ways:

1. as an additional tool to speed the normal valuation process of gathering comparables and adjusting for differences in parameters such as location, floor area, etc.;
2. checking for value inconsistencies in special valuations (e.g. for taxation purposes). This work could be carried out by clerical staff, with a considerable saving in professional staff time;
3. for mass appraisal for taxation purposes; and
4. for preliminary valuation before the inspection of the property. The valuer then could

have a suggested figure on which to work. This method would be very suitable for bulk valuation requirements, such as the taxation of immovable property.

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4. MULTIPLE REGRESSION ANALYSIS (MRA) VALUATION METHOD

4.1 Introduction

Regression analysis is probably the most popular statistical technique in the business world. Financial analysts use regression to relate the movement of a stock price to the movement of the market as a whole. Economists build regression models to predict tax collections, unemployment, and other variables (Shiffler and Adams, 1995). Regression analysis, it can be argued, is the most commonly used statistical method for mass appraisal in real estate. e.g. a house is valued based on factors, such as size, number of bedrooms, age, central heating and the selling prices of other houses.

4.2 MRA definition and assumptions

The multiple regression model, being:

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots + b_kX_k + e \tag{4.1}$$

contains $(k+1)$ unknown regression coefficients b_1 through b_k as well as b_0 that must be estimated.

In matrix form, it can be expressed as

$$\mathbf{Y} = \mathbf{XB} + \mathbf{e} \qquad (4.2)$$

where $\mathbf{Y} = (Y_1, Y_2, \ldots Y_n)$, $\mathbf{B} = (b_0, b_1, \ldots b_k)$, $\mathbf{e} = (e_1, e_2, \ldots e_n)$ and where $\mathbf{X}$ is

$$\mathbf{X} = \begin{matrix} 1 & X_{11} & . & . & X_{k1} \\ 1 & X_{12} & . & . & X_{k2} \\ 1 & . & . & . & . \\ 1 & . & . & . & . \\ 1 & X_{1n} & . & . & X_{kn} \end{matrix} \qquad (4.3)$$

A solution to compute b_k is to find the equation of the line that connects the greatest number of sample data points. Alternatively, the estimated regression coefficients $b_0, b_1, \ldots b_k$ that minimise the sum of squares of errors (SSE) could be selected and this can be done by the "least squares" method. (SSE is defined as:

$$SSE = \sum (Y - \tilde{Y})^2 \qquad (4.4)$$

where Y is the dependent sale price and $\tilde{Y}$ is the predicted value).

Mendenhall and Sincich (1992, p.477) explain that b_k coefficients are calculated using the least square matrix equation:

$$(X'X)\mathbf{B} = X'Y \qquad (4.5)$$

Thus, $(X'X)$ is the coefficient matrix of the least squares $b_0, b_1, \ldots b_k$, $X'Y$ gives the matrix of constants that appear on the right-hand side of the equality signs and the least squares solution is:

$$\mathbf{B} = (X'X)^{-1} X'Y \qquad (4.6)$$

Implementing the criterion of "least squares" is difficult without the aid of a computer program. The danger with this process is the dependence on the computer. The computer performs the computation, but it does not propose a model, gather the data, check the assumptions, make the decisions, and so on. If the program is used without assessing critically the inputs and outputs, then all managerial functions are assigned to the program. Moreover, the validity of the results cannot be assumed if the inputs are not appropriate or inaccurate and if the outputs are unusable for the purpose. A computer program is (in this case) a "means to an end". It is essential to ensure that the most appropriate "means" is used and that the "means" continues in all cases to provide a useful "end".

The validity and interpretation of an MRA model depends upon the extent to which certain assumptions are met (IAAO, 1990a, p.383-386). The MRA models are dependent on the existence and the accuracy of complete data sets e.g. if the variable "number of bedrooms" is going to be used in a model, it must appear in the data for the entire sample of houses. Furthermore, the sold properties upon which the model is constructed must be representative of properties to which the model will be applied. The marginal contribution to market value of each independent variable must be constant over the entire range of the variables and must not be influenced by any other variable. The error term is defined as:

$$\text{Error term} = \text{assessment value} - \text{sale price}; \qquad (4.7)$$

and it should be normally distributed and have a constant variance (violation of the last assumption is known as heteroscedasticity). The independent variables must not be correlated e.g. it can be argued that number of bedrooms and size of house cause multicollinearity because as the number of bedrooms is increased the size of house is normally increased too.

4.3 Testing the normality: Kolmogorov-Smirnov test

A simple way to test the normality is by creating a histogram distribution with a normal curve superimposed. The curved line indicates what the distribution would be, if the variable had a normal distribution with the same mean and variance. However histograms provide only a visual basis for checking normality, and it is often desirable to compute a statistical test to verify that the data are normally distributed. The Kolmogorov-Smirnov test is used to determine how well a random sample of data fits a particular distribution (uniform, normal or Poisson). It is based on a comparison of the sample cumulative distribution function to the hypothetical cumulative distribution function. Press et al. (1992, pp. 623-625) explain that the Kolmogorov-Smirnov statistic (*KS*) is a particularly simple measure: it is defined as the maximum value of the absolute difference between two cumulative distribution functions and can be used, for example, for comparing one data set's $S_n(x)$ to a known cumulative distribution function $P(x)$. The *KS* statistic is:

$$KS = \max|S_n(x) - P(x)| \text{ where } x \text{ is } -\infty < x < \infty \tag{4.8}$$

Press et. al. (1992) explain (p. 624) that what makes the *KS* statistic useful is that its distribution in the case of the null hypothesis (data sets drawn from the same distribution) can be calculated, at least to useful approximation, thus giving the significance of any observed non-zero value of KS. The function that enters into the calculation of the significance is:

$$Q_{ks}(\lambda) = 2\sum_{j=1}^{\infty}(-)^{j-1}e^{-2j^2\lambda^2} \tag{4.9}$$

which is a monotonic function with value limits $Q_{ks}(0) = 1$ and $Q_{ks}(\infty) = 0$.

The significance level of an observed value of KS is given approximately by the formula:

$$probability(KS > observed) = Q_{ks}([\sqrt{N_e} + 0.12 + 0.11/\sqrt{N_e}\,]KS) \tag{4.10}$$

where N_e is the effective number of data points:

$$N_e = \frac{N_1 N_2}{N_1 + N_2} \tag{4.11}$$

N_1 is the number of data points in the first distribution and N_2 is the number of data points in the second distribution.

The nature of the approximation involved in (4.10) is that it becomes asymptotically accurate as the N_e becomes large, but is already quite good for $N_e \geq 4$.

4.4 Identification of outliers

Outliers in multiple regression analysis represents cases whose estimated values differ from sales prices by unusually large amounts. When regression residuals are normally distributed, two-thirds of sale prices can be expected to fall within one standard error (SE) of their estimated values, 95 percent within two SE, and 99 percent within three *SE* (IAAO, 1990a, p. 383, 384). *SE* is estimated as follows (Shiffler and Adams 1995, p. 556):

$$SE = \sqrt{\frac{SSE}{n_s - (k+1)}} \tag{4.12}$$

where n_s is the size of sample and k is the number of independent variables.

It is good practice to examine critically all residuals that exceed a specified amount or percentage of sale price, for example, those that exceed more than two *SE* (IAAO, 1990a, p. 383, 384). IAAO (ibid.) explains that outliers can have at least three causes. First, data may be incorrectly coded, thus, once data errors have been corrected, the model should be rerun. Second, outliers may result from a failure to screen sales adequately or to adjust them for personal property, financing, and the like. Such sales should be excluded or adjusted as appropriate and the models rerun, although it is far better to address such problems during routine sales data processing before models are developed. Third, outliers can result from unusual property characteristics or an unusual combination of characteristics. Such properties should not be indiscriminately purged from the model. In any model, outliers are always expected. In many cases, they provide clues as to additional variables or other refinements that might improve the model.

4.5 Stepwise method

One of the most effective means for mass appraisals is "stepwise multiple regression analysis" (IAAO, 1990a, p.377). The stepwise multiple regression method was applied in the development of multiple regression models of houses and apartments in the Strovolos municipality. This method selects independent variables for a regression equation. At each step, an independent variable which has the smallest probability of F not in the equation is entered, if that probability is sufficiently small. Variables already in the regression equation are removed if their probability of F becomes sufficiently large. The method terminates when no more variables are eligible for inclusion or removal.

F is calculated as follows (Mendenhall and Sincich, 1992, pp. 494-497):

$$F = \frac{\sum (Y_i - \bar{Y})^2 / k}{SSE / \left[n_s - (k+1)\right]} \tag{4.13}$$

where Y is the dependent sale price and $\bar{Y}$ is the mean value of the sale price.
Under the null hypothesis, this F test statistic has an F probability distribution with k degrees of freedom (DF) in the numerator and $\left[n_s - (k+1)\right]$ DF in the denominator.

4.6 Adjustments for time

When real estate markets are changing it is important to adjust sale prices for time in developing an MRA-based valuation model (IAAO, 1978, p. 241). If the time of a sale is not controlled, several undesirable results will occur. First, predicted values will lie below current market values in rising markets and via versa. Second, regression coefficients will be less stable (i.e., t_s- and F-values will decline). Third, measures of "good fit" will tend to fail. In addition to being undesirable in and of itself, the latter result has the added shortcoming of making it difficult for the assessor to interpret the regression results accurately. Adjusting sale prices for time tends to produce current market values, improve model stability, improve measures of "good fit", and facilitate the interpretation of results. In addition, it permits the assessor to utilize older sales, thereby expanding the sample size and/or making possible refined stratification techniques. Time-adjustment factors can be developed and applied on either a compound or constant (straight-line) basis (IAAO, 1990a, p. 580-584). Four techniques of deriving time-adjustment factors from market data are paired sales analysis, re-sales analysis, sales ratio trend analysis, and MRA. In the case of MRA, if time of sale is one of the independent variables, its effect on sales prices can be estimated and the rate of change in price levels extracted.

4.7 Analysis of Variance

The analysis of variance is used to test the hypothesis that there is no linear relationship between the dependent variable and the independent variable(s). The total variation in the dependent variable is divided into two components, one that can be attributed to a particular regression model (labelled regression), and one that cannot (labelled residual). If the observed significance level for the F-test is small, the hypothesis that there is no linear relationship can be rejected. The mean square for each entry is the sum of squares divided by the degrees of freedom. If the regression assumptions are met, the ratio of the mean square regression to the mean square residual is distributed as an F statistic with k and $n_s - (k+1)$ DF. F serves to test how well the regression model fits the data. The larger mean square is conventionally placed in the numerator and the smaller in the denominator. The degrees of freedom associated with the numerator and denominator are used in the evaluation of F statistics. If the probability associated with the F statistic is small, the hypothesis that the $R^2 = 0$ is rejected (see equation 4.18).

4.8 Sample size

MRA has been proven beyond doubt to be capable of generating highly accurate appraisals for residential properties when property data are reasonably accurate and when there are adequate sales (IAAO, 1985, p. 9). In general, reliable equations can be developed from 100 or more usable sales obtained over no more than a three-year period. The reliability of ratio study statistics depends on the representativeness of the sample (IAAO, 1990a, p. 606). Representativeness, in turn, is a function of several factors, particularly sample size. In general, the larger the sample, the more reliable the calculated statistics. If ratios are normally distributed, it is possible to calculate the sample size required to estimate measures of central tendency of the population with a given degree of confidence (IAAO, 1990a, p. 606).

The appropriate formula is:

$$n_r = \sqrt{\frac{(t_s^2)(COV/100)^2}{h_t^2}} \tag{4.14}$$

where COV is the coefficient of variation and is defined as

$$COV = \frac{(100)(\sigma_{sd})}{\overline{A/S}} \tag{4.15}$$

where n_r is the required sample size, t_s is the t-statistic corresponding to the desired confidence level, h_t is the tolerance for error expressed as a percentage, σ_{sd} is the standard deviation and $\overline{A/S}$ is the mean of the assessment sale price ratio.

4.9 Testing the normality of assessment-sale price ratio

It is often important to determine whether ratio data are normally distributed (IAAO, 1990a, p. 617). When ratios are normally distributed, the standard deviation and coefficient of variation provide very complete indicators of appraisal uniformity. When ratios are not normally distributed, however, they provide misleading measures of uniformity. In addition, the normality of ratios influences the choice between parametric and non-parametric tests of appraisal performance. When ratios are normally distributed, parametric tests are more efficient. When ratios are not normally distributed, only non-parametric tests are strictly valid. Frequency distributions and histograms are good indicators of the normality of ratio data.

4.10 Testing the normality of the error term

The error term must be normally-distributed. Violations of this condition affect the interpretation of the standard error of the estimate and the coefficient of the variation (IAAO, 1990a, p. 385-386). However, Mendenhall and Sincich (1992, p.519) explain that of the regression assumptions, the assumption that error is normally distributed is the least restrictive when regression analysis is applied in practice. That is, moderate departures from the assumption of normality have very little effect on the validity of the statistical tests, confidence intervals, and prediction intervals. Furthermore, when non-normality of the random error term is detected, it can often be rectified by applying various transformations e.g. square root, logarithmic and arc sine (Mendenhall and Sincich, 1992.).

4.11 Testing the variance of the error term

The variance of the error term must be constant (IAAO, 1990a, p. 385-386). This can be identified by plotting the error term (residuals) against sale prices per square metres or against assessments per square metre. Norusis / SPSS Inc. (1993, p. 336) explain that the following remedial measures can be tried if variance is not constant:

1. when the variance is proportional to the mean of Y for a given X, use the square root of Y if all Y_i are positive;
2. when the standard deviation is proportional to the mean, try the logarithmic transformation;
3. when the standard deviation is proportional to the square of the mean, use the reciprocal of Y; and
4. when Y is a proportion or rate, the arc sine transformation may stabilise the variance.

4.12 Regression Statistics

Multiple R, R^2 and *Adjusted* R^2 (AR^2) are statistics showing how well models are fitted. Multiple R is the correlation coefficient between the observed and predicted values of the dependent variable. It ranges in value from 0 to 1. A small value indicates that there is little or no linear relationship between the dependent variable and the independent variables. Johnson and Wichern (1992, p. 11) explain that the sample correlation coefficient is a measure of the linear association between two variables and does not depend on the units of measurements. The sample correlation coefficient, for the *ith* and *kth* variables, is defined as:

$$r_{ik} = \frac{\sum_{j=1}^{n_s}(X_{ij} - \overline{X}_i)(X_{kj} - \overline{X}_k)}{\sqrt{\sum_{j=1}^{n_s}(X_{ij} - \overline{X}_i)^2}\sqrt{\sum_{j=1}^{n_s}(X_{kj} - \overline{X}_k)^2}} \quad (4.16)$$

$$\overline{X}_i = \frac{1}{n_s}\sum_{j=1}^{n_s} X_{ij} \qquad i=1,2,..,k \text{ (} k \text{ is the number of variables)} \quad (4.17)$$

If the probability is small (.05 or less is often used), the null hypothesis is rejected. Norusis / SPSS Inc. (1993, p. 318) explain that R^2 is a measure of the goodness of fit of a linear model. It is sometimes called the coefficient of determination. It is the proportion of the variation in the dependent variable explained by the regression model. It is also the square of the multiple R, the correlation of the observed and predicted values of the dependent variable.

Mendenhall and Sincich (1992, p. 494) explain that the sample multiple coefficient of determination R^2 is defined as:

$$R^2 = 1 - \frac{\sum(Y_i - \tilde{Y}_i)^2}{\sum(Y_i - \overline{Y}_i)^2} = 1 - \frac{SSE}{SS_{YY}} \quad (4.18)$$

Norusis / SPSS Inc. (1993, p. 350) explain that the AR^2 is an estimate of how well the model fits the population. The sample R^2 thus tends to overestimate the goodness of fit of the model in the population. AR^2 corrects the optimistic bias of the sample R^2 by taking the sample size and the number of predictors into account. Unlike R^2, AR^2 does not necessarily increase as additional variables are added to an equation. Mendenhall and Sincich (1992, p. 494) explain that unlike, R^2, AR^2

takes into account both the sample size n_s and the number of b parameters in the model. AR^2 will always be smaller than R^2, and more importantly, cannot be "forced" to 1 by simply adding more and more independent variables to the model. AR^2 is defined as:

$$AR^2 = 1 - \frac{n_s - 1}{n_s - (k+1)}(1 - R^2) \quad (4.19)$$

Beta coefficients, sometimes called standardized regression coefficients, are the regression coefficients when all variables are expressed in standardized (Z-score) form. Transforming the independent variables to standardized form makes the coefficients more comparable since differences in the units of measurement are eliminated. These measure the relative importance of individual variables, and thus measure the percentage change in sale price (S) associated with a percentage change in the independent variable (X_j) with all other variables held constant (IAAO, 1990a, p. 377). Beta coefficients are related to regression coefficients b_j by the following formula:

$$Beta_j = b_j(\sigma_X/\sigma_S) \quad (4.20)$$

where σ_X is the standard deviation of the independent and σ_S is the standard deviation of the dependent sale price.

The sig. T is a statistic used to test the null hypothesis that there is no linear relationship between a dependent variable and an independent variable or, in other words, that a regression coefficient is equal to 0.

4.13 Performance of MRA

A measure of the prediction error, which is probably the most commonly used, is the mean absolute percent error (*MAPE*). *MAPE* is the arithmetic mean of the absolute values of the percent errors. This is calculated as follows:

$$MAPE = \sum_{i=1}^{n_s} (|\frac{S_i - A_i}{S_i}|) \times \frac{100}{n_s}\% \qquad (4.21)$$

where n_s is the number of the sample, S_i is the sale price and A_i is the assessed value.

The coefficient of dispersion is the most used measure of uniformity (IAAO, 1990a, p. 534) in ratio studies (*A/S*). The *COD* in respect of the median of the ratio $\mathbf{A/S}$ is calculated as follows:

$$COD = \frac{100}{median(\mathbf{A/S})}(\frac{\sum_{i=1}^{n_s} |A_i / S_i - median(\mathbf{A/S})|}{n_s} \qquad (4.22)$$

The *COD* for single-family homes and condominiums should be 15.0 or less (IAAO, 1990b, p. 24). In areas of new or fairly similar residences, it should be 10.0 or less. Furthermore, it should be noted that the *COD* is a non-parametric statistic (IAAO, 1978, p. 138), that is, it requires no assumption about the distribution of the data.

4.14 Knowledge Elicitation

The most frequent methods used for knowledge elicitation are: observation, introspection, interviewing and model criticism. The observational method relies on watching the valuer carry out valuations, taking care not to say or do anything that might influence his usual approach. Introspection relies on the valuer to act as the builder of theories about his own behaviour during the valuation task. He must identify the basis of his knowledge or skill, what information is necessary to it and how it is utilised within the valuation process (Gronow and Scott, 1986b, pp. 400-403). Furthermore, Gronow and Scott (ibid.) explained that interviewing can best be described as a mixture of observation, introspection and interrogation. It can be pure interrogation, the interrogator asking the valuer what he does in the performance of his valuation function, and interjecting to prompt his introspective process at suitable junctions. On the other hand, the valuer may be asked to solve realistic valuation problems with commentary as in the observational method, while the interrogator asks questions about the valuation process being carried out. Model criticism is widely used for the system builder, after an initial period of study, guided reading and past cases, to construct a model of what the interrogator considers valuation expertise to consist. He then takes that model to the expert valuer for his criticism, judgement, observations and ideas.

There is clearly scope for error in the process of knowledge elicitation and of the above methods none holds a clear advantage over the others for acquiring knowledge from valuers. Any of the methods may be used singly but all have disadvantages to a greater or lesser degree. It is more usual for the system builder to combine the approaches (Gronow and Scott, 1986b, p. 403).

Interviewing is the chosen knowledge elicitation method for this research because it is a mixture of observation, introspection and interrogation. Presumably, interviewing was not being used in isolation. The questions posed as well as the analysis of the answers (see Appendices IV, VI, VII), are based on extensive literature searches, observations and a thorough investigation of the problem and potential solutions. Interviews are focused to identify the required information needed by the valuer in Cyprus to assess a building site, a house and an apartment in a multi-storey building.

4.15 Data preparation

An empirical study in Strovolos Municipality (see Plans A and B in Appendix V) was performed in order to examine and apply MRA. Data had been collected from 20 October 1994 to 31 October 1997 for 211 houses and 492 apartments, corresponding to the 64% and to the 56% of the whole transactions respectively. Initially, the research intended to collect all the 67 variables for houses and apartments derived from interviewing an expert valuer of the Lands and Surveys Department (see Appendix VI), so that the information gathered from such investigation could enable the research to make an analysis of market value and the determinants. Three data collection forms and a code list were prepared for the collection of data (see Appendix VII). In the event, thirty variables were collected because data collection is a time-consuming and a high cost procedure, and because one of the objectives of this research is to develop a CAMA system with minimum cost of maintenance (see p. 4). It was decided to proceed to the development of MRA models on the basis of the thirty variables only and if these do not satisfy IAAO criteria, then to proceed to further data collection. The thirty variables are displayed in Table 4.1. The indications H, A and HA show that the corresponding variable was used for houses, apartments and, both houses and apartments respectively. The selection procedure is described for those variables where there is complexity.

1	Age	HA
2	Block	HA
3	Building condition	H
4	Building type	A
5	Coverage factor of the Planning Zone	HA
6	Date of (contract of) Sale	HA
7	Density factor of the Planning Zone	HA
8	Depth	H
9	Existence of Master Bedroom	H
10	Extra room (office)	H
11	Floor Number	A
12	Frontage	H
13	Geographical code	HA
14	House Type	H
15	House/Apartment size	HA
16	Maximum number of permitted storeys	HA
17	Maximum permitted height of building	HA
18	Number of Apartments in the Building	A
19	Number of floors in the Building	A
20	Number of WCs	H
21	Orientation of the house (main entrance)	H
22	Parking type	H
23	Permitted use of building	A
24	Plot	HA
25	Plot shape	H
26	Plot (land) size	H
27	Relation of building site to road	H
28	Sale price/m^2	HA
29	Sheet/Plan code	HA
30	Street name (code)	HA

Table 4.1. Collected variables for houses and apartments

The age of house (variable 1) was found through the deposited contract of sale or through building permits or by interviewing owners. The variable "age" of the building of apartments was identified through the date of issue of the building permit. There were cases in which the date of issue was not found. In this case, firstly, year of construction was calculated as follows:

Year of building construction = 0.992967*Year of issue of Division Permit -1.275550 (4.23)

and secondly, age was estimated.

The above equation is a result of a simple regression analysis from 124 buildings with standard error 2.18 (3 outliers were excluded).

The building type (variable 4) and the permitted use of building (variable 23) were coded as follows:

1. residential;
2. mixed use residential and commercial.

The date of sale (variable 6) was calculated starting with the date 20/10/94 as follows:

$$\frac{number\_of\_days\_starting\_from\_20/10/94}{30} \quad (4.24)$$

Depth and frontage (variables 8 and 12) were recorded manually using a specific scale-ruler from survey plans of Strovolos at scales of 1:2500 and 1:1250. As a consequence a maximum operator error of ± 2 meters in linear measurements may occur.

Geographical code (variable 13) is a number that represents the quarters of Strovolos Municipality and takes the following values:

1. Chryseleousa;
2. Agios Dimitrios;
3. Apostolos Varnavas; and

4. Agios Vasileios.

Size of house/apartment (variable 15) was found from the Lands and Surveys Department's official records or was calculated from sales contract with attached architectural plans (of scales 1:100 or 1:50) using a common scale-ruler applying the following formulas[1] :

House size = Covered Area+0.2*(Uncovered area + Basement area) of Verandas (4.25)

Apartment size = Covered Area+0.2*Uncovered area of Verandas (4.26)

The plot (land) size corresponding to a purchased house (variable 26) was mainly taken from the Lands and Surveys records and plans, but in many cases this was calculated directly from architectural plans (on scales 1:100 and 1:50) using a common scale-ruler.

The stepwise method was applied for all the variables of 211 houses and the 492 apartments separately. The variable "Sale price/m^2" was used as dependent and the rest of Table 4.1 as independent. Table 4.2 shows the regression statistics. Comparing residuals with the *SE* identified outliers. Seven sales of houses and twenty-two sales of apartments greater than two *SE*s (0.18678 and 0.1122 CYP*10^{-3} respectively) were identified, and these were classified as the outliers. The small number of outliers, 3.3% and 4.5% respectively, suggests that the model fits well.

[1] This policy for estimating the house size is being followed by the valuation section of the Lands and Surveys Department after investigation and analyses made in 1980 for the implementation of the General Valuation of Cyprus.

	Houses	Apartments
R	.63897	.61047
R^2	.40829	.37268
AR^2	.38788	.36622
SE	.09339	.05611

Table 4.2. Regression statistics of 211 houses and 492 apartments

On the first run of the stepwise MRA with 211 houses and 492 apartments, the following variables were selected:

Variable for Houses	Variable for Apartments
Age	Age
Block	Block
House size	Number of apartm. in the building
Number of WC	Plot
Plot	Size of apartment
Plot (land) size	
Street name (code)	

Table 4.3. Variables of the first run of the stepwise MRA with 211 houses and 492 apartments

On the second run, the variables of Table 4 were selected.

Variable of Houses	Variable of Apartments
Age	Age
Block	Block
Coverage factor of the planning zone	Number of apartments in the building
Frontage	Plot
Geographical code	Size of apartment
House size	
House type	
Number of WC	
Plot	
Plot (land) size	
Plot shape	

Table 4.4 Variables of the second run of the stepwise MRA with 204 houses and 470 apartments

In the variables of Table 4.4 the variable "date" of sale was also included in the preparation of data for time-adjustment purposes.

Figures 4.1 and 4.2 show the histograms of the sale price (10^{-3}*£/m^2) of houses and apartments. The summaries of statistics for the houses and the apartments are shown in Tables 4.5 and 4.6.

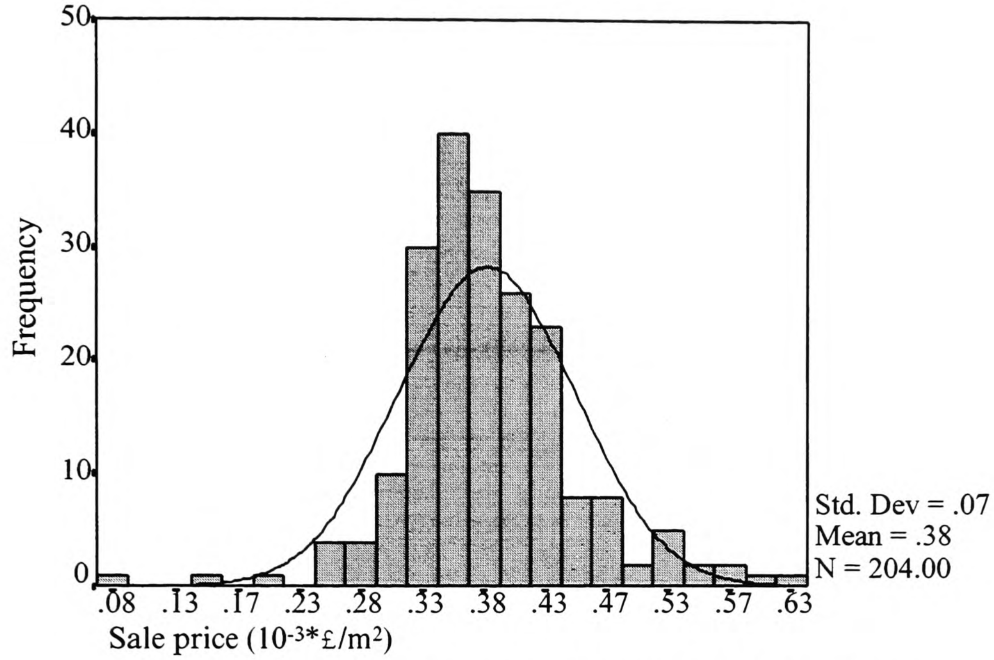

Figure 4.1 Histogram of the sale price (10^{-3}*£/m^2) for Houses

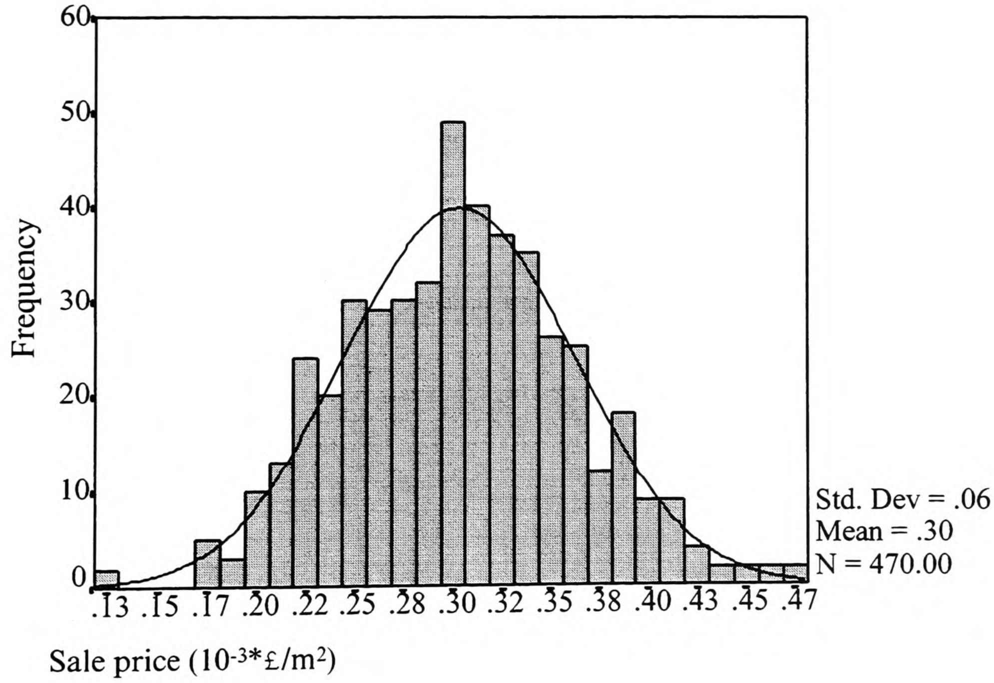

Figure 4.2 Histogram of the sale price (10^{-3}*£/m^2) for Apartments .

Variable	Mean	Std Dev	Minimum	Maximum
Age	.08	.12	.01	.70
Block	.08	.02	.01	.13
Coverage factor of the planning zone	.48	.07	.100	.700
Date of Sale	.17	.10	.000	.355
Frontage	.15	.08	.000	.460
Geographical code	.34	.11	.1	.4
House size	.18	.05	.052	.390
House type	.46	.16	.2	1.3
Number of WC	.18	.07	.0	.5
Plot	.17	.10	.0116	.3012
Plot (land) size	.25	.11	.114	1.087
Plot Shape	.95	.23	0	1

Table 4.5 Summary statistics of 204 Houses

Variable	Mean	Std Dev	Minimum	Maximum
Age	.14	.07	.04	.33
Block	.10	.04	.01	.13
Date of sale	.15	.10	.000	.371
Number of apartments in the building	.15	.10	.02	.51
Plot	.14	.07	.0030	.3011
Size of apartment	.11	.03	.040	.289

Table 4.6 Summary statistics of 470 Apartments

Samples shown in Tables 4.5 and 4.6 represent sold houses and apartments respectively. Comparing descriptive statistics (such as means and standard deviations), and frequency distributions between sold and unsold properties is one means of monitoring representativeness (IAAO, 1990a). However, this requires the existence of the population in computing format. Most of the variables shown in Tables 4.5 and 4.6 exist in the Lands and Surveys Department but in the manual records. The volume of work for collection of the population would be too great and beyond the capacity of this research work.

4.16 Conclusions

MRA can be considered as the most popular statistical technique and has been used in property valuation as a method for the assessment of values for taxation purposes in many countries.

However, MRA can be applied effectively only for "homogeneous" group of properties in a well-defined geographical area. Moreover, the sold properties upon which the model is constructed must be representative of properties to which the model will be applied and the error term is assumed to be normally distributed. A complete set of accurate data is required because MRA models are data-dependent. The process from data collection and data maintenance to data preparation and to definition of "homogeneous" areas is very important to keep MRA efficient, effective, cheap and easy to use.

Even the initial difficulties in data collection, the methodology followed for collecting data provided the much needed information for the research about the house and apartments transactions, characteristics as well as the property market in general. The collected data were twenty-five variables for 211 houses but using stepwise method and time adjustment thirteen variables and seven cases were found unnecessary and excluded. In the same way the collected data for apartments were eighteen variables for 492 cases but using stepwise method and time adjustment twelve variables and twenty-two outliers were exclude. It is worth noting that the data, (including outliers) corresponds to 64% and to 56% of the whole transactions from 20 October 1994 to 31 October 1997 respectively.

The methodology followed in this Chapter will provide a CAMA system capable of revaluing residential properties for taxation purposes at a certain date, with minimum data and minimum cost.

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5. MODULAR ARTIFICIAL NEURAL NETWORK VALUATION (MANN) METHOD

5.1 Introduction

Artificial Neural Networks (ANNs) became popular in the 1990s and have generally been presented as a major tool in the development of artificial intelligence systems. ANN computing is one of the most rapidly expanding areas of current research, attracting people from a wide variety of disciplines. These are systems based on the operation of components of the human brain. Gallant (1992, p. 3) describes neural networks to be a system consisting of a set of computational units and a set of one-way data connections joining units. At certain times, a unit examines its inputs and computes a signed number called an "activation" as its output that is then passed along those connections affected by signed number called a "weight".

Modular neural networks can be viewed as an evolution of neural networks because they combine various networks and methods that improve intelligent systems. The whole system becomes more robust and reliable than the individual sub-system that it incorporates.

5.2 Artificial Neural Networks (ANNs): advantages and disadvantages

A major attraction of ANN models is that they can serve as knowledge bases for classification within expert systems. Learning algorithms allows the generation of knowledge bases automatically from training examples. This is known as adaptive learning. These systems are important because of their ability to handle partial and "noisy" (distorted) data.

Picton (1994, p. 12) explains that an ANN tends to work in parallel, with the work being distributed among the processing elements. This has led to another term that is used to describe neural networks, namely "parallel distributed processors". The advantage of being parallel is the potential for very high processing speeds. The advantage of distributed processing is a certain degree of tolerance. This tolerance gives the network capability of "graceful degradation" since it is supposed that if part of the network malfunctions, the whole system could still continue to operate, albeit less than perfectly.

Maren et al. (1990, p. 7) explain that an important advantage of ANNs is the ease of insertion into existing technology. Because a network can be rapidly prototyped, trained, tested, verified, and translated into low cost hardware implementation, it is easy to insert neural networks for specific purposes into existing systems.

Furthermore, Zurada (1992, p.76) considers ANNs as systems representing collective, non-algorithmic, low-precision, non-linear computing machines which learn during training from examples and are data-controlled.

During the last three decades, many researchers developed their own version of neural networks e.g. Rumelhart et al. (1986), Kohonen (1984) and Grossberg (1976), and networks have been applied successfully in many applications e.g. pattern recognition, signal filtering, classification, image analysis, speech recognition etc.

ANNs use two types of classification. The first one is Unsupervised Learning (or Clustering), where a set of observations have the aim of establishing the existence of classes or clusters in the data. The second one is Supervised Learning where a given number of classes are known for a set of observations and the aim is to establish whether a new observation can be classified into one of the existing classes.

5.3 Selection of an Artificial Neural Network system

The main reasons for selecting artificial neural networks for producing an individual market valuation at a certain date are the following:

1. *Heterogeneity of residential properties;* by tradition, Cypriots design and build their own houses using a civil engineer and an architect of their own choice. This causes heterogeneity because houses and apartments in a neighbourhood are built by various engineers attempting to satisfy the different preferences of their customers e.g. in design, extent, luxury, building construction, number of rooms and storeys. It is anticipated that data heterogeneity will be accommodated by

the trained and adaptable ANN learning system. Zurada (1992, pp. 25-78) and Haykin (1994, pp. 1-41) reported a number of advantages of artificial neural networks e.g. adaptivity and self-learning. It should be mentioned following Adair and McGreal (1987) that models based on multiple regression analysis need to be generated for a homogeneous group of properties.

2. *Sales evidence;* the use of statistical techniques in property valuation e.g. multiple regression analysis, require a representative sample of sales evidence, an adequate number of sales in a homogeneous area, (an area consisting of properties with similar characteristics). Due to the variety of residential areas in Cyprus, it can be argued that these areas consist of many homogeneous areas. This severely limits the number of sale transactions of similar properties in similar areas. It can also be argued that the presented sale prices at the Lands and Surveys Department are not all of them genuine because people tend to declare lower sale prices in an attempt to pay lower transfer fees and less Capital Gains tax. It is worth noting that transfer fees are not calculated on the declared sale price but on the property value as estimated by the Valuer of the Lands and Surveys Department. The high level of success reported by Evans et al. (1992) in a limited set of data is a strong evidence of the appropriateness of artificial neural networks under these situations. Furthermore, Do and Grudnitski (1992) demonstrated the superiority of artificial neural networks over a multiple regression analysis using limited data.

3. *It performs nonparametric statistical inference (model-free estimation);* Haykin (1994, p. 4) explained that networks learn from examples by constructing an

input-output mapping for the problem at hand. He commented that such an approach brings to mind the study of *nonparametric statistical inference* which is a branch of statistics dealing with *model-free estimation*. Michie et al. (1994, pp. 41-42) explained that in a casual network, if one knows the conditional probability distribution of each variable, one can compute the joint probability distribution of all variables in the network. This can reduce the complexity of determining the distribution enormously. Furthermore, Michie et al. (ibid., p. 90) explained that the probabilistic interpretation of multilayer perceptron outputs in classification problems applies if the network is trained to its minimum error, and then only if the training data accurately represents the underlying probability density.

4. *Adaptation ability;* Haykin (1994, p. 4) explained that neural networks have a built-in capability to adapt their weights to changes in the surrounding environment. Their training to operate in a specific environment can be easily retained to deal with minor changes in the operating environmental conditions.
5. *Self-organisation ability;* a neural network can create its own organisation or representation of the input information during learning and operation (Maren et al., 1990, p. 7).
6. *Non-linearity*; Haykin (1994, p. 4) refers that a neuron is basically a non-linear device. Consequently, a neural network, made up of an interconnection of neurons, is itself non-linear.
7. *Uniformity of neural networks analysis and design*; Haykin (ibid., p. 5) refers that neural networks enjoy universality as information processing elements

because:

- neurons, in one form or another, represent a common ingredient to all networks;
- this commonality makes it possible to share theories and learning algorithms in different applications of neural networks;
- modular networks can be built through a seemless integration of modules.

5.4 Artificial Neural Network algorithms

In this section the following three ANN algorithms are presented: back-propagation (BP), probabilistic network (PNN) and self-organising feature map (SOFM). These algorithms were used to train ANN models composing the modular ANN valuation system.

5.4.1 Back-Propagation (BP)

BP is a general purpose network paradigm trained through supervised learning (Rumelhart and McClelland, 1986). It is used mainly for pattern recognition, signal filtering, noise removal, signal/image segmentation, classification, mapping, adaptive robotic control and data compression. BP learns by calculating an error between a desired and an actual output and by propagating this error information back to each node in the network. This back-propagated error is used to drive the learning at each node. Any multi-dimensional function can in theory be synthesised by a BP network. It is good at forming internal representations of features in input data or classification and other tasks. However, it is slow in learning, especially in complex problems which may require hundreds of thousands of training cycles. Another disadvantage is that it is difficult to determine in advance the number of hidden layers and number of processing elements in each hidden layer. BP learning can get stuck in a local minimum and thus does not necessarily minimise the global error. BP is also known as adaline (Adaptive Linear Elements) network when it uses nodes with linear transfer functions and it consist of a single layer (Widrow and Hoff, 1960). Even though it is fast and easily implemented, only linear-separable classification spaces are possible because there is an assumed linear relationship between input and output.

Haykin (1999, pp. 173-175) explains that the BP algorithm is implemented by the following steps:

Step 1: Initialization.

Pick up the synaptic weights and thresholds from a uniform distribution whose mean is zero and whose variance is chosen to make the standard deviation of the induced local fields (see 5.1) of the neurons lie at the transition between the linear and saturated parts of the sigmoid activation function.

Step 2: Presentations of training examples.

Present the network with an epoch of training examples. For each example in the set, perform the sequence of forward and backward computations described under points 3 and 4 respectively.

Step 3: Forward computation.

Let a training example in the epoch be denoted by (**x**(n), **d**(n)), with the input vector **x**(n) applied to the input layer of sensory nodes and the desired response vector **d**(n) presented to the output layer of computation nodes. Compute the induced local fields and function signals of the network by proceeding forward through the network, layer by layer. The induced local field $u_j^{(l)}(n)$ for neuron j in layer l is

$$u_j^{(l)} = \sum_{i=0}^{m0} w_{ji}^{(l)}(n) y_i^{(l-1)}(n) \tag{5.1}$$

where $y_i^{(l-1)}(n)$ is the output (function) signal of neuron i in the previous layer l-1 at iteration n and $w_{ji}^{(l)}(n)$ is the synaptic weight of neuron j in the layer l that is fed from neuron i in layer l-1. For i=0, we have $y_0^{(l-1)}(n) = +1$ and $w_{j0}^{(l)}(n) = b_j^l(n)$ is the bias applied to neuron j in layer l. Assuming the use of a sigmoid function, the output signal of neuron j in layer l is

$$y_j^{(l)} = \varphi_j(u_j(n)) \tag{5.2}$$

If neuron j is in the first hidden layer (i.e., l=1), set

$$y_j^{(0)}(n) = x_j(n) \tag{5.3}$$

where $x_j(n)$ is the jth element of the input vector **x**(n). If neuron j is in the output layer (i.e., l=L, where L is referred to as the *depth* of the network), set

$$y_j^{(L)}(n) = o_j(n) \tag{5.4}$$

Compute the error signal

$$e_j(n) = d_j(n) - o_j(n) \tag{5.5}$$

where $d_j(n)$ is the *j*th element of the desired response vector **d**(n).

Step 4: Backward computation.

Compute the δs (local gradients) of the network, defined by

$$\delta_j^{(l)}(n) = \begin{cases} e_j^{(L)}(n)\varphi'_j(u_j^{(L)}(n)) & \text{for neuron } j \text{ in output layer } L \\ \varphi'_j(u_j^{(l)}(n))\sum_k \delta_k^{(l+1)}(n) w_{kj}^{(l+1)}(n) & \text{for neuron } j \text{ in hidden layer } l \end{cases} \tag{5.6}$$

where the prime in $\varphi'_j(.)$ denotes differentiation with respect to the argument. Adjust the synaptic weights ($w_{ji}^{(l)}(n)$) of the network in layer l according to the generalized delta rule:

$$w_{ji}^{(l)}(n+1) = w_{ji}^{(l)}(n) + a[w_{ji}^{(l)}(n-1)] + \eta\delta_j^{(l)}(n) y_i^{(l-1)}(n) \tag{5.7}$$

Momentum a prevents the network getting stuck in a local minimum, leading to a failure to converge and subsequently in reaching a global minimum. The adaptive learning rate η is used to speed up learning. If the error exceeds the old error by more than a predefined ratio, no weight change takes place and the learning rate decreases. If the error is less, then the learning rate is increased.

Step 5: Iteration.

Iterate the forward and backward computations under points 3 and 4 by presenting new epochs of training examples to the network until the stopping criterion is met.

5.4.2 Probabilistic Network (PNN)

The PNN is trained through supervised learning and can be used for classification problems, for pattern recognition (images, sonar radar) and optimisation and it is able to form optimal representations of pattern features following the energy surface to obtain optimisation minimum. The PNN is a direct outgrowth of earlier work with Bayesian classifiers (Wasserman, 1993, p. 37). Bayes strategies are those used to classify patterns in such a way that minimizes the "expected risk" (Specht, 1990, p. 109).

Bayesian classification requires a probability density function (pdf) for each class. In practice, it is often difficult to determine the pdf with high accuracy (Wasserman, 1993, p. 41). Fortunately, Parzen (1962, pp. 1065-1076) developed such a technique, commonly called the method of Parzen windows. For each sample in the training set (in that class) a unit area Gaussian curve is drawn centered at the value of the feature. Parzen showed that with a large number of samples and suitable scaling the composite curve approaches the true pdf (Wasserman, 1993, p. 42).

$$f_a(\mathbf{X}) = 1/[(2\pi)^{p/2}\sigma^p](1/n_a)\sum_{i=1}^{n_a}\exp[-(\mathbf{X}-\mathbf{Y}_{ai})'(\mathbf{X}-\mathbf{Y}_{ai})/2\sigma^2] \quad (5.8)$$

where

$f_a(\mathbf{X})$ is the value of the pdf of class A at point **X**

i is the training vector number

p is the number of components in the training vector

σ is the smoothing variable

n_a is the number of training vectors in class A

X is the test vector to be classified

$\mathbf{Y}_{ai}$ is the ith training vector from class A

t is the vector transpose

While this formula may appear complicated, the idea is simple: add up the values of the n-dimensional Gaussians, evaluated at the training vector point in n-dimensional space, and scale the sum to produce the estimated probability density at that point. As the number of training vectors (and their Gaussians) increases, the estimated pdf approaches the true value (Wasserman, 1993, p. 42-43).

The selection of polynomials as the approximating function is somewhat arbitrary; linear combinations of a wide variety of orthogonal basis functions may be used instead. There is no clear choice regarding which functions to use. However, the Taylor expansion using polynomials (Specht, 1966) has been well developed, and successfully applied (Wasserman, 1993, p. 42-43). Expanding the argument of the exponential, applying the Taylor expansion and the multinomial theorem produces the following results:

$$f_a(\mathbf{X}) = 1/[(2\pi)^{p/2}\sigma^p]\exp[(-\mathbf{X}'\mathbf{X})/2\sigma^2]P^A(\mathbf{X}) \tag{5.9}$$

where

$$\begin{aligned} P^A(\mathbf{X}) &= D^A_{0...0} + D^A_{10...0}x_1 + D^A_{010...0}x_2 + ... + D^A_{0...01}x_p + D^A_{20...0}x_1^2 \\ &+ D^A_{110...0}x_1x_2 + ... + D^A z_1 z_2 ... z_p x_1^{z1} x_2^{z2} ... x_p^{zp} + ... \end{aligned} \tag{5.10}$$

and $P^A(\mathbf{X})$ is the polynomial approximation for vectors from category A; such a polynomial is required for each category (Wasserman, 1993, p. 48-49).

Where

$$D_{z_1 z_2 ... z_p} = 1/(z_1! z_2! ... z_p! \sigma^{2h})(1/n_a)\sum_{i=1}^{n_a} y_{ai1}^{z1} y_{ai2}^{z2} ... y_{aip}^{zp} \exp(B_{ai}/\sigma^2) \tag{5.11}$$

where
$$B_{ai} = (-1/2)\sum_{j=1}^{p} y_{aij}^2 = (-1/2)(\mathbf{Y}'_{ai}\mathbf{Y}_{ai}) \tag{5.12}$$

and where
$$h = z_1 + z_2 ... z_p \tag{5.13}$$

Low degree (2 or 3) polynomials will suffice to achieve a satisfactory accuracy in the pdf approximation (Wasserman, 1993, p. 49).

The set of weights entering a pattern layer neuron represent a specific training vector; each weight has the value of a component of that vector. Each pattern layer neuron sums the weighted inputs from every distribution layer neuron, then applies the nonlinear function $f(.)$ to that sum to produce the output $\mathbf{Z}_{ci}$, where the first subscript, c, indicates the class of the associated training vector, and the second identifies the pattern layer neuron computing that class. Thus the resulting output is:

$$\mathbf{Z}_{ci} = \exp[(\mathbf{X}_{Ri}^{t}\mathbf{X}_{i} - 1) / \sigma^{2}] \tag{5.14}$$

(Wasserman, 1993, p. 53).

Each neuron in the summation layer receives all pattern layer outputs associated with a given class. Thus, the output of each summation layer is:

$$S_{c} = \sum_{i=1} \exp[(\mathbf{X}_{i}^{t}\mathbf{X}_{Ri} - 1) / \sigma^{2}] \tag{5.15}$$

In the decision layer, each neuron forms a comparison, outputting a one if S_a is greater than S_b, and zero otherwise, thereby indicating the class of the current input vector (Wasserman, 1993, p. 53).

5.4.3 Self-Organising Feature Map (SOFM)

The self-organizing feature map (SOFM) algorithm is an unsupervised learning algorithm where the input patterns are freely distributed over the output node matrix (Kohonen, 1990,1995). The weights are adapted without supervision in such a way that the density distribution of the input data is preserved and represented on the output nodes. This mapping of similar input patterns to output nodes which are close to each other represents a discretisation of the input space, allowing a visualisation of the distribution of the input data. The output nodes are usually ordered in a two dimensional grid, and the weights of the output nodes in the neighbourhood of the winning output node are adapted simultaneously. Its ability to self-organise and to classify made them popular. This has led them to be used in diverse applications, including speech recognition, image analysis and control.

Haykin (1999, pp. 453-454) explains that the following steps are used by SOMF algorithm:

Step 1: Initialization.

Choose random values for the initial weight vectors $\mathbf{w}_j(0)$. The only restriction here is that the $\mathbf{w}_j(0)$ be different for $j = 1,2,..., l$, where l is the number of neurons in the lattice. It may be desirable to keep the magnitude of the weights small.

Step 2: Sampling.

Draw a sample $\mathbf{x}$ from the input space with a certain probability; the vector $\mathbf{x}$ represents the activation pattern that is applied to the lattice. The dimension of vector $\mathbf{x}$ is equal to m.

Step 3: Similarity matching.

Find the best-matching (winning) neuron $i(\mathbf{x})$ at time step n by using the minimum-distance Euclidean criterion:

$$i(\mathbf{x}) = \arg\min_j \left\| \mathbf{x}(n) - \mathbf{w}_j \right\|, \quad j=1,2,...,l \qquad (5.16)$$

Step 4: Updating.

Adjust the synaptic weight vectors of all neurons by using the update formula

$$\mathbf{w}_j(n+1) = \mathbf{w}_j(n) + \eta(n) h_{j,i(\mathbf{x})}(n)(\mathbf{x}(n) - \mathbf{w}_j(n)) \qquad (5.17)$$

where $\eta(n)$ is the learning-rate parameter, and $h_{j,i(\mathbf{x})}(n)$ is the neighbourhood function centered around the winning neuron $i(\mathbf{x})$; both $\eta(n)$ and $h_{j,i(\mathbf{x})}(n)$ are varied dynamically during learning for best results.

Step 5: Continuation.

Continue with step 2 until no noticeable changes in the feature map are observed.

5.5 Modular Artificial Neural Networks

According to Haykin (1994, p. 475) a Modular network is defined as follows:

"A neural network is said to be modular if the computation performed by the network can be decomposed into two or more modules (subsystems) that operate on distinct inputs without communicating with each other. The outputs of the modules are mediated by an integrating unit that is not permitted to feed information back to the modules. In particular, the integrating unit both (1) decides how the outputs of the modules should be combined to form the final output of the system, and (2) decides which modules should learn which training patterns."

Haykin (ibid., pp. 477-478) explained that modular networks have the following advantages:

1. *speed of learning;* complex functions may be decomposed to simpler functions. A modular network has the ability to discover the decomposition because it is able to learn the set of simpler functions faster than a multilayer perceptron can learn the undecomposed complex function;
2. *data representation;* the representation of input data developed by a modular network tends to be easier to understand than in the case of an ordinary

multilayer perceptron because a modular network has the ability to decompose a complex task into a number of simpler tasks;

3. *hardware constraints;* it may be argued that in order to reduce the number of neurons in an ANN, the representation of multidimensional spaces may be distributed among multiple networks (Jacobs et al., 1991).

Furthermore, Gallinari (1995, pp. 582-583) described some problems that may lead to the need for modular systems. These are described as follows:

1. *reducing model complexity*; modular systems keep the complexity of a neural network proportional to the task;
2. *incorporating knowledge*; the system architecture may incorporate *a priori* knowledge when there exists an intuitive or a mathematical understanding of problem decomposition;
3. *data fusion and prediction averaging*; modular systems allow us to take into account data from different sources and nature. Combining or averaging the output of several modules may lead to increased robustness and better generalisation.
4. *hybrid systems*; heterogeneous systems allow us to combine different techniques to perform successive tasks;
5. *learning different tasks simultaneously*; specialised modules may be shared among several systems trained to perform different tasks;
6. *robustness and incrementality*; cooperative systems perform better and are more robust than single-stage systems (de Bolivier, et al., (1991); Fogelmann, et al., (1993)). They are easily modified and extended.

5.6 System Design

In this work a modular artificial neural network valuation (MANN) system was developed for the assessment of houses and apartments (see figures 5.1 and 5.2). The MANN systems for houses and apartments are multi-feature and multi-assessor systems consisting of selected features given in Table 4.4 including the variable "date" of sale for time-adjustment purposes. These features were used as input to the BP, PNN and SOFM networks which are labelled as assessors. The outputs of the three assessors were combined by cumulative average in order to obtain the assessment (£)/m^2 (subsystem 1). The features were also used as input to the MRA (subsystem 2). In the case of the houses, the outputs of the two subsystems were further combined by cumulative averaging in order to obtain the overall assessment (£)/m^2. In the case of the apartments, the two outputs were further combined by calculating the maximum value of the combiner and the MRA in order to obtain the overall assessment (£)/m^2.

Though Haykin's definition of a MANN implies that the integrating unit will be fully automated, the approach adopted here requires manual intervention to select the optimal mode of averaging. It is clear, however, that the distinguishing feature of a MANN is that the modules operate on distinct inputs without communicating with each other and that subsequent manual selection does not violate the basic assumption of the MANN methodology.

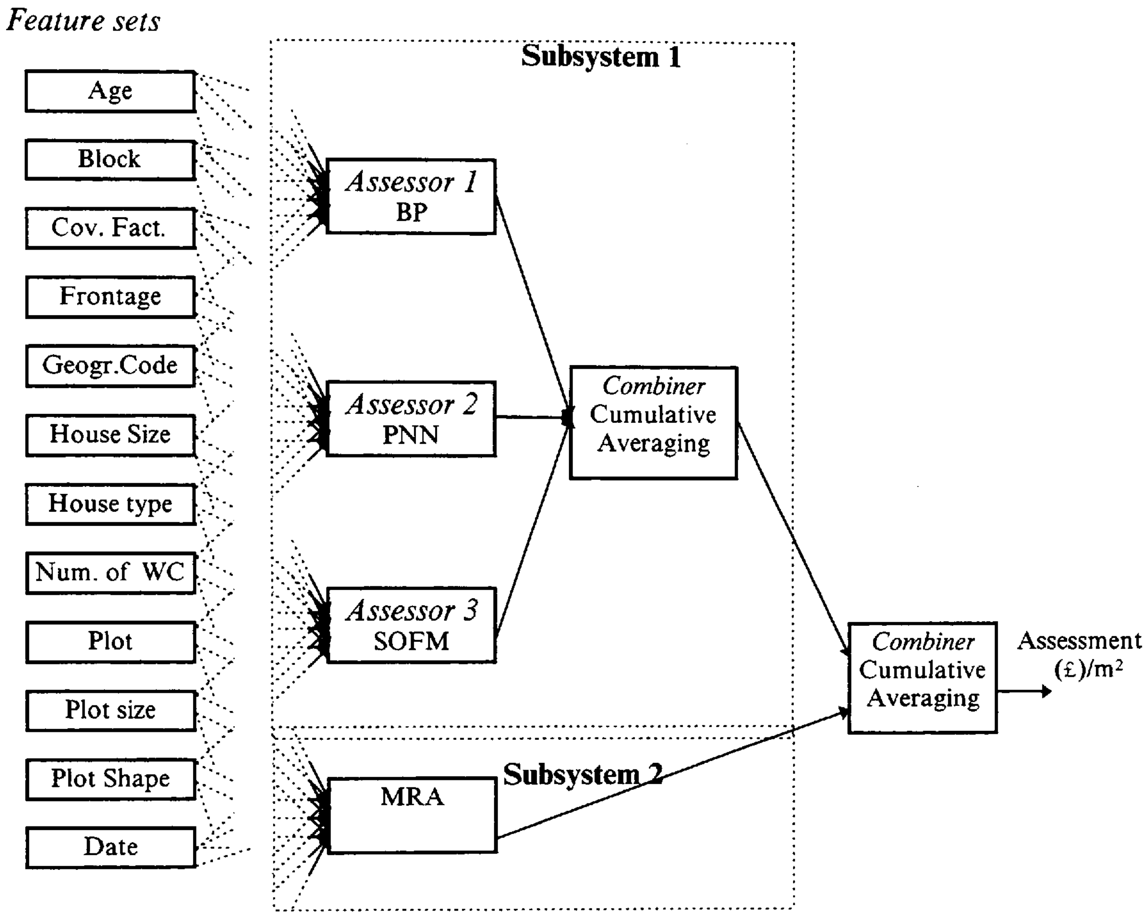

Figure 5.1 MANN system for houses.

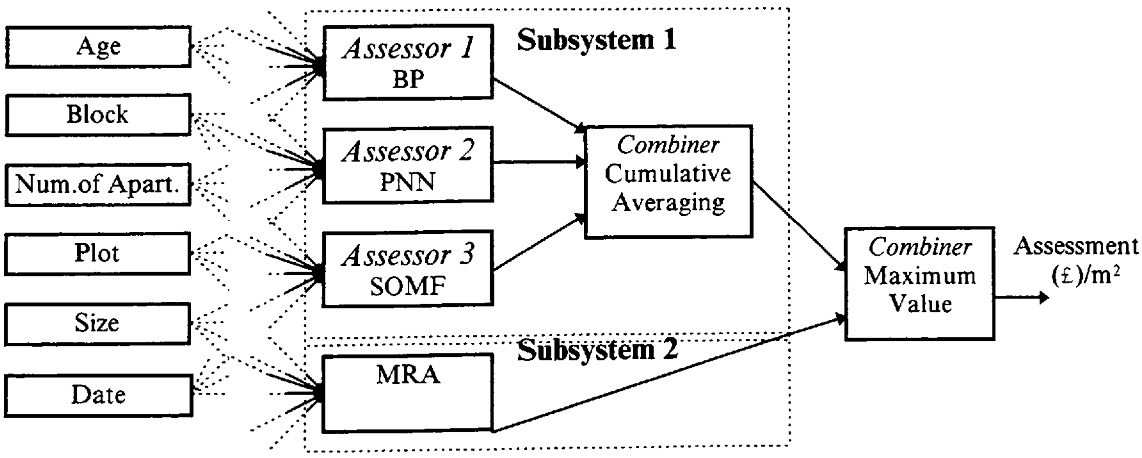

Figure 5.2 MANN system for apartments.

The ANN types were selected because of the advantages presented by many researchers world-wide (see 5.2, 5.4). Additionally, BP and SOMF were selected because of the benefits presented by other authors in property valuation applications (see 3.5). The architectures of the ANNs were determined by the input and output data. In the case of the BP, the number of hidden layers was explored using the trial and error method. The architectures which gave the best performance were adopted.

The same data used in Chapter 4 are used in this Chapter for the development and the testing of the MANN system (see summaries of statistics Tables 4.5 and 4.6). However it was decided that a bootstrapping procedure would be used. Michie et al. (1994, pp. 108-109) explain that a number of replicate samples are created, each sample being a replicate (randomly chosen) of the original sample. The average error rates over all bootstrap samples are then combined to give an estimated error rate for the original rule. Ten different sets of houses and ten different sets of apartments were selected at random for training and evaluating the performance of the ANNs assessors, the MRA (subsystem 2) and the whole MANN system. The training set of houses consisted of 154 houses and the testing set of 50. In the same way the training set of apartments consisted of 350 apartments and the testing set of 120. Testing sets are chosen to be approximately a quarter of the whole samples arbitrarily, having in mind that training sets must be as much as greater so that more knowledge to be generated from training examples.

The design of the MANN system was based on the theory of modular artificial neural network systems (see 5.5) where specialised modules are shared among several systems trained to perform different tasks. The main reason of adopting the principles of modular artificial neural networks is the hypothesis that co-operative systems perform better and are more robust than single-stage systems (de Bolivier, et al., (1991); Fogelmann, et al., (1993)). The MANN system gave better results and was more reliable than an individual assessor or method e.g. ANNs. The developed prototype attempts to provide the necessary assessing system for an equitable property taxation. This system revalues residential properties at a certain date, with minimum acceptable mean error and minimum data.

A brief description of the architecture and implementation details of the ANNs follows.

5.6.1 Back-Propagation (BP)

The BP was implemented in Matlab 4.2. Many architectures were tested including two-layer BPs using a sigmoid transfer function. The single layer (l=1) feedforward network with linear transfer function (purelin), with momentum (a=0.95) and adaptive learning rate ($\eta = 10^{-4}$) adopting the TRAINLM function (Demuth and Beale, 1998, pp. 5-31, 5-32) was the best one. Both BP for houses and apartments were trained in two epochs and the sum-squared error was varied from 0.34 to 0.27 for the ten set of houses and 0.70 to 0.77 for the ten set of apartments. An epoch is the presentation of the set of training vectors to a network and the calculation of new weights and biases (Demuth and Beale, 1998, p. A-4).

The TRAINLM function was used for the training of BP and the calculation of the weights. Demuth and Beale (1998, pp. 5-31, 5-32) explain that this function uses the Levenberg-Marquardt algorithm where the weights ($\mathbf{w}_i$) are calculated as follows:

$$\mathbf{w}_{i+1} = \mathbf{w}_i - [\mathbf{J}^T\mathbf{J} + \mu\mathbf{I}]^{-1}\mathbf{J}^T\mathbf{e} \qquad (5.18)$$

where **J** is the Jacobian matrix, which contains first derivatives of the network errors with respect to the weights and biases, and **e** is a vector of errors. When the scalar μ is zero, this is just Newton's method. When μ is large, this becomes gradient descent with a small step size. Newton's method is faster and more accurate near an error minimum, so the aim is to shift towards Newton's method as quickly as possible. Thus, μ is decreased after each successful step (reduction in performance function) and is increased only when a tentative step would increase the performance function. In this way, the performance function will always be reduced at each iteration of the algorithm.

5.6.2 Probabilistic Network (PNN)

The PNN network was implemented in Matlab 5.2 by adopting the NEWPNN function (Demuth and Beale, 1998, pp. 6-12, 6-13). The NEWPNN creates a two layer network. The first layer weights to input matrix and the first layer biases are all set to *0.8326/spread* resulting in radial basis functions that cross 0.5 at weighted inputs of *+/-spread.* The second layer weights are set to the target matrix). Both houses and apartments were tested with various *spreads* but at the end the default (0.1) was adopted for houses and the 0.2 for apartments because they had the best results. When an input is presented, the first layer computes distances from the input vector to the training input vectors, and produces a vector whose elements indicate how close the input is to a training input. The second layer sums these contributions for each class of inputs to produce as its net output a vector of probabilities. At the end a compete transfer function on the output of the second layer picks the maximum of these probabilities, and produces a 1 for that class and a 0 for the other classes (Demuth and Beale, 1998, p. 6-12). The training sets of sale prices /m² ($sale\_price$) were coded in various ways but at the end the following were adopted because produced the best results:

Case 1: Houses

Step 1: $y_i = \text{ROUND}\ [\ (sale\_price - 250) / 3]$ (5.19)

where ROUND means: round the result to the nearest integer.

Step 2: IF $y_i < 1$
$y_i = 1$
ENDIF

Step 3: IF $y_i > 115$
$y_i = 115$
ENDIF

Case 2: Apartments

Step 1: $y_i = \text{ROUND}\ [\ (sale\_price - 145) / 3]$ (5.20)

Step 2: IF $y_i < 1$
$y_i = 1$
ENDIF

Step 3: IF $y_i > 115$
$y_i = 115$
ENDIF

Both codes y_i for houses and apartments are used by the function IND2VEC (Demuth and Beale, 1998, p. 13-64) in order to create sparse matrices of vectors containing a 1 in each row. The sparse matrices were used by the function NEWPNN of the PNN. In the same way at the decoding the function VEC2IND (Demuth and Beale, 1998, p. 13-295) was used to create the predicted y_i. The values of predicted y_i were transformed to sale prices /m² (*sale_price*) as follows:

Case 1: Houses

$$sale\_price = 3 * y_i + 250 \quad (5.21)$$

Case 2: Apartments

$$sale\_price = 3 * y_i + 145 \quad (5.22)$$

5.6.3 Self-Organising Feature Map (SOFM)

The SOFM network was implemented in Matlab 4.2 adopting the TRAINSM function (Demuth and Beale, 1994, p. 13-153). This function trains a self-organising map with SOMF algorithm. At the similarity matching (see 5.4.3, step 3) of this application the Manhattan, the Euclidean and the Grid distances were tested (Demuth and Beale, 1994, p. 13-69, 70, 71). Manhattan and Euclidean distances had the best results with insignificant difference. Demuth and Beale

(1994, pp. 13-71) explained that the Manhattan distance (*nbman*) between two neurons is the sum of the absolute elements in the vector obtained by subtracting the neurons' coordinates. The Manhattan distance between two vectors **x** and **y** is calculated as:

$$\text{Manhattan distance} = \text{sum}(\text{abs}(x - y)) \qquad (5.23)$$

The *nbman (10,10)* returns the 100x100 neighbourhood matrix for a layer with 100 neurons arranged in two dimensions. Each element (i,j) of the neighbourhood matrix is the vector distance between neurons i and j.

The best SOMF assessors in MANN systems for houses and apartments were trained in 1000 epochs and produced 10x10 kohonen maps. At the end of the training phase, the output nodes are labelled with the class of the majority of the input patterns assigned to each node. It can be argued that, in the evaluation phase, an input pattern belongs to the class label of the winning output node where it has been assigned. According to Michie et al. (1994, p. 222), in use, there are very few indications as to how many times the examples should be repeatedly fed to the system for training. All such parameters can only be decided on a trial-and-error basis. A further training in 10000 epochs was tested but without significant difference in the results.

The values of the houses and apartments of the test sets were estimated as follows:

Step 1: Existence of same winning output node.

When the same winning output node appeared in both maps produced by training and testing sets, the average value of the properties in the training set was adopted for the properties of the testing sets;

Step 2: Non-existence of same winning output node.

When a winning output node (win_i) appeared only in the Kohonen map produced by the testing set, the average value of the corresponding properties of the training set in the neighbourhood of the winning node (see figure 5.3) was adopted.

win_{i-9}	win_{i-10}	win_{i-11}
win_{i-1}	win_i	win_{i+1}
win_{i+9}	win_{i+10}	win_{i+11}

Figure 5.3 Neighbours of the winning output node (win_i)

5.6.4 Subsystem 1 Combiner

The assessment results derived from the three network assessors of the houses and apartments were combined by cumulative average, in order to obtain the assessment (£)/m^2 of the subsystem 1.

5.6.5 MRA (subsystem 2)

Both the MRA subsystems for houses and apartments were implemented using SPSS statistical packages.

5.6.6 System Combiner

The assessment results derived from the two subsystems were combined by cumulative average for houses in order to obtain the overall assessment (£)/m^2 of the MANN system. In the case of apartments the assessment results were combined by calculating the maximum value.

5.7 Conclusions

Cyprus is a small island (9,251 square kilometres) and the number of properties is large (approximately 2 million). Residential areas are heterogeneous because most people prefer to buy land and use a civil engineer and an architect of their own choice for the construction of a house instead of purchasing a dwelling from an already built up area. There are many areas where the amount of sales evidence is limited and sometimes sale prices are understated.

The benefits provided by ANNs such as adaptation, self-organisation, model-free estimation, parallel processing and non-linearity are crucial in the design of a tool capable of assessing houses and apartments in high performance. The developed MANN system was based on the modular artificial neural networks theory and this makes it more robust and reliable than an individual assessor or method.

The system combines the assessment results of three artificial neural network assessors: i) back-propagation (BP), ii) probabilistic network (PNN) iii) self-organising feature map (SOFM); and iv) MRA. The outputs of the three networks were combined by cumulative average to obtain the assessment result of the three neural networks (Subsystem 1). This result is further combined with the assessment result of the MRA to obtained the overall assessment of the system. The architecture of ANNs were determined by the inputs and output and the design details were determined using the trial and error method.

The methodology followed in this Chapter provides a vital mechanism whereby the assessment of houses and apartments for taxation purposes in Strovolos Municipality can be achieved in a unique speedy and efficient manner. Generally, it will provide a practical model for solving the revaluation problems of land taxation in Cyprus and will make a unique contribution to knowledge within this field.

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6. DEVELOPMENT AND TESTING OF MRA AND MANN VALUATION SYSTEMS

6.1 Introduction

This Chapter analyses the results of the MRA and MANN valuation systems for the assessment of houses and apartments in Strovolos municipality. The models have been designed to revalue residential properties for taxation purposes at a certain date, with minimum acceptable mean error, minimum data and minimum cost. The MRA results show good performance according the IAAO criteria because *COD*s of 10.3% and 12.3% for houses and apartments respectively and are acceptable for taxation purposes. The MANN system incorporating MRA for the revaluation of the same properties in the same area, combined the assessment results of three neural network assessors: 1) back-propagation (BP), 2) probabilistic network (PNN) 3) self-organising feature map (SOFM); and 4) MRA. The *MAPE* and the *COD* of the MANN system for houses were 10.67% and 10.57% respectively. The *MAPE* and the *COD* for apartments were 8.68% and 8.41% respectively. These findings compare favourably with other studies and also satisfy the IAAO criteria.

6.2 MRA valuation model

The variables derived from the second run of the stepwise MRA with 204 houses and 470 apartments (see Table 4.4) were used for the development and the testing of the MRA valuation models (see also Table 6.1). The variable "date" of sale was used for time adjustment purposes.

Variable of Houses	Variable of Apartments
Age	Age
Block	Block
Coverage factor of the planning zone	Number of apartments in the building
Frontage	Plot
Geographical code	Size of apartment
House size	Date
House type	
Number of WC	
Plot	
Plot (land) size	
Plot shape	
Date	

Table 6.1 Variables used for the development of the MRA models for 204 houses and 470 apartments

6.2.1 Correlation

Tables 6.2 and 6.3 show the correlation coefficients (1-tailed significance) of dependent and independent variables for the houses and apartments respectively. The sign "*" on the right denotes that the calculated 1-Tailed Probability is greater than 0.05. Table 6.2 shows that the most highly correlated variable with the variable "Sale price/m^2" of houses was the "plot (land) size". Furthermore, the parameters "block" and "frontage" affected the sale price/m^2 of houses considerably.

	Sale Price/m²	Age	Block No	Cover. Factor	Plot size	Frontage	Geogr. code
Sale Price/m²	1.000	-.217	.377	-.126	.435	.295	-.076*
Age	-.217	1.000	-.209	.252	.228	.045*	-.429
Block No	.377	-.209	1.000	-.091*	.137	.051*	.312
Cover. Factor	-.126	.252	-.091*	1.000	-.230	-.178	-.116
Plot size	.435	.228	.137	-.230	1.000	.426	-.219
Frontage	.295	.045*	.051*	-.178	.426	1.000	-.203
Geogr. code	-.076*	-.429	.312	-.116	-.219	-.203	1.000
House type	-.222	-.202	.045*	.077*	-.455	-.317	.211
Plot	-.094*	-.235	.313	-.048*	-.135	-.103*	.302
Plot shape	-.039*	-.209	.074*	-.025*	-.239	-.236	.130
House size	.170	-.475	.115*	-.146	.359	.369	-.016*
WC	.147	-.639	.003*	-.167	-.188	-.033*	.439
Date	.037*	.098*	.137	.086*	.037*	-.146	.147

Table 6.2 Correlation (1-tailed significance) for houses

	House type	Plot	Plot shape	House size	WC	Date
Sale Price/m²	-.222	-.094*	-.039*	.170	.147	.037*
Age	-.202	-.235	-.209	-.475	-.639	-.098*
Block No	.045*	.313	.074*	.115*	.003*	.137
Cover. Factor	.077*	-.048*	-.025*	-.146	-.167	.086*
Plot size	-.455	-.135	-.239	.359	-.188	.037*
Frontage	-.317	-.103*	-.236	.369	-.033*	-.146
Geogr. code	.211	.302	.130	-.016*	.439	.147
House type	1.000	.204	.262	-.240	.212	.058*
Plot	.204	1.000	.113*	.032*	.072*	.095*
Plot shape	.262	.113*	1.000	.103*	.112*	.015*
House size	-.240	.032*	.103*	1.000	.329	.037*
WC	.212	.072*	.112*	.329	1.000	.044*
Date	.058*	.095*	.015*	.037*	.044*	1.000

Table 6.2 Correlation (1-tailed significance) for houses- continuation

The most highly correlated variable with the variable "Sale price/m^2" of apartments is the age. The parameters "size of apartment" and "number of apartments" in the building affect sale price/m^2 considerably.

	Sale Price/m^2	Age	Block No	Num. of Apartments	Date	Plot	Size of Apart.
Sale Price/m^2	1.000	-.495	.210	-.261	-.042*	-.071*	-.305
Age	-.495	1.000	-.097	.271	.120	-.035*	-.102
Block No	.210	-.097	1.000	-.210	.028*	.489	-.031*
Num. of Apartments	-.261	.271	-.210	1.000	.072*	-.041*	-.092
Date	-.042*	.120	.028*	.072*	1.000	.000*	.061*
Plot	-.071*	-.035*	.489	-.041*	.000*	1.000	.040*
Size of Apartment	-.305	-.102	-.031*	-.092	.061*	.040*	1.000

Table 6.3 Correlation (1-tailed significance) for apartments

6.2.2 Regression Statistics

Table 6.4 shows R, R^2, AR^2 and SE derived from multiple regression analysis.

	Houses	Apartments
R	.76196	.66257
R^2	.58059	.43900
AR^2	.55424	.43173
SE	.04793	.04425

Table 6.4 Regression Statistics of 204 houses and 470 apartments

The statistics R, R^2 and AR^2 show how well models are fitted. The correlation coefficient (R) for houses between the variable "Sale Price/m^2" and the independent variables is high (0.76) and denotes a strong evidence that there is a linear relationship between them. In the same way R for apartments could be considered high (0.66) but is not as strong as the R of houses. However, both SE are low 0.048 and 0.044 (10^3*£/m^2) and it can be concluded that the models may fit well.

6.2.3 Analysis of Variance

Tables 6.5 and 6.6 show analyses of variance and display these two sums of squares under the heading of sum of squares. For regressions the F statistic was 22.033 and 60.386 respectively and the observed significance level (signif F) was less than 0.00005 for both. Thus the hypothesis that the R^2 was 0 was rejected for both.

Analysis of Variance			
	DF	Sum of Squares	Mean Square
Regression	12	.60751	0.05063
Residual	191	.43886	0.00230
F = 22.03335		Signif F = .0000	

Table 6.5 Analysis of Variance for Houses

Analysis of Variance			
	DF	Sum of Squares	Mean Square
Regression	6	.70948	.11825
Residual	463	.90663	.00196
F = 60.38629		Signif *F* = .0000	

Table 6.6 Analysis of Variance for Apartments

6.2.4 Results

Tables 6.7 and 6.8 show the independent variables in the equation derived from regression analysis of the variables shown in Table 6.1. The most important variable in Table 6.7 related with sale price/m^2, is the age with the greatest (absolute) beta coefficient (-0.59358). This means that, with all other variables held constant, a decrease in age of, say, 10% means a younger building will increase the sale price/m^2 of a house by 5.9%. The second important variable that affects sale price/m^2 is the plot (land) size (0.58868). An increase in plot size will increase sale price/m^2. The third important variable that affects sale price/m^2 is the house size (-0.55965). An increase in house size will increase sale price considerably, but statistically sale price/m^2 is reduced. The sig *T*, shows that the null hypothesis (that there is no linear relationship between dependent and independents) was rejected, except for the case of the coefficient of the variable "date" of sale, because this had a sig. *T* 0.9284 which is much greater than 0.05. It should be noted that date was enforced in the regression model for time adjustment purposes.

Variable	*B*	*SE B*	*Beta*	*T*	Sig *T*
Age	-.360697	.048664	-.593586	-7.412	.0000
Plot (land) size	.386437	.044381	.588683	8.707	.0000
House size	-.831863	.108674	-.559654	-7.655	.0000
Block	1.545957	.219417	.383680	7.046	.0000
Geogr. code	-.229217	.041491	-.335677	-5.524	.0000
Number of WC	.291705	.071294	.273779	4.092	.0001
Frontage	.168171	.050702	.189312	3.317	.0011
House type	-.076098	.024940	-.172688	-3.051	.0026
Coverage fact.	.169904	.054930	.163498	3.093	.0023
Plot shape	.040631	.016481	.128138	2.465	.0146
Plot	-.091536	.037857	-.126094	-2.418	.0165
Date	-.003092	.034345	-.004406	-.090	.9284
(Constant)	.272710	.043565		6.260	.0000

Table 6.7 Parameters in the equation for houses

The most important variable in Table 6.8 is the age of apartment with the largest (absolute) coefficient (-0.48807). This means that, with all other variables held constant, an increase in apartment age of, say, 10%, means older building will decrease sale price by 4.8%. Second important variable is the apartment size (-0.35491). An increase in apartment size will increase sale price but statistically sale price/m^2 is reduced. The third most important variable is the block (0.21324).

Variable	*B*	*SE B*	*Beta*	*T*	Sig *T*
Age	-.424688	.031804	-.488078	-13.353	.0000
Apartment size	-.628562	.062572	-.354912	-10.045	.0000
Block	.348198	.067177	.213242	5.183	.0000
Plot	-.150584	.033062	-.182793	-4.555	.0000
Numb.of Apart.	-.075060	.021947	-.126974	-3.420	.0007
Date	.023455	.019809	.041748	1.184	.2370
(Constant)	.428355	.011555		37.070	.0000

Table 6.8 Variables in the equation for apartments

The sig *T* indicates that the null hypothesis (that there is no linear relationship between dependent and independents) was rejected, except from the case of the coefficient of the variable "date" of sale, because this had sig. *T* 0.2370 which is much greater than 0.05. It should be noted that date was enforced in regression model for time adjustment purposes.

Furthermore, both the *MAPE* and the *COD* for houses are estimated at 10.3% and for apartments are estimated at 12.3%. The *COD* for single-family homes and condominiums should be 15.0 or less (IAAO, 1990b, p.24). In areas of new or fairly similar residences, it should be 10.0 or less (ibid.). *COD*s of 10.3% and 12.3% indicate good performance.

6.2.5 Sample Size

The value of $\overline{A/S}$ ratio and the σ_{sd} were calculated for houses at 1.02 and 0.14 respectively. For a t statistic 2 and a 5% tolerance of error, the COV and the required sample size were estimated at 13.7 and 5.5 respectively.

The value of $\overline{A/S}$ ratio and the σ_{sd} for apartments were calculated to be 1.02 and 0.16. For a t statistic 2 and a 5% tolerance of error, the COV and the required sample size were estimated 15.6 and 6.2 respectively.

6.2.6 Testing the Normality of Ratio Data

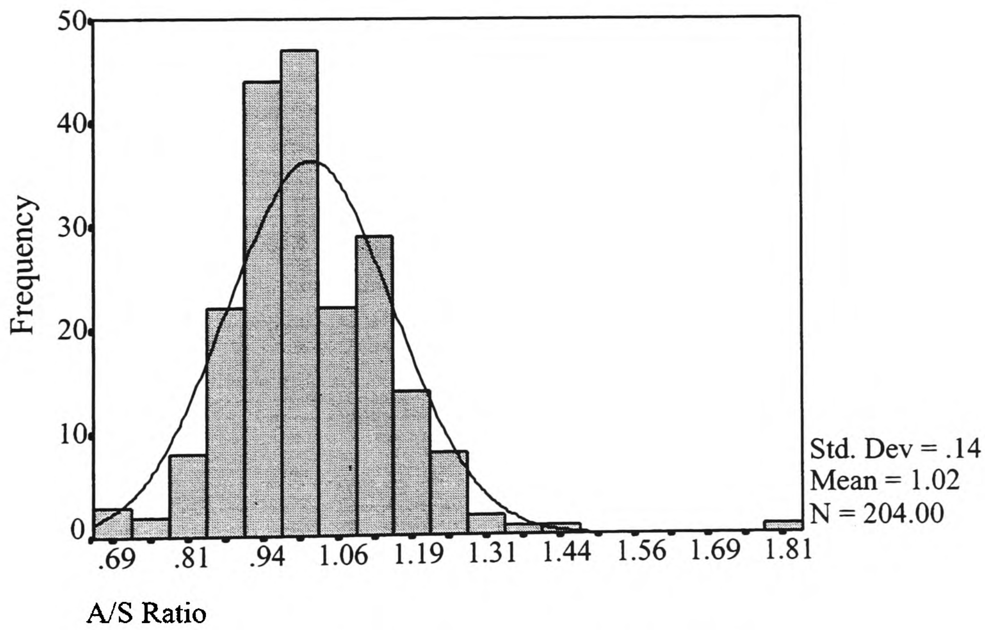

Figure 6.1 Histogram of A/S ratio for houses

Figures 6.1 and 6.2 show histograms of A/S ratio for houses and apartments respectively. These indicate that the distributions are approximately normal. Tables 6.8 and 6.9 show the Kolmogorov - Smirnov test for A/S ratio for houses and apartments respectively. The observed significance level of 0.1186 for the houses is a strong evidence that the distribution of the A/S ratio is approximately normal.

A/S ratio- - - - - Kolmogorov - Smirnov Goodness of Fit Test				
Test distribution - Normal			Mean: 1.02	
Cases: 204			Standard Deviation: .14	
Most extreme differences				
Absolute	Positive	Negative	K-S Z	2-Tailed P
.08321	.08321	-.05340	1.1885	.1186

Table 6.9 A/S ratio: Kolmogorov - Smirnov Goodness of Fit Test for houses

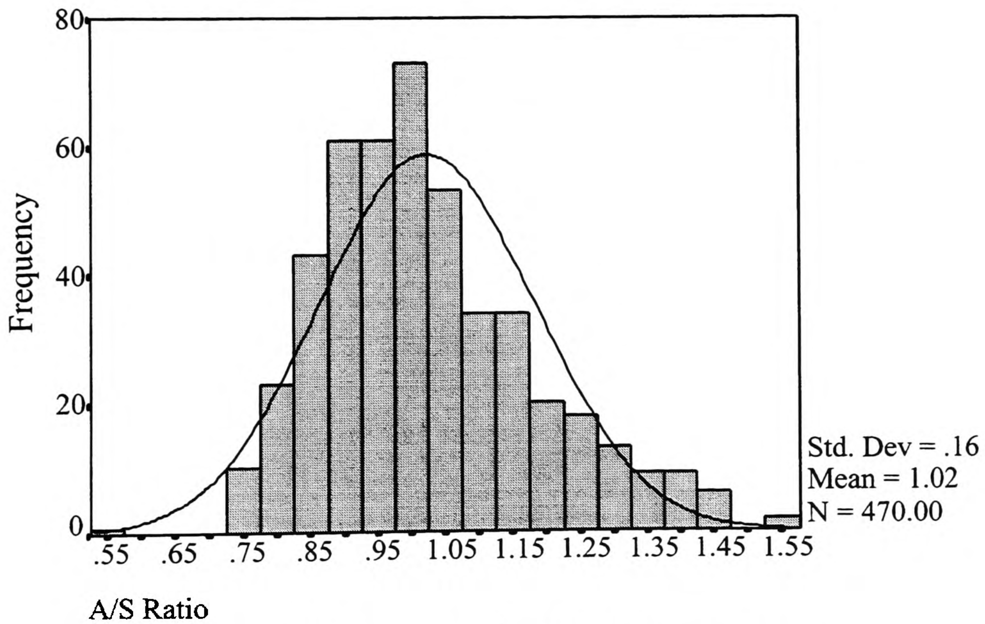

Figure 6.2. Histogram of A/S ratio for apartments

However the observed significance level of 0.0012 for the apartments is not strong evidence that the distribution of the A/S ratio is approximately normal.

A/S ratio- - - - - Kolmogorov - Smirnov Goodness of Fit Test				
Test distribution - Normal		Mean: 1.02		
Cases: 470		Standard Deviation: .16		
Most extreme differences				
Absolute	Positive	Negative	K-S Z	2-Tailed P
.08893	.08893	-.04667	1.9279	0.0012

Table 6.10 A/S ratio: Kolmogorov - Smirnov Goodness of Fit Test for apartments

6.2.7 Testing the normality of the error term

Both Tables 6.11 and 6.12 show the Kolmogorov - Smirnov test for residuals of houses and apartments respectively. The observed significance levels of 0.7340 and 0.8578 are strong evidence that residuals are normally distributed.

Residual - - - - - Kolmogorov - Smirnov Goodness of Fit Test				
Test distribution - Normal		Mean: .00000		
Cases: 204		Standard Deviation: .0459254		
Most extreme differences				
Absolute	Positive	Negative	K-S Z	2-Tailed P
.04804	.04804	-.02769	.6862	.7340

Table 6.11 Residuals of Houses: Kolmogorov - Smirnov Goodness of Fit Test

Residual - - - - - Kolmogorov - Smirnov Goodness of Fit Test				
Test distribution - Normal			Mean: .00000	
Cases: 470			Standard Deviation: 0.0439673	
Most extreme differences				
Absolute	Positive	Negative	K-S Z	2-Tailed P
.02790	.02790	-.02408	.6049	.8578

Table 6.12 Residuals of Apartments: Kolmogorov - Smirnov Goodness of Fit Test

6.2.8 Testing the variance of the error term

Both Figures 6.3 and 6.4 show that the residuals are randomly distributed for houses and apartments and the variances are approximately constant.

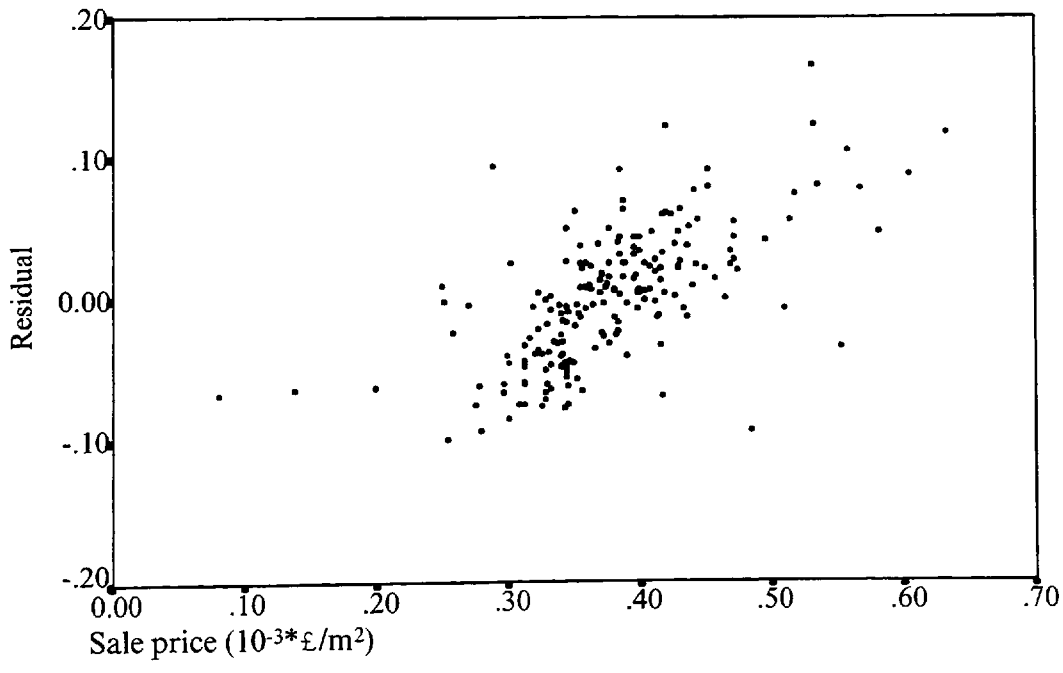

Figure 6.3 Scatterplot of Residual of houses to Sale price (10^{-3}*£/m^2)

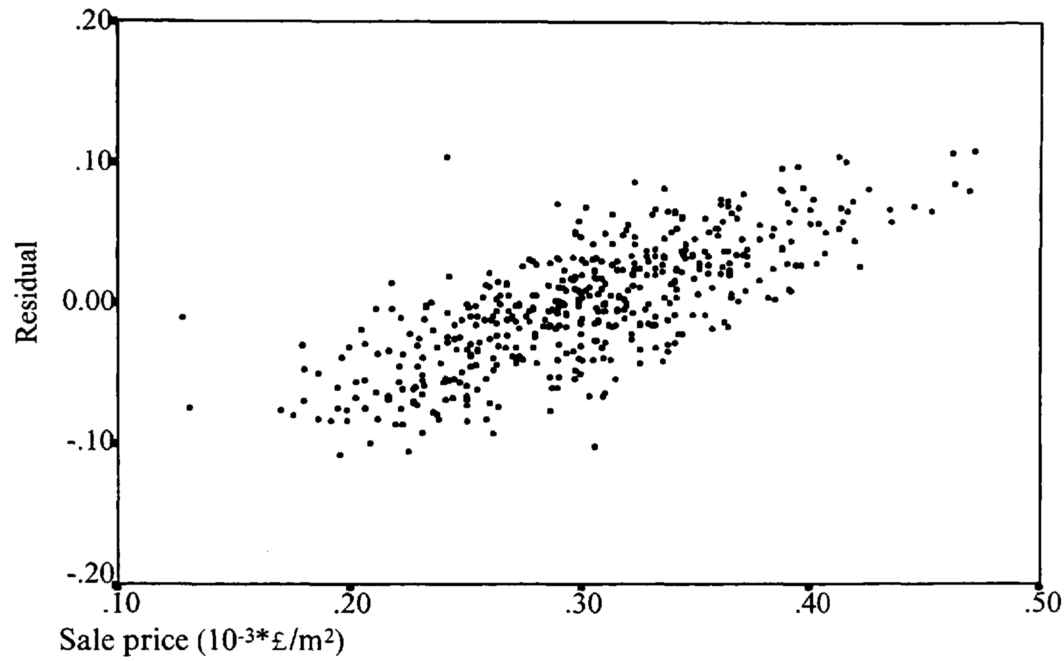

Figure 6.4 Scatterplot of Residual of apartments to Sale price (10^{-3}*£/m^2)

6.3 MANN development and testing

The MANN system incorporating MRA (see Figures 5.1 and 5.2) was developed using Matlab versions 4.2 and 5.2, and SPSS packages. The variables shown in Table 6.1 were the input features and the sale price (10^{-3}*£/m^2) the output feature. A bootstrapping procedure was used for evaluating the whole system. Ten different sets of houses and ten different sets of apartments were selected at random for training and evaluating the performance of the ANNs assessors and the MRA (subsystem 2). The *MAPE* and the *COD* for the ten sets were computed for each assessor, each subsystem and for the whole MANN system.

6.3.1 Case 1: Houses

The training set of houses consisted of 154 houses and the testing set of 50 houses. For the multi-feature, multi-assessor analysis the assessment results for each testing set per assessor are given in Table 6.13. Additionally the results of subsystem 1 and the results of the MRA (subsystem 2) are given too. At the last row of the Table 6.13 the results of the MANN system are presented. For each assessor, the average assessment was computed for the ten sets of all the twelve features for houses. The best assessor was the BP with 11.41% *MAPE* and 11.38% *COD*. The second one was the SOMF assessor with 12.40% *MAPE* and 12.06% *COD*. The PNN assessor was the third with both measures at 12.82%. Subsystem 1 produced better results than the individual assessors with 10.77% *MAPE* and 10.65% *COD*. MRA produced similar results to those of the BP's. These were 11.40% *MAPE* and 11.33 % *COD*. The MANN system produced the best results with 10.67% *MAPE* and 10.57% *COD*. Furthermore, Tables 1, 2, 3, 4, 5 and 6 of Appendix VIII show the number (%) of houses with predicted values within an error band for each assessor, each subsystem and for the whole MANN system. Table 6 shows that for the nine testing sets the MANN system attained 10% or smaller prediction error for 50% and more of the cases.

6.3.2 Case 2: Apartments

The training set of apartments consisted of 350 apartments and the testing set consisted of 120 apartments. For the multi-feature, multi-assessor analysis the classification results for each testing set per assessor are given in Table 6.14. Additionally the results of the subsystem 1 (see figure 5.2) and the results of the MRA (subsystem 2) are given too. At the last row of the Table 6.14 the results of MANN system are presented. For each assessor, the average assessment was computed for the ten sets of all the six features for apartments. The best assessor was the BP with 9.06 % *MAPE* and 8.02 % *COD*. The second was the PNN assessor with 12.17% *MAPE* and 11.90% *COD*. The SOMF assessor was the third with 12.23% *MAPE* and 11.63% *COD*. The subsystem 1 produced better results than the PNN and SOMF with 9.91% *MAPE* and 9.09% *COD*. MRA produced the same results with the BP. The MANN system produced the best results in *MAPE* with 8.68%. However, the *COD* measure of the MANN system was 8.41% and it was better than the *COD* of the PNN and SOMF. Furthermore, Tables 7, 8, 9, 10, 11 and 12 of Appendix VIII show the number (%) of Apartments with predicted values within an error band for each assessor, each subsystem and for the whole MANN system. Table 12 shows that for the nine testing sets the MANN system attained 10% or smaller prediction error for more than 63% of the cases.

	Assessor		Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10	**Mean**	**Std**
SUBSYSTEM 1	Back-Propagation	MAPE	12.29	11.37	11.05	10.96	10.79	10.59	9.72	11.99	11.58	13.80	11.41	1.11
		COD	11.49	11.55	11.11	10.97	10.86	10.70	9.80	11.89	11.62	13.76	11.38	1.03
	Probabilistic Network	MAPE	14.83	13.04	16.15	11.44	11.94	15.40	11.10	10.60	9.78	13.88	12.82	2.18
		COD	14.66	13.06	16.36	11.46	11.97	15.35	11.13	10.58	9.81	13.84	12.82	2.18
	Self-Organising Feature Map	MAPE	15.00	12.92	13.11	11.07	10.82	12.69	12.21	12.35	9.11	14.76	12.40	1.77
		COD	12.92	13.01	13.04	11.08	10.40	12.32	12.25	12.12	8.71	14.76	12.06	1.66
	Combined Results	MAPE	12.92	10.83	12.07	10.16	9.85	11.36	9.98	9.70	7.85	12.93	10.77	1.59
		COD	11.80	10.77	12.11	10.18	9.87	11.22	10.05	9.70	7.91	12.92	10.65	1.44
SUBSYSTEM 2	Multiple Regression Analysis	MAPE	12.29	11.37	10.77	10.96	10.79	10.59	9.72	11.99	11.75	13.80	11.40	1.13
		COD	11.49	11.55	10.74	10.97	10.87	10.70	9.80	11.89	11.54	13.76	11.33	1.04
MANN SYSTEM	ANNs and MRA	MAPE	12.37	10.41	11.21	10.44	9.90	10.38	9.43	10.54	9.02	12.97	10.67	1.23
		COD	11.18	10.46	11.38	10.43	9.96	10.40	9.54	10.57	8.87	12.95	10.57	1.11

Table 6.13. Results of the MANN system for houses

	Assessor		Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10	**Mean**	**Std**
SUBSYSTEM 1	Back-Propagation	MAPE	7.96	8.54	8.95	7.98	9.31	9.95	9.69	9.81	9.18	9.20	9.06	0.71
		COD	7.18	7.91	8.16	7.69	7.63	8.13	8.17	8.18	8.58	8.55	8.02	0.43
	Probabilistic Network	MAPE	12.27	14.58	11.34	13.21	11.88	11.20	12.40	10.29	11.00	13.56	12.17	1.31
		COD	12.03	14.73	11.11	13.31	10.88	11.17	12.20	10.38	10.48	12.72	11.90	1.39
	Self-Organising Feature Map	MAPE	11.25	12.25	12.58	12.01	12.05	13.75	12.47	11.79	13.24	10.92	12.23	0.85
		COD	10.70	12.09	11.79	11.78	11.15	12.62	11.64	10.85	12.67	10.97	11.63	0.70
	Combined Results	MAPE	9.16	10.23	9.80	10.04	9.80	10.50	10.71	9.35	9.67	9.87	9.91	0.48
		COD	8.65	9.90	8.88	9.91	7.98	9.63	9.40	8.29	8.99	9.30	9.09	0.66
SUBSYSTEM 2	Multiple Regression Analysis	MAPE	7.95	8.54	8.95	7.98	9.31	9.95	9.69	9.81	9.18	9.20	9.06	0.71
		COD	7.18	7.91	8.15	7.69	7.63	8.13	8.17	8.18	8.58	8.55	8.02	0.43
MANN System	ANNs and MRA	MAPE	7.72	8.98	8.40	9.24	8.32	9.41	9.21	8.41	8.23	8.85	8.68	0.54
		COD	7.76	9.03	8.02	9.30	7.58	8.87	8.70	7.90	8.11	8.80	8.41	0.60

Table 6.14. Results of the MANN system for apartments

6.3.3 Repeatability

It is desirable that the value estimates for houses and apartments are not changed significantly when new cases are entered in the developed models. This characteristic is known as repeatability or stability of the system.

The repeatability of the MANN system has been tested using the bootstrapping procedure where ten different sets for houses and ten different sets for apartments have been chosen randomly. As a result of this, the training sets are varied and the entering of new cases in the sample is mimicked by the bootstrapping procedure. Tables 6.13 and 6.14 show the results of each assessor, subsystem and the MANN for each sample set. In the case of the MANN system for houses the estimated standard deviation (Std) for the ten sets is 1.11 and for apartments is 0.60. This shows that the *COD*s are not varied significantly by entering new cases and that the MANN meets the requirement for repeatability of the system.

6.3.4 Discussion

This study shows that the MANN system can be used successfully in mass appraisal assessment of houses and apartments for taxation purposes. The system was designed applying modular artificial neural network theory, utilizing various types of ANNs and incorporating MRA. The further development was based on the inputs and output features. The specific parameters of the ANNs and the characteristics of the system combiners were determined using the trial and error method. The weights of the MANN system were estimated using the training samples. This made the system completely automated for the assessment of any other sample of houses and apartments in Strovolos Municipality. The system, minimising observed bias, facilitates the comparison of results using different methods, and more importantly in providing tools for mass appraisal.

In this Chapter it has been presented how the combination of different features and different ANN assessors can improve the assessment performance of individual features or assessors. Furthermore, it has been shown how ANNs can be combined with MRA. This results in a mass appraisal system which combines different feature sets, different assessors and methods, leading to a more robust and reliable model than an individual assessor or method. The method followed and the results of the prototype in Strovolos Municipality are strong evidence that MANN systems can be developed and applied all over Cyprus for any property type using appropriate inputs and design details.

Additionally, the study shows that the MANN system mimics the tasks carried out by the expert valuer who makes his decisions using the Direct Value Comparison method (DVC). DVC is based on comparing the property to be valued with similar properties and the prices achieved for them and allowing for differences between them, thereby determining the price likely to be achieved for the property in question (Britton et al., 1989).

This study agrees with previous studies referred in Chapter 3.5, on the point that ANNs can be applied successfully to residential mass appraisal. In addition, the study agrees with Worzala et al. (1995) and Lenk et al. (1997) on the point that BP network results are very similar to MRA. Moreover, the study disagrees with Tay and Ho (1991) and Do and Grudnitski (1992) on the point that BP networks outperform the linear MRA. McGreal et al. (1998) comment that whilst some very close predictions are possible, others can deviate significantly from sale price and that the use of neural networks are problematic for mass appraisal purposes. The methodology followed by this study can be a solution to the McGreal et al. (ibid.) problem. Furthermore, McGreal et al. (1998) agrees with Worzala et. al. (1995) on the point that "a more sceptical approach" must be adopted to the potential merits of ANNs within the valuation process. The MANN methodology followed by this research can be argued to be that "more sceptical approach".

6.4 Conclusions

The following can be concluded for the MRA in Strovolos Municipality:

1. Good performance; according the IAAO criteria, *COD*s of 10.3% and 12.3% are acceptable for taxation purposes.
2. Objectivity; MRA can measure the importance of the variables objectively where a valuer can not with the traditional methods. In this sense it can be considered superior to results produced by valuers.

3. Sensible results; the three most important variables for houses in Strovolos municipality are: age, plot (land) size and house size. In the same way the most important variables for apartments are age, apartment size and block (location).
4. Low cost; the need for twelve parameters for houses and six for apartments, most of which exist in the Lands and Surveys Department, makes the use of stepwise regression analysis cheap in data selection and maintenance.
5. Easy use; as soon as the regressors are estimated, SPSS, SAS, database management systems or any other software that can make calculations can be used for mass appraisal, provided that the values of the twelve variables for houses and the six for apartments are given.

The following can be concluded for the MANN system in Strovolos Municipality:

1. Promising tools; the results in this work show that modular systems are promising tools in property valuation and in mass appraisal.
2. Robustness and incrementality; the combination of different features and different assessors improved the overall assessment performance of the system and made it more robust and reliable than an individual assessor. Different features provide different representations of the input data and different assessors provide different generalisations by realising different decision boundaries. The combination of the assessing results of the individual input patterns, utilises all the available information which may be lost when using the

statistics of the input data, and enhanced further the assessment performance of the system. The evaluation results could be varied further using more data from more subjects, both for training and testing the system.

3. Applicable in mass appraisal; the proposed methodology can be applied for the development of a MANN system in mass appraisal for taxation purposes.

The above applications show that the MANN and MRA can be applied successfully in Cyprus. It is worth noting that the process followed from data collection and data maintenance, to data preparation and to the clustering of areas is very important to keep MANN and MRA efficient, effective, cheap and easy to use.

The Central Government as well as the Lands and Surveys Department should use this study as a basis for:

- valuing the importance of each variable;
- performing data collection to the whole Republic, for revaluation purposes; and
- performing revaluation for taxation purposes.

6.5 Recommendations

The following suggestions can be made to the Central Government of Cyprus and the Lands and Surveys Department:

1. Similar studies should take place in various municipalities, quarters, towns, improvement boards and villages for each main category of property so as to determine what variables are going to be selected;
2. It is necessary to determine the various sources and the various ways of collecting that data at the lowest cost. Use should be made of information technology e.g. image processing, where it is possible;
3. Determination of land value (homogenous) areas should be done after statistical analysis. The proposed determination of land value areas at CILIS may lead to a failure of the MRA because the sale evidence may not be sufficient for each land value area. So the Department must reconsider the determination of those areas.
4. Similar studies need to be performed in order to find out where clustering of areas is needed for the identification of the boundaries of (land value) areas.

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7. CONCLUSIONS

This Chapter appraises the extent to which the research aims have been fulfilled. The limitations which have confined the research and the potential problems which might be encountered if the proposed approach for the mass appraisal of land properties for taxation purposes in Cyprus were to be introduced are outlined. Recommendations for further research are made, in the light of the most recent advances in computing technology. In conclusion, the unique contribution of the research to the field of property taxation and to computer assisted mass appraisal in the context of Cyprus is demonstrated.

7.1 Aims of the research

It is considered appropriate to re-state in brief the aims of the research which were set and have been described and explained in detail in Chapter One in order to place the results of this study in context.

The research work has been carried out in two majors stages.

In the first stage, the research analysed the Cypriot general valuation, taxation and rating laws as well as analysing the valuation problems in order to make recommendations to the Central Government in Cyprus and the local authorities so that they could improve the quality, efficiency and equity of their taxation and rating systems (Refer Chapter Two). Refer also, in Appendix IX for copies of published work and papers presented based on this research are included. The results of the first stage of the research showed that there are problems with the existing tax base which comprises valuations as at both 1909 and 1980. An updated tax base would improve both the efficacy and the perceived equity of the tax, and will assist uniformity. Furthermore, the Sagric International's consultancy, DataCentralen's proposals for the introduction of a CAMA system in Cyprus for tax purposes, as well as the application of MRA and ANN in real estate world-wide, were analysed (Refer Chapter Three).

The building and evaluation of MRA and ANN systems using modular artificial neural networks method for a revaluation in Cyprus are the focus of the second stage of the research which involved the methodology followed (Refer Chapters Four and Five), and the development and testing (Refer Chapter Six). The research has identified the MANN system as an efficient and effective means of carrying out the required general revaluation. Although based on the first stage, this second has constituted the major theme of this thesis. It was supported in part by the recent rapid development of computer technology and the widespread use of artificial neural networks as non-parametric statistical techniques in many different applications.

7.2 Results of the research

Based on these hypotheses, the research activities conducted have included literature reviews, interviews, prototyping, data analysis and testing (see Chapters 4, 5 and 6). As a result, the findings of the research conclude that a CAMA approach for the general revaluation in Cyprus will be an efficient and effective approach to a successful taxation system that is needed in this country. The following sub-sections itemise the findings and the conclusions derived from them.

7.2.1 Immovable property taxation and rating in Cyprus

The research has identified a number of problems which Cyprus faces in its property taxation. Property taxation in this country is inequitable, inconvenient, unfair, unjust and inconsistent (see 2.11) (for more details see Chapter 2 and published articles in Appendix IX). All property-based taxes in the Republic could be improved, both from the taxpayers', the tax collectors' and the municipalities' point of view so that an equitable, convenient, certain, up-to-date system would result and the operational and administrative costs decrease. Improvements would provide the local authorities a strong and stable financial foundation on which to build the provision of quality services. Apart from the problems in the legal framework, the most acute problem in property taxation is the inequity of out of date tax bases, because the assessment of taxes are based on old values and their capital values do not reflect all the valuable characteristics at current values. Current capital values will assist equity and uniformity. Additionally, the Lands and Surveys Department could present capital values of similar properties in the area, as evidence to support estimated sale prices for transfer fee purposes. This would result in greater levels of Capital Gains Tax and transfer fees. These conclusions further support the hypothesis that Cyprus needs general revaluation. The last General Valuation in Cyprus took about twelve years to be completed by the Lands and Surveys Department. The Direct Value Comparison (DVC) was adopted and no computerised method or tools were used to assist the whole process. The long time taken over that revaluation and its high cost are the main reasons why a new revaluation has not taken place in Cyprus since 1980. This fact further supports the hypothesis that Cyprus needs CAMA tools for performing general revaluation and that it could support regular and frequent revaluations in the future.

7.2.2 CAMA systems

Having recognised the importance of CAMA tools in general revaluation and property taxation, the study investigated the Sagric International consultancy and the DataCentralen A/S development in Cyprus. Both proposals for a CAMA system were mainly based on single and multiple regression analysis. Further investigation on MRA in international literature shows that MRA is probably the most popular statistical technique in the business world. In property valuations, it was introduced in 1965 by Pendleton in the District of Columbia and it can be argued that is the most common method for mass appraisal because many countries in the world use MRA in property assessment. However, MRA can be applied effectively for "homogeneous" group of properties in a well-defined geographical area. Moreover, the sold properties upon which the model is constructed must be representative of properties to which the model will be applied and the error term is assumed to be normally distributed. A complete set of accurate data is required because MRA models are data-dependent. The process from data collection and data maintenance to data preparation and to the definition of "homogeneous" areas is very important to keep MRA efficient, effective, cheap and easy to use. Given the above assumptions, the use of this method is acceptable for the purposes of ensuring the consistency and equity that are intended (for more details see Chapter Three, Four and published articles in Appendix IX).

A further investigation on CAMA techniques lead to ANNs. ANNs have the ability to learn from experience and are widely used in pattern recognition exercises e.g. classification problems. Furthermore, they perform nonparametric statistical inference and model-free estimation. Some researchers showed that ANNs outperform MRA and some others that the results derived from both methods are very similar (see 3.5). However, there are researchers that expressed their reservations on the application of ANNs in property valuation. Having studied all the previous applications of ANNs in property valuation, this study makes an efficient and effective use of ANNs. This strategy led to the development of the MANN incorporating MRA (see 5.6) which is mainly based on a modular artificial neural networks method. A modular artificial neural network can be viewed as an evolution of neural networks because it combines various networks and methods which improves the performance of intelligent systems by combining the advantages of the different networks used. The whole system becomes more robust and reliable than an individual neural network and it is a wholly original approach to property valuation. Modular artificial neural networks allow model complexity to be reduced, fusion of data from different sources and nature to be taken into account, different techniques to be combined and different tasks to be performed (see Chapter Three and Five). However, ANNs developments require extensive testing. It is crucial that the test suite covers all likely input conditions, especially at the extremes. Once deployed, the performance of the ANNs should be monitored, either manually or automatically. A degradation of neural network predictive accuracy indicates that retraining is needed or that a fundamental change has occurred in the function being modelled.

7.2.3 A pilot study

An empirical study in Strovolos municipality was performed in order to examine and apply the MRA and ANN methodologies. Data have been collected from the 20th of October 1994 to 31st of October 1997 for 211 houses and 492 apartments corresponding to the 64% and to the 56% of the whole transactions respectively.

The stepwise multiple regression method was applied for the development of MRA models of houses and apartments. This method selects independent variables for a regression equation. The results show *COD*s of 10.3% for houses and 12.3% for apartments which are not only acceptable for taxation purposes but also denote good performance. The three most important variables for houses in Strovolos Municipality are: age, plot (land) size and house size. In the same way, the most important variables for apartments are: age, apartment size and block (location). It can be argued that these results are predictable. Another significant factor of the MRA is that it can measure the importance of the variables objectively, where a valuer with the traditional methods can not. Lands and Surveys Department in Cyprus must perform similar studies in various municipalities, quarters, towns, improvement boards and villages for each main category of property so as to determine what variables are going to be selected. The MRA application shows that the produced results satisfy *COD* criteria for mass appraisal. It is worth noting that the process followed from data collection and data maintenance, to data preparation and to the clustering of areas is very important to keep MRA efficient, effective, cheap and easy to use.

The MANN system combined the assessment results of three neural network assessors: 1) BP, 2) PNN, 3) SOFM; and that of 4) MRA. The *MAPE* and the *COD* for houses were 10.67% and 10.57% respectively. The *MAPE* and the *COD* for apartments were 8.68% and 8.41% respectively. These findings compare favourably with other studies and satisfy *COD* criteria for mass appraisal techniques. The results of the MANN system show that modular systems are promising tools in property valuation and in mass appraisal. The combination of different features and different assessors improved the overall assessment performance of the system and made it more robust and reliable than an individual assessor. Different features provide different representations of the input data and different assessors provide different generalisations by realising different decision boundaries. The combination of the assessing results of the individual input patterns utilises all the available information that may be lost when using the statistics of the input data, and enhanced further the assessment performance of the system. The evaluation results could be varied further using more data from more cases, both for training and testing the system.

The developed MANN models for houses and apartments represent the benefits which can be brought about by CAMA systems and more specific by MANN incorporating MRA. The feedback from the subjects, as summarised above, also indicates that the MANN incorporating MRA can be applied successfully in property assessment for taxation purposes.

7.3 Limitations of this research

This research has been limited in terms of its coverage and the degree to which it has fulfilled its aims and objectives.

The limitations which confined the research and hence the methods of analysis have been described in detail in Chapters One and Four respectively. These are mainly in the following areas:

1. some initial difficulty in collecting data for houses and apartments in Strovolos Municipality, Cyprus; and
2. the limited property transactions in certain areas of the Strovolos Municipality. This is a constraint for the models developed.

Within these limitations, the research has fulfilled its aims. The methodology which was employed by the research and the results produced are valid and reliable.

7.4 Recommendations for further research

The problems and the need of Cyprus for an equitable, convenient, fair, just and consistent property taxation system have been identified, outlined and analysed (see 2.12).

The MANN system which incorporates the MRA approach for the property assessment for revaluation and taxation purposes in Cyprus has been proposed as solution to the problem of valuation inequity. The models have been designed to revalue residential properties at a certain date, with minimum acceptable mean error, minimum data and minimum cost. Their feasibility has been tested and support of this approach has been obtained by calculating the *COD* which is internationally accepted (IAAO, 1990b). Additionally the *MAPE* which can be argued is the most common method of statistical evaluation was estimated and evaluated.

There are five major areas, identified from the current research, on which further work can be carried on.

1. *Property taxation:*

- Work can be carried out on landed taxation in Cyprus, based on British and International experience (McCluskey, 1999, Youngman and Malme, 1994).
- Further research should examine the likely effect of merging taxes into a single one, including the resulting procedures of collecting revenues and appeal procedures against those who challenge the process and/or refuse to pay taxes. Additionally, the research should examine how the procedural cost could be minimised and how the taxation system could become more efficient, cost-effective, time-effective and flexible (Youngman, 1994).
- Furthermore, the research should examine the inclusion of rural areas which are currently not affected directly by taxation laws, because of the continued rise of land values, the computerisation of Lands and Surveys Department, the need for local services and the improvement of those areas. Rates can be regulated by local authorities, and specific rebates or cash-back schemes introduced where and when appropriate.

2. *Implementation of the MANN system incorporating MRA for other property types:*

In terms of the MANN system incorporating MRA and understanding of the property market in Cyprus, a further research could be taken place in various municipalities, quarters, towns, improvement boards and villages so as to examine the suitability of this system for other property types. This will enable the objective measurement of the effect of the variables on property prices and the determination of what variables are going to be selected and used for property assessment. Moreover, the importance of the variables could be measured using sensitivity analysis.

3. *New CAMA systems incorporating fuzzy logic and genetic algorithms:*

- fuzzy logic is a mathematical approach dealing with the imprecise nature of everyday language and of the world around us. Fuzzy set theory extends the concepts of set membership from the binary all-or-nothing view of traditional logic to a more natural one, where items can have degrees of membership ranging from 0.0 to 1.0. The basic set operations of union, intersection, and complement have been redefined to work on fuzzy sets (Bigus, 1996, p.198). Unlike ANNs where their power is based on their ability to learn from data, the power of fuzzy systems lies in their ability to quantify linguistic inputs, quickly and to give a working approximation of complex and often unknown system input-output rules. There is a natural synergy between neural networks and fuzzy systems that makes their hybridization a powerful tool for intelligent control and other applications (Haykin, 1999, p.793). In the MANN system a fuzzy logic system could replace, for example, the system combiner (see Figure 7.1) .

- genetic algorithms perform a search for the solution to a problem by generating candidate solutions from the space of all solutions and testing the performance of the candidates (Michie et al., 1994, p. 234). It is assumed that there is a population of individuals, each one of which, represents a candidate problem-solver for a given task. Like evolution, genetic algorithms test each individual from the population and only the fittest survive to be reproduced for the next generation. The algorithm creates new generations until at least one individual is found that can solve the problem adequately (ibid., p. 235). At the development stage of the MANN system, some parameters were determined on a trial-and-error basis. For example, there are very few indications as to how many times the training set should be repeatedly fed to a Kohonen system for training or how many hidden layers are going to be used in a BP network, or which is the best value of a spread parameter in a PNN. All these were determined on a trial-and-error basis. Genetic algorithms are the solution to the trial-and-error problem. Andreou et al. (1998) used genetic algorithms to optimize the parameters of a radial basis network in a modelling for forecasting exchange-rate shocks. In the same way, genetic algorithms could be used to optimize the BP, PNN and SOMF network parameters of the MANN system (see Figure 7.1).

Figure 7.1 show the MANN system of Figure 5.2 for apartments designed on the basis of incorporating fuzzy logic and genetic algorithms.

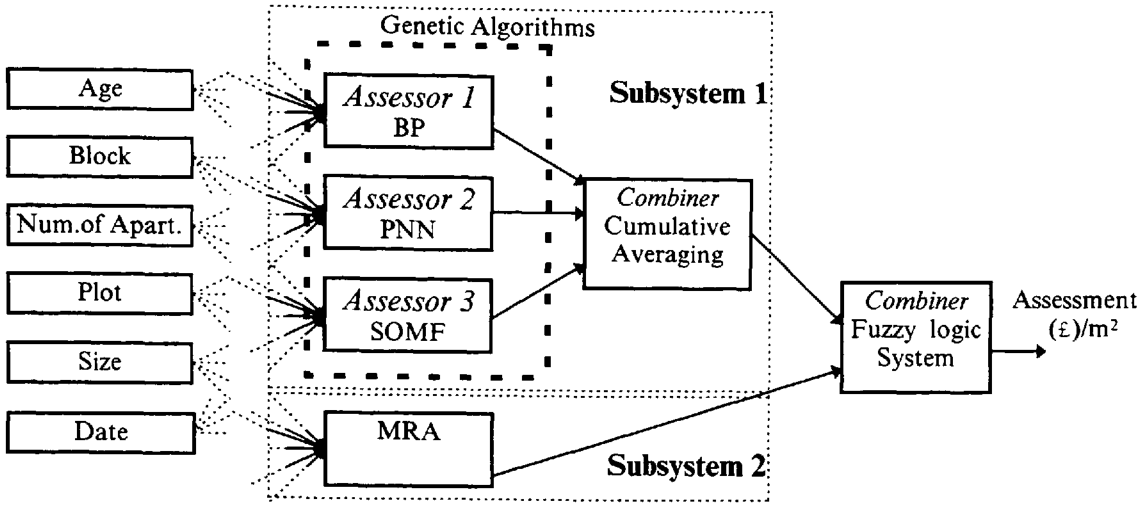

Figure 7.1 MANN system for apartments incorporating fuzzy logic and genetic algorithms

4. *Availability of the MANN system through the Internet by licensed users:*

The term, "Internet" is based on the words "international" and "network" and means a world-wide network of computers. Important components of Internet are electronic mail and world wide web. The web is the graphical front end of the Internet used for information retrieval. Dixon (1998) commented that the rapid growth of the Internet and its increasing use in business and commerce has led many to believe it will also impact on the role of the property professional and influence future property markets. A further research should examine how the MANN system, together with property characteristics provided by the Lands and Surveys Department, could be used through the Internet by licensed users e.g. government employees from the Department of

Finance for property taxation purposes. This will benefit users because it will be able to provide an estimate of the value of a property at a specific date immediately. It will free the valuer from the manual mode of working.

5. *Including MANN in the developed CILIS system of the Lands and Surveys Department*:

Figure 7.2 shows the CILIS system developed by the DataCentralen A/S. This consisted of the Legal/Fiscal subsystem and the GIS subsystem.

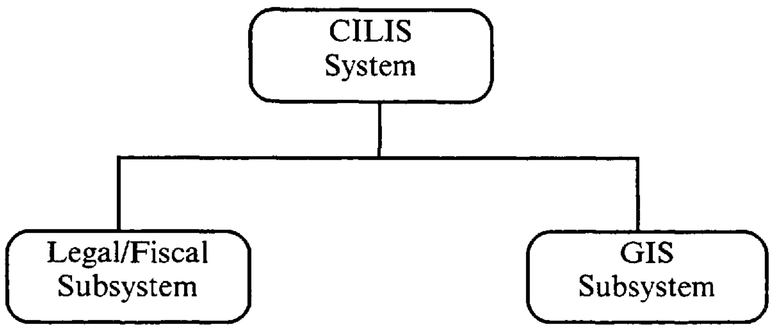

Figure 7.2 CILIS system

The main functions of the fiscal subsystem are the following:

1. maintenance of the fiscal data and related property characteristics;
2. property enquiry;
3. property reporting;
4. computer assisted valuation audit system; and
5. computer assisted mass appraisal and special valuation.

The latter has been explained in 3.4.2. Further research could examine how the MANN system could be incorporated with the DataCentralen's developed models on computer assisted mass appraisal and special valuation (see Figures 7.3, 7.4).

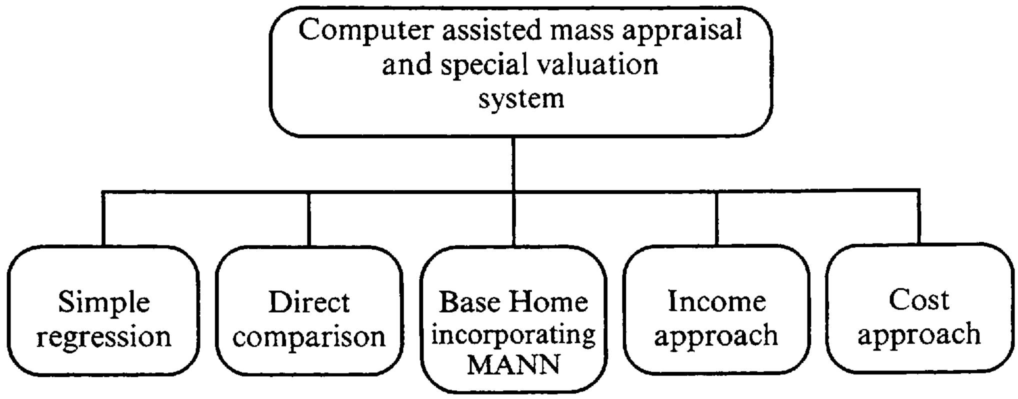

Figure 7.3 Computer assisted mass appraisal and special valuation system including MANN system

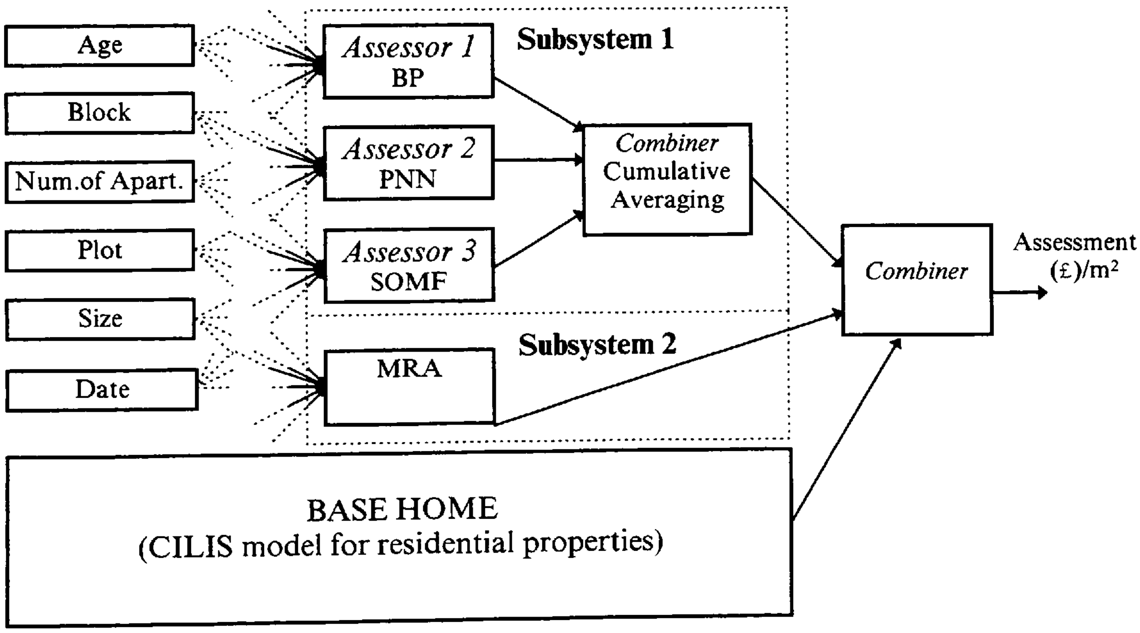

Figure 7.4 MANN system for apartments incorporating BASE HOME of CILIS.

7.5 Summary

The research has fulfilled its aims within acceptable limitations.

In the context of the analysis of the identified and specified problems of immovable property taxation and rating in Cyprus and the need for general revaluation in an efficient, effective and low cost way, this research was led to the development of the MANN system, incorporating MRA as a CAMA tool.

The research has made recommendations to the Central Government in Cyprus and the local authorities so that they could improve the quality, efficiency and equity of their taxation and rating systems. The research has developed a wholly original approach to property valuation for taxation purposes based on CAMA, using the MANN system incorporating MRA which has been demonstrated and tested. A novel framework has thus been established upon which future research into CAMA systems can be developed.

A significant and original contribution has been made by way of an alternative approach to the property valuation for taxation purposes which is novel not only in the context of Cyprus but also world-wide.

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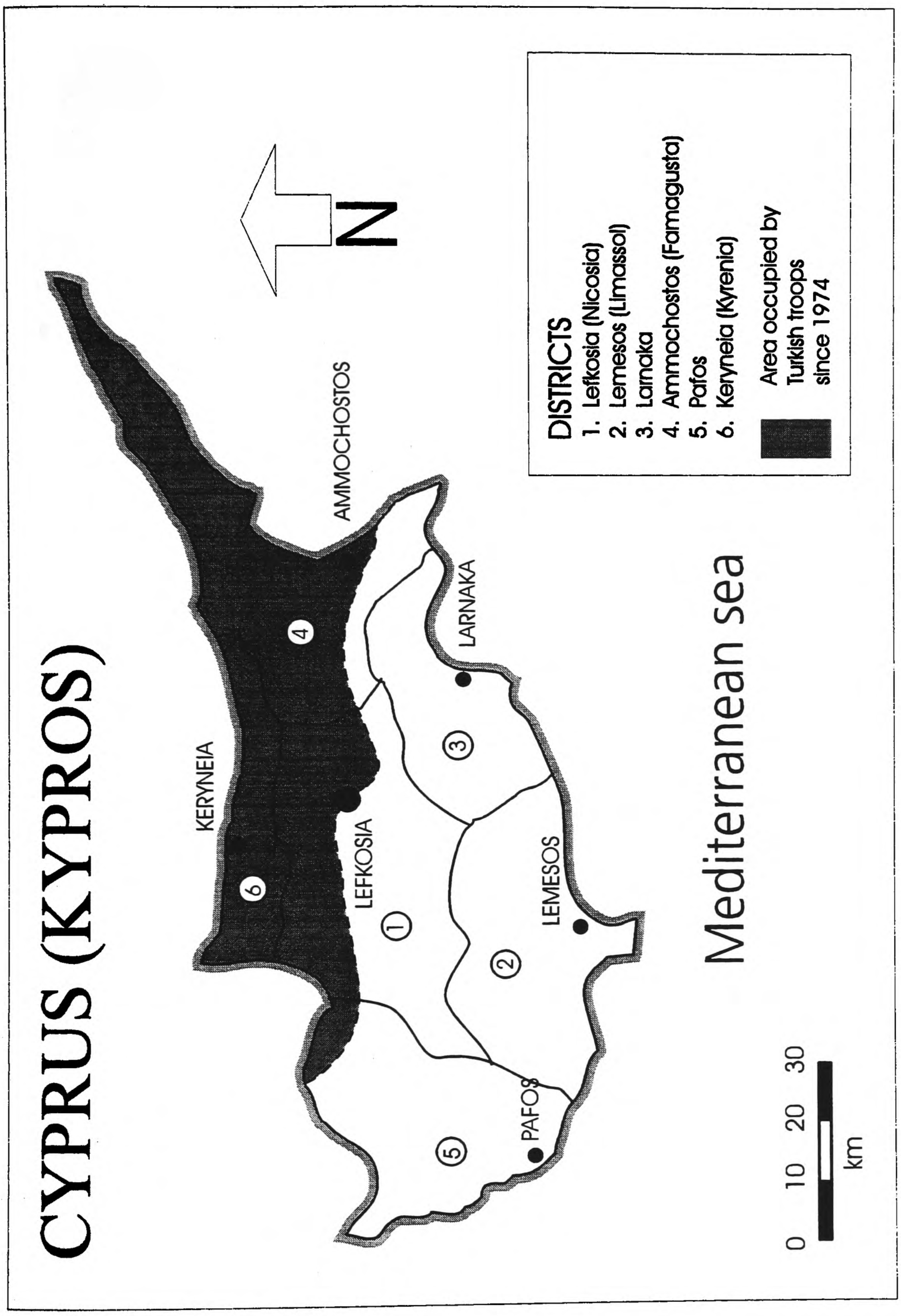
APPENDIX I Map of Cyprus (Kypros)


CYPRUS (KYPROS)
KERYNEIA
AMMOCHOSTOS
LEFKOSIA
LARNAKA
LEMESOS
PAFOS
Mediterranean sea
N
DISTRICTS
1. Lefkosia (Nicosia)
2. Lemesos (Limassol)
3. Larnaka
4. Ammochostos (Famagusta)
5. Pafos
6. Keryneia (Kyrenia)
Area occupied by Turkish troops since 1974
0 10 20 30
km

APPENDIX II Lands and Surveys Department

The Department of Lands and Surveys is the oldest Department in the government services, dating back to 1858 when the island was still under Ottoman occupation. Kotsonis (1990) explained that the British administration improved and enlarged both its methods and its functions considerably. Initially, its main function was to investigate ownership of land and issue registrations of title. After independence in 1960, it gradually expanded to the present form which consists of a composite service comprising land registration, survey, cartography, valuation, land management, tenure and administration. Each branch is headed by a senior officer under the overall authority of the Director.

More specifically the functions of the branches are as follows:

1. the Survey Branch is responsible for all geodetic, topographical and cadastral surveys, mapping and photogrammetry and provides the cadastral basis for land registration;
2. the Registration Branch undertakes all the work connected with the registration of title, (issuing of certificates of registration, transfers, mortgages, keeping records for all charges and prohibitions) and preparing rating lists (valuation is not included);
3. the Tenure Branch is responsible for all land tenure matters, including general registration and land consolidation;
4. the Management Branch is responsible for the management of state lands and the administration of compulsory acquisition and requisition cases. It is also responsible for the review and collection of rents payable under leases of state lands;

5. The Valuation Branch is responsible for carrying out valuations for all purposes, namely for central government and local authorities taxation, general valuation, reserved prices for properties sold at public auctions; for compensation after compulsory acquisitions or requisitions; advises the government on the acquisition, lease and management of state lands. Furthermore, the Valuation Branch is responsible for the provision of an information service to the public and private sector e.g. for sales history data.

In addition, the Department of Lands and Surveys is the state agency responsible for the application of the laws relating to landed property matters, for example:

1. The Immovable Property (Tenure, Registration and Valuation) Law, Capital 224 (1946);
2. The Immovable Property (Transfer and Mortgage) Law (9/1965);
3. The Compulsory Acquisition of Property Law (15/1962);
4. The Requisition of Property Law (21/1962);

and provisions of many other laws which deal with land. Its Director is the adviser to the government for the formulation of land policy and its implementation. The Director exercises quasi-judicial powers in respect of boundary disputes, correction of errors or omissions in the Land Register and on the plans; compulsory partitions of immovable property held in undivided shares and eliminating ownership in shares where partition of the property is impossible.

Because the Department is in the process of computerising its records and procedures, a new branch, the Cyprus Land Information Centre, is being established

APPENDIX III Analysis of Apartment sales in Strovolos Municipality

Serial No	Quarter of Strovolos Municipality	File no.	Agreement Date	Transferred Date	Share	Prices (£)		
1	STROVOLOS - AP.VARNAVAS & AG.MAKARIOS	S 144/1995		09/01/95	1/2	13000	14000	12500
2	STROVOLOS - AP.VARNAVAS & AG.MAKARIOS	S 145/1995		09/01/95	1/2	13000	14000	12500
3	STROVOLOS - AGIOS VASILEIOS	S 248/1995		12/01/95	1/1	42000		15300
4	STROVOLOS - AGIOS DIMITRIOS	S 286/1995		13/01/95	1/1	18000		5300
5	STROVOLOS - AP.VARNAVAS & AG.MAKARIOS	S 304/1995		16/01/95	1/1	29000		11000
6	STROVOLOS - CHRYSELEOUSA	S 351/1995		17/01/95	1/1	25000		10000
7	STROVOLOS - CHRYSELEOUSA	S 357/1995		17/01/95	1/1	25500		10700
8	STROVOLOS	S 583/1995		24/01/95	1/1	26500		12400
9	STROVOLOS - AGIOS DIMITRIOS	S 602/1995		25/01/95	1/1	17000	19000	10000
10	STROVOLOS - AGIOS VASILEIOS	S 684/1995		26/01/95	1/1	22000		12000
11	STROVOLOS - AGIOS DIMITRIOS	S 747/1995		30/01/95	1/1	33000		15700
12	STROVOLOS - AGIOS DIMITRIOS	S 915/1995		02/02/95	1/1	46500		17800
13	STROVOLOS - CHRYSELEOUSA	S 5484/1995	18/02/95	05/07/95	1/1	31500		12400
14	STROVOLOS - CHRYSELEOUSA	S 1466/1995		20/02/95	1/1	22000	28000	13000
15	STROVOLOS - AGIOS DIMITRIOS	S 1576/1995		23/02/95	1/1	35500		14500
16	STROVOLOS - AGIOS DIMITRIOS	S 2948/1995	27/02/95	10/04/95	1/1	26700		10500
17	STROVOLOS - AGIOS DIMITRIOS	S 1747/1995		01/03/95	1/1	27000	30000	13500
18	STROVOLOS - AP.VARNAVAS & AG.MAKARIO	S 1848/1995		03/03/95	1/1	22000	29000	9500
19	STROVOLOS - CHRYSELEOUSA	S 1854/1995		03/03/95	1/1	22500	26000	12600
20	STROVOLOS - AGIOS DIMITRIOS	S 1905/1995		07/03/95	1/1	40000		24000
21	STROVOLOS - CHRYSELEOUSA	S 1953/1995		09/03/95	1/1	46000	50000	23000
22	STROVOLOS - AGIOS VASILEIOS	S 2032/1995		10/03/95	1/1	38500		11500
23	STROVOLOS - AP.VARNAVAS & AG.MAKARIO	CS 298/1995	13/03/95	08/05/95	1/1	28000		9300
24	STROVOLOS - AGIOS DIMITRIOS	CS 458/1995	13/03/95	04/08/95	1/1	29500		10600
25	STROVOLOS - CHRYSELEOUSA	S 2200/1995		16/03/95	1/1	24000		6600
26	STROVOLOS - CHRYSELEOUSA	S 2301/1995		17/03/95	1/1	21000	28000	10000
27	STROVOLOS - CHRYSELEOUSA	S 2739/1995		31/03/95	1/1	28250		11500
28	STROVOLOS - AGIOS DIMITRIOS	S 2747/1995		31/03/95	1/1	29000		13000
29	STROVOLOS - CHRYSELEOUSA	S 2833/1995		05/04/95	1/1	24000		9600
30	STROVOLOS - AP.VARNAVAS & AG.MAKARIO	S 2933/1995		07/04/95	1/1	42000		18000
31	STROVOLOS - AGIOS VASILEIOS	CS 480/1995	10/04/95	31/05/95	1/1	36500		17200
32	STROVOLOS - AP.VARNAVAS & AG.MAKARIO	S 3026/1995		12/04/95	1/1	35000		14600
33	STROVOLOS - AGIOS DIMITRIOS	S 3134/1995		14/04/95	1/1	29500		16700
34	STROVOLOS - CHRYSELEOUSA	S 6099/1995	15/04/95	25/07/95	1/1	25000		12700
35	STROVOLOS - CHRYSELEOUSA	S 3203/1995		18/04/95	1/1	30000		12600
36	STROVOLOS	S 5535/1995	19/04/95	06/07/95	1/1	36500		14000
37	STROVOLOS - AGIOS DIMITRIOS	S 3398/1995		27/04/95	1/1	34350		15700
38	STROVOLOS - AGIOS DIMITRIOS	S 3403/1995		27/04/95	1/1	22000		8400
39	STROVOLOS - AGIOS DIMITRIOS	S 3493/1995		02/05/95	1/1	33000		16000
40	STROVOLOS - AGIOS DIMITRIOS	S 3493/1995		02/05/95	1/1	36000		18500
41	STROVOLOS - AGIOS DIMITRIOS	S 3493/1995		02/05/95	1/1	31000		14000
42	STROVOLOS - AGIOS VASILEIOS	S 3553/1995		03/05/95	1/1	27000		12000
43	STROVOLOS - AGIOS DIMITRIOS	CS 534/1995	03/05/95	12/07/95	1/1	42000		14000
44	STROVOLOS - AGIOS DIMITRIOS	S 3566/1995		04/05/95	1/1	27000		16000
45	STROVOLOS - AP.VARNAVAS & AG.MAKARIO	CS 555/1995	11/05/95	04/09/95	1/1	28000		12500
46	STROVOLOS - AGIOS DIMITRIOS	S 4138/1995		23/05/95	1/1	30000		10900
47	STROVOLOS - AGIOS VASILEIOS	S 4188/1995		24/05/95	1/1	22600		8700
48	STROVOLOS - AGIOS DIMITRIOS	S 4282/1995		26/05/95	1/1	23500	29000	10600
49	STROVOLOS - AGIOS DIMITRIOS	CS 672/1995	26/05/95	01/09/95	1/1	60500		20200
50	STROVOLOS - AGIOS DIMITRIOS	S 4388/1995		30/05/95	1/1	19000		5300
51	STROVOLOS - CHRYSELEOUSA	S 4468/1995		02/06/95	1/1	29300		13000
52	STROVOLOS - CHRYSELEOUSA	S 4503/1995		05/06/95	1/1	25000	27000	11400
53	STROVOLOS - AGIOS DIMITRIOS	S 4614/1995		07/06/95	1/1	27000	32000	13500
54	STROVOLOS - AGIOS DIMITRIOS	S 4725/1995		09/06/95	1/1	17000		7400
55	STROVOLOS - AGIOS DIMITRIOS	S 4731/1995		09/06/95	1/1	25000		13800
56	STROVOLOS - AGIOS DIMITRIOS	S 4743/1995		09/06/95	1/1	28000		11000
57	STROVOLOS - AGIOS DIMITRIOS	S 4811/1995		14/06/95	1/1	25000	30000	14400
58	STROVOLOS - AP.VARNAVAS & AG.MAKARIO	CS 893/1995	15/06/95	19/09/95	1/1	32000		12000
59	STROVOLOS - CHRYSELEOUSA	S 5188/1995		26/06/95	1/1	24000		9500
60	STROVOLOS - AGIOS VASILEIOS	S 5392/1995		03/07/95	1/1	29700		17400
61	STROVOLOS - AGIOS DIMITRIOS	S 5402/1995		03/07/95	1/1	38200		13000
62	STROVOLOS - CHRYSELEOUSA	S 5485/1995		05/07/95	1/1	40000		16900
63	STROVOLOS - CHRYSELEOUSA	CS 828/1995	05/07/95	02/08/95	1/1	45000		23700
64	STROVOLOS - CHRYSELEOUSA	S 5566/1995		07/07/95	1/1	20000	26000	10500
65	STROVOLOS - AGIOS DIMITRIOS	S 5669/1995		12/07/95	1/1	35000		18000
66	STROVOLOS - AGIOS VASILEIOS	S 2561/1995	16/07/95	27/03/95	1/1	25200		16300

67	STROVOLOS - AGIOS VASILEIOS	S 5825/1995		17/07/95	1/1	29700	40000	17400
68	STROVOLOS - AGIOS DIMITRIOS	S 5804/1995		17/07/95	1/2	24000		15700
69	STROVOLOS - AGIOS DIMITRIOS	S 5805/1995		17/07/95	1/2	24000		15700
70	STROVOLOS - AGIOS DIMITRIOS	S 6315/1995		31/07/95	1/1	27250		10800
71	STROVOLOS - AGIOS DIMITRIOS	S 6412/1995		02/08/95	1/1	34000		13800
72	STROVOLOS	S 6541/1995		04/08/95	1/1	36500		19200
73	STROVOLOS - CHRYSELEOUSA	S 6516/1995		04/08/95	1/1	34000		14300
74	STROVOLOS - CHRYSELEOUSA	S 6908/1995		18/08/95	1/1	18000	21000	8000
75	STROVOLOS - AGIOS DIMITRIOS	S 7015/1995		23/08/95	1/1	50000		18500
76	STROVOLOS	S 8025/1995	28/08/95	26/09/95	1/1	28000		9100
77	STROVOLOS - AP.VARNAVAS & AG.MAKARIOS	7160/1995		28/08/95	1/1	29500		11500
78	STROVOLOS - AGIOS VASILEIOS	S 7306/1995		01/09/95	1/2	15000		15000
79	STROVOLOS - AGIOS VASILEIOS	S 7307/1995		01/09/95	1/2	15000		15000
80	STROVOLOS - AGIOS DIMITRIOS	S 7340/1995		04/09/95	1/1	25000	27000	12000
81	STROVOLOS - AGIOS DIMITRIOS	S 7452/1995		07/09/95	1/1	24750		16500
82	STROVOLOS - AP.VARNAVAS & AG.MAKARIOS	7530/1995		11/09/95	1/1	26000		9500
83	STROVOLOS - AGIOS DIMITRIOS	S 7605/1995		12/09/95	1/1	28000		8800
84	STROVOLOS - AP.VARNAVAS & AG.MAKARIOS	7667/1995		14/09/95	1/1	25000	37000	11800
85	STROVOLOS - AP.VARNAVAS & AG.MAKARIOS	7688/1995		14/09/95	1/1	17500	27000	9800
86	STROVOLOS - AGIOS DIMITRIOS	S 8070/1995		28/09/95	1/1	30000		10300
87	STROVOLOS - CHRYSELEOUSA	S 8118/1995		29/09/95	1/1	40000		19500
88	STROVOLOS - AGIOS DIMITRIOS	S 8164/1995		02/10/95	1/1	40000	45000	15900
89	STROVOLOS - CHRYSELEOUSA	S 8291/1995		06/10/95	1/1	38500		15000
90	STROVOLOS - AGIOS DIMITRIOS	S 8350/1995		09/10/95	1/1	31000		15000

Prices (£): the first price is the sale price, the second one is the estimated value by Land Officer for transfer fees' purposes, if it is different from the declared sale price. Both of these prices refer to the transferred share. The third one is the open market capital value at the first of January 1980 and it corresponds to the whole property.

APPENDIX IV Transcripts of the interview with Mr Antonakis Panayi of the Lands and Surveys Department

Transcripts of the interview with Mr Antonakis Panayi of the

Lands and Surveys Department

March 1997

(Mr Antonakis Panayi is the Valuation Officer in charge of the Lemesos (Limassol) District Land Office and deals with all kinds of valuations, including valuations for acquisitions, taxation, sales at auction etc. He is a technician member of the Royal Institution of Chartered Surveyors (RICS Tech) and has twenty five years experience in the property valuation in Cyprus.)

Q. Which is the most common used method of valuation ?

Ans. The most common and reliable method is the direct comparison method. This requires the existence of transactions in the area because the properties under valuation has to be compared with similar concluded properties.

Q. Which are the physical characteristics of a building site that may affect its market value?

Ans. These are the following: location, size, frontage, depth, shape, road site relation, road level, proximity to services, nuisances in the area, type of subsoil and depth of the water horizon.

Q. Which are the legal characteristics of a building site that may affect its market value?

Ans. These are the following: planning zone including permitted use, density factor, coverage factor, maximum number of permitted stories and sometimes other legal restrictions.

Q. Which are the fiscal and transactions characteristics of a building site that may affect its market value?

Ans. Sometimes the purchaser's motivation may affect value. Social standing of citizens in the area may affect property value too.

Q. Which are the physical characteristics of a house that may affect its market value?

Ans. These are the following: location, size, age, design, house type, view, orientation, number of bedrooms, existence of master room and office, number of parking places, type of parking place (covered, uncovered), number of WCs, existence of cooling and heating systems, type of floor material, windows, ceiling, existence of fire places, swimming pool, tennis court etc. If the house is not new we have to know its overall condition. Additionally it is useful to know when it was the last maintenance, the type and cost of maintenance. Furthermore, the type of walls and external coat of the wall as well as plumbing installations and sewerage connection may affect house value.

Q. Which are the legal characteristics of a house that may affect its market value?

Ans. The same characteristics that are valid for building sites are also valid for houses.

Q. Which are the fiscal and transactions characteristics of a house that may affect its market value?

Ans. The same characteristics that are valid for building sites are also valid for houses.

Q. Which are the physical characteristics of an apartment that may affect its market value?

Ans. The characteristics of a house are also valid in this case. Additionally the following may affect the market value: number of units and number of floors in the building, the floor, the building use (residential or mixed use), existence of lift, condition of mechanical and electrical installations as well as the overall condition of the building.

Q. Which are the legal characteristics of an apartment that may affect its market value?

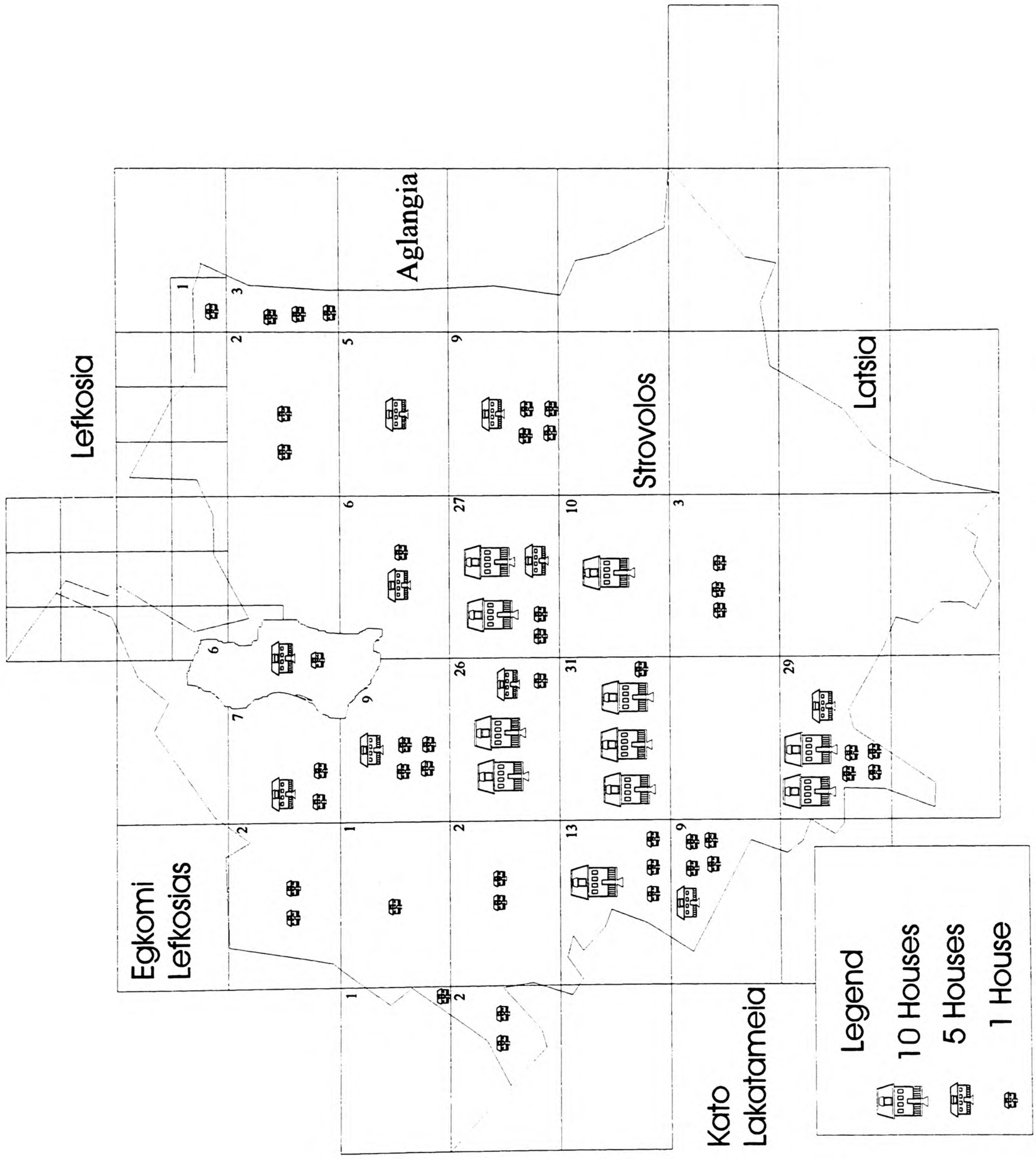
Ans. The same characteristics that are valid for building sites and houses are also valid for apartments.

Q. Which are the fiscal and transactions characteristics of an apartment that may affect its market value?

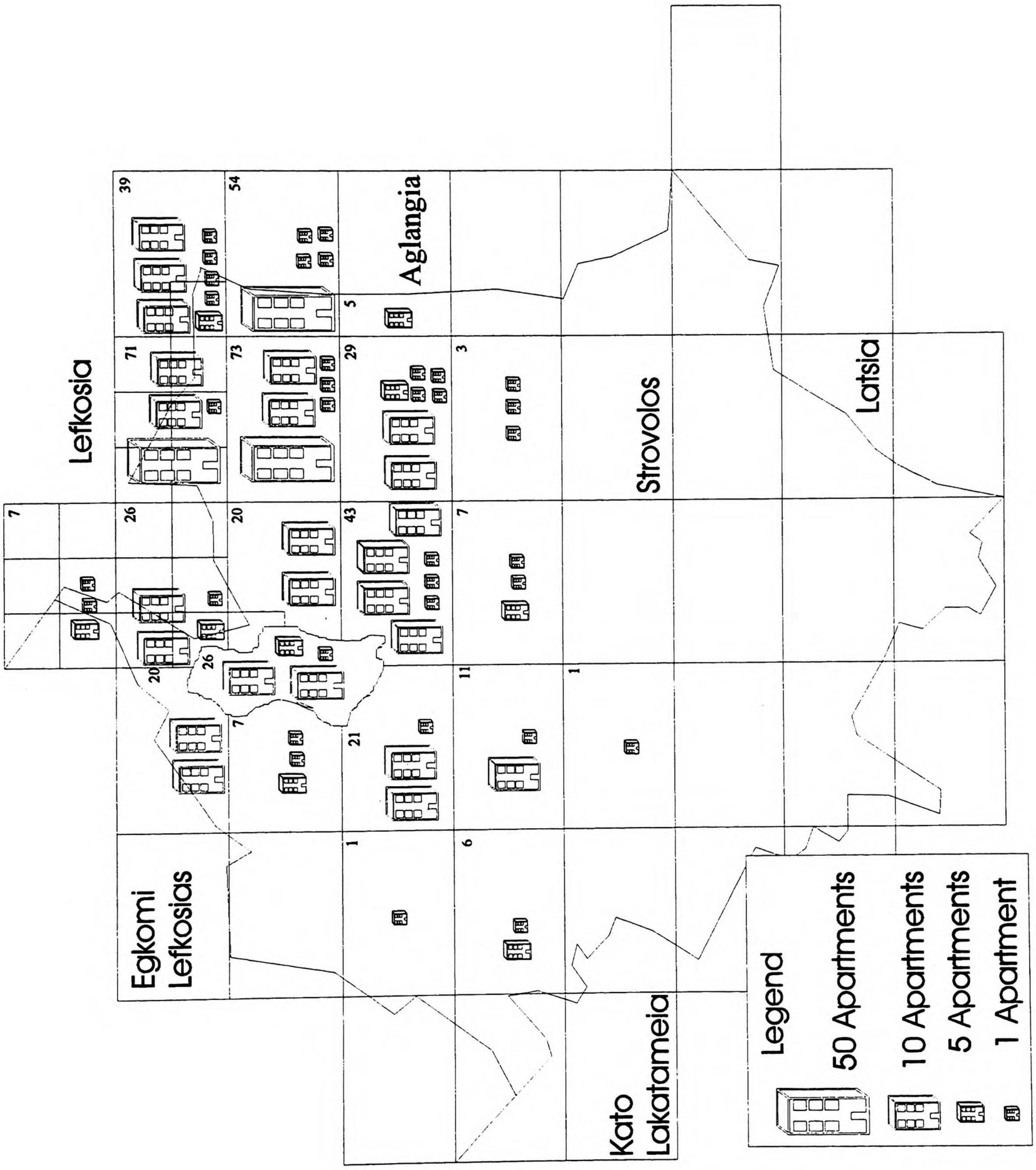
Ans. The same characteristics that are valid for building sites and houses are also valid for apartments.

APPENDIX V Plans of Strovolos Municipality

Plan A: Strovolos Municipality with 204 houses



Plan B: Strovolos Municipality with 470 apartments



APPENDIX VI Variables for houses and apartmeuts derived from interview with Mr Antonakis Panayi of the Lands and Surveys Department.

Ser. No	Variable derived from interviews	Selected Variable (see Table 4.1)
1	Acceptance value Law 81/70 (£)	
2	Age	*1
3	Amenities / Extra	
4	Block	*2
5	Building block	
6	Building condition	*3
7	Building height	
8	Building type	*4
9	Ceiling type	
10	Cooling system	
11	Coverage factor of the planning zone	*5
12	Date of (contract of) sale	*6
13	Density factor of the planning zone	*7
14	Depth (m)	*8
15	Depth of water horizon (m)	
16	Design	
17	Electrical Installations	
18	Existence of Master Bedroom	*9
19	External coat of wall	
20	External walls type	
21	Extra room (office)	*10
22	Fireplace	
23	Floor material type	
24	Floor number	*11
25	Frame type	
26	Frontage (m)	*12
27	Geographical code (area)	*13
28	Heating type	
29	House type	*14
30	House/Apartment size	*15
31	Lift	
32	Lift Provision	
33	Maintenance & Repairs	
34	Market value 1980 (£)	
35	Maximum number of permitted stories	*16
36	Maximum permitted height of building	*17
37	Mechanical installations	
38	Nuisances in the area	
39	Number of apartments in the building	*18
40	Number of bedrooms	
41	Number of floors in the building	*19
42	Number of parking places	
43	Number of WCs	*20

44	Orientation of the house (main entrance)	*21
45	Parking type	*22
46	Permitted use of building	*23
47	Plot	*24
48	Plot shape	*25
49	Plot size	*26
50	Plumbing installations	
51	Preserved building	
52	Proximity to facilities (km)	
53	Purchaser's motivation	
54	Relation of building site to road	*27
55	Renovation / date	
56	Road-building site level	
57	Roof type	
58	Sale Price/m^2	*28
59	Sewerage	
60	Sheet/Plan code	*29
61	Size of out buildings	
62	Social standing of citizens	
63	Street name (code)	*30
64	Subsoil	
65	View	
66	Walls (internal) type	
67	Window type	

APPENDIX VII Data collection forms and a code list

PARCEL AND LOCATION

Geogr. code Block Registr.No Municipality

House ☐ Apartment ☐ House type

Sheet/Plan Plot

Street name Number

Planning Zone Stories Cov

Dens Use Height

Road-Site relation. Plot size (m^2)

Depth (m) Frontage (m)

Road level Plot shape

Subsoil Social standing of Citizens

Purchaser's motivation Nuisances in the area Y ☐ N ☐

Depth of water horizon(m)

	Service	Proximity to facilities (km)
1	Church	
2	School	
3	Bank	
4	Post office	
5	Gov. Offices	
6	Shops	
7	Bus station	

Ser	Date of (contract) of sale	Sale Price	Acceptance value Law 81/70	Market value 1980

BUILDING

Geogr. Area Block Registr.No Build. Block Municipality

Number of apartments in the building

Number of floors

Building height

Roof type

Frame type

External walls type

External coat of wall

Preserved building Yes No ☐ ☐

Lift Yes No ☐ ☐

Lift provision Yes No ☐ ☐

Electrical installation

Plumbing installations

Mechanical installations

Sewerage

Building condition

Building type

UNIT

Geogr. Area | Block | Registr.No | Build. Block | Unit no

Cooling System Yes ☐ No ☐

Heating type

Floor No

Floor material type 1 2 3 4

Window type

Ceiling type

Walls (Internal) type

Age

Orientat.

View

Design

Renovation/ Date

Amenities/ Extra 1 2 3 4

Maintenance & Repairs

Fire Place Yes ☐ No ☐

Parking Place type

Number of Parking Places

Type of Room	Num. of Rooms	Type of Space	Size (m²)
Bedrooms		Enclosed	
Master Bedroom		Covered Verandah	
Toilets (WC)		Uncovered Verandah	
Office		Basement	
		Semi-Basement	
		Out Buildings	

CODE LIST

Parcel

House (property) type

1. Bulding-site
2. Single house (1 levels)
3. Single house (2 levels)
4. Single house (3 levels)
5. Semi-detached house (1 levels)
6. Semi-detached house (2 lev)
7. Upper-floor house
8. Back-yard/
   ancillary buildings
9. Multistorey-residential
10. Multistorey-mixed
11. Housing complex (single house)
12. Housing complex (semi-detached)
13. Semi-detached house (3 lev)

Social standing of citizens

1. Low
2. Medium-low
3. Medium-high
4. High

Plot shape

0. Irregular
1. Regular (21mx24m)

Road level

1. Below in a gully
2. Below
3. Over
4. Level

Road-site relation

0. Right of way
1. One side
2. Corner
3. Frontage from three sites
4. Frontage from four sites
5. Return frontage

Purchaser's motivation

1. To reside
2. To reside in a specific area
3. To reside in the longterm (for children)
4. To reside and use it for handicraft
5. To invest

Subsoil

1. Rocky
2. Gravel
3. Sand
4. Muddy
5. Clay
6. Caves

Building

Frame type

1. Stone
2. Brick
3. Mudbrick
4. Reinforced concrete
5. Timber
6. Mixed

External walls type

1. Brick
2. Concrete blocks
3. Cavity walls with insulation in the middle
4. Cavity walls
5. Prestressed concrete
6. Stone
7. Mud
8. Stone and mud
9. Timber
10. Claddings

Roof type

1. Local tiles
2. Slates
3. French tiles
4. Metallic tiles
5. Asbestos cement
6. Galvanised steel
7. Aluminium
8. Zinc
9. Asphalt
10. Built-up bitumen felt
11. Pitched traditional
12. Pitched terrace
13. Flat reinforced concrete
14. Flat concrete
15. Terrace and timber

External coat of wall

1. Sagre
2. Sprits
3. Rock covering
4. Fair face
5. Plaster
6. Graffiato
7. Marble

Electrical installations

1. High standard in good condition
2. High standard in bad condition
3. Standard in good condition
4. Standard in bad condition
5. Poor in good condition
6. Poor in bad condition

Plumbing installations

1. Plastic
2. Metallic
3. Copper

Mechanical install.

1. Very good
2. Good
3. Bad

Sewerage

1. Connected
2. Provision of connection
3. No connection in the short term

Building condition

1. Very good
2. Good
3. Bad

Unit

View

1. Restricted
2. Standard
3. Public square
4. Street walk
5. Open space/landscape
6. Sea

Heating type

0. None
1. Provision for storage Heating
2. Provision for central
3. Central
4. Central (air)
5. Storage heating

Window type

1. Timber
2. Aluminum (single glazed)
3. Aluminum (double glazed)
4. Metallic
5. Pvc
6. Mixed

Floor material type

1. Concrete
2. Hard wood
3. Carpet fitted
4. Traditional local marbles
5. Mosac tiles
6. Ceramics
7. Parque
8. Monocotoura
9. Marble local manuf.
10. Marble imported
11. Terazzo
12. Granite

Walls (internal) type

1. Three coat plaster work painted
2. Plaster, spatula and painted work

Design

1. Bad
2. Good
3. Very good

Maintenance & repairs

1. Very good
2. Good
3. Bad

Ceiling type

1. Concrete, spatula three coat plaster Work
2. False- hard wood
3. False- gypsum coated soft wood

Renovation

0. None
1. Fully
2. Substantial
3. Partially

Entrance orientation

1. North
2. South
3. West
4. East
5. North-west
6. North-east
7. South-west
8. South-east

Amenities/extra

0. None
1. Swimming pool-indoor
2. Swimming pool-outd.
3. Patio
4. Porch
5. Garden
6. Fields
7. Yard
8. Common yard

Parking place type

0. None
1. Attached
2. Detached
3. Built in
4. Uncovered
5. Covered
6. Basement
7. Semi-basement

APPENDIX VIII Number (%) of Houses and Apartments with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	46	52	50	54	48	56	60	46	56	38
10-20	34	36	38	30	40	34	30	40	28	42
20-30	12	4	8	14	10	6	10	10	12	16
30-40	8	8	4	2	2	2	0	4	2	2
40-50	0	0	0	0	0	2	0	0	2	0
>50	0	0	0	0	0	0	0	0	0	2

Table Appendix VIII.1 Back-Propagation: Number (%) of Houses with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	46	52	48	62	52	42	62	56	56	50
10-20	30	22	30	18	30	22	18	28	34	24
20-30	8	18	10	10	14	22	14	14	8	16
30-40	12	6	2	8	2	12	4	2	0	6
40-50	0	0	0	0	0	2	0	0	0	0
>50	4	2	10	2	2	0	2	0	2	4

Table Appendix VIII.2 Probabilistic Network: Number (%) of Houses with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	36	46	58	52	58	48	48	46	66	48
10-20	42	26	26	32	32	36	38	40	30	30
20-30	10	24	6	10	6	10	8	6	2	12
30-40	4	4	0	4	4	0	0	4	0	4
40-50	4	0	2	2	0	2	2	4	0	0
>50	4	0	8	0	0	4	4	0	2	6

Table Appendix VIII.3 Self-Organising Feature Map: Number (%) of Houses with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	50	64	66	58	60	54	62	64	72	50
10-20	34	22	18	30	30	28	30	20	24	26
20-30	4	10	6	8	8	10	4	12	2	16
30-40	8	4	4	4	2	6	4	4	2	4
40-50	2	0	2	0	0	2	0	0	0	2
>50	2	0	4	0	0	0	0	0	0	2

Table Appendix VIII.4 Subsystem 1 (Combined Results): Number (%) of Houses with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	46	52	60	54	48	56	60	46	56	38
10-20	34	36	26	30	40	34	30	40	28	42
20-30	12	4	10	14	10	6	10	10	12	16
30-40	8	8	4	2	2	2	0	4	2	2
40-50	0	0	0	0	0	2	0	0	0	0
>50	0	0	0	0	0	0	0	0	2	2

Table Appendix VIII.5 Subsystem 2 (Multiple Regression Analysis): Number (%) of Houses with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	50	56	60	58	50	60	64	60	64	44
10-20	28	30	26	32	40	26	32	24	30	34
20-30	12	10	10	8	10	8	4	12	4	14
30-40	8	4	0	2	0	4	0	4	0	6
40-50	2	0	4	0	0	2	0	0	2	0
>50	0	0	0	0	0	0	0	0	0	2

Table Appendix VIII.6 MANN (ANNs and MRA): Number (%) of Houses with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	68	68	65	72	55	57	64	60	66	63
10-20	28	23	28	22	38	31	24	30	22	29
20-30	5	10	8	7	8	13	12	9	11	7
30-40	0	0	0	0	0	0	0	0	1	0
40-50	0	0	0	0	0	0	0	0	0	0
>50	0	0	0	0	0	0	0	1	1	1

Table Appendix VIII.7 Back-Propagation: Number (%) of Apartments with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	48	44	58	48	50	51	44	58	53	40
10-20	34	33	24	32	32	37	35	31	28	39
20-30	13	13	13	14	15	9	17	11	17	18
30-40	5	8	3	4	3	3	4	1	2	3
40-50	0	1	1	1	1	1	0	0	0	0
>50	0	1	1	1	0	0	0	0	0	0

Table Appendix VIII.8 Probabilistic Network: Number (%) of Apartments with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	54	51	49	53	49	43	50	52	43	52
10-20	29	32	32	30	34	34	25	28	38	31
20-30	14	12	12	12	11	15	18	16	13	14
30-40	2	3	4	5	6	7	6	5	4	3
40-50	1	1	3	0	0	1	0	0	3	1
>50	0	2	1	1	0	0	1	0	0	0

Table Appendix VIII.9 Self-Organising Feature Map: Number (%) of Apartments with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	58	61	64	63	58	52	56	60	58	58
10-20	35	28	24	26	33	33	28	31	34	33
20-30	7	10	9	10	8	14	16	9	8	9
30-40	0	1	2	1	1	1	0	0	0	0
40-50	0	0	1	0	0	0	0	0	0	0
>50	0	1	0	1	0	0	0	0	0	0

Table Appendix VIII.10 Subsystem 1 (Combined Results): Number (%) of Apartments with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	68	68	65	72	55	57	64	60	66	63
10-20	28	22	28	22	38	31	24	30	22	29
20-30	5	10	8	7	8	13	12	9	11	7
30-40	0	0	0	0	0	0	0	0	1	0
40-50	0	0	0	0	0	0	0	0	0	0
>50	0	0	0	0	0	0	0	1	1	1

Table Appendix VIII.11 Subsystem 2 (Multiple Regression Analysis): Number (%) of Apartments with predicted values within an error band.

Error Band (%)	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10
≤10	67	67	72	68	65	58	66	64	67	64
10-20	32	25	23	21	32	33	26	31	27	31
20-30	2	7	5	10	3	8	8	5	7	5
30-40	0	1	0	0	0	1	0	0	0	0
40-50	0	0	1	0	0	0	0	0	0	0
>50	0	1	0	1	0	0	0	0	0	0

Table Appendix VIII.12 MANN (ANNs and MRA): Number (%) of Apartments with predicted values within an error band.

APPENDIX IX Published Articles and Papers

Immovable property taxation and rating in Cyprus: facts and problems

Panayiotis Andrea Panayiotou,
Land Officer, Cyprus.

Frances Plimmer,
The University of Glamorgan, UK.

Antonakis Panayi,
Land Valuation Officer, Cyprus.

David Jenkins,
The University of Glamorgan, UK.

Abstract

This paper describes the taxation and rating of land in Cyprus (or Kypros) and makes recommendations to remedy some of the problems identified. The paper is based on a two-year study which analysed the Cypriot general valuation, taxation and ratings laws as well as analysing the valuation problems in order to make recommendations to the Central Government in Cyprus and the local authorities so that they could improve the quality, efficiency and equity of their taxation and rating systems.

Introduction

The Republic of Cyprus is the third largest island in the Mediterranean with an area of 3,572 square miles (9,251 square kilometres) and with a population of approximately 700,000 refer map (see Appendix A). Its open-based economy is relatively poor in natural resources and is thus highly dependent on the import and export of goods and services. The

Cypriot Employers and Industrialists Federation (1996) explain that since its independence in 1960, Cyprus's development has been internationally acknowledged as a success story in both the economic and social fields. Despite the acute political problems which emerged in 1974 when Turkey invaded the island, occupying about 38 per cent of its territory, the economy quickly recovered as a result of the concerted efforts of both the public and the private sector.

Kotsonis (1990) commented that evidence uncovered in the fifth century BC excavated at Dali village reveals that the King of Idalion and the town itself rewarded a physician who had cured those wounded during a siege with the grant of royal lands, to the value of one silver talent in full ownership. Kotsonis (1990) explained that this indicates that there were then not only royal lands but also private ownership, describing the properties donated as neighbouring the lands of certain named individuals. The inscription indicates also the existence of land taxation and rights of inheritance even in those days.

Kotsonis (1990) explained that after the establishment of the Republic in 1960, agriculture continued to be the backbone of the economy of the island. However, with the post-independence days came the boom of an expanding tourist industry, coupled with unprecedented residential, commercial and industrial expansion. All this exerted a tremendous pressure on the limited available land resources and the competition of uses became more acute.

Taxation of landed property has always been a significant financial resource for the socio-economic development of the island because such resources have been extensively used for local authority services, education, sewerage, construction of roads and generally for the improvement of areas. According to the Immovable Property (Tenure, Registration and Valuation) Law, Capital 224, 1946, Cyprus's Lands and Surveys Department is entrusted to produce valuations of all taxable landed property for taxation purposes. This is called a General Valuation and occurs whenever required by the Council of Ministers, so far this has occurred only in 1909 and 1980. The bases of tax assessments used in Cyprus today have been the "market" value and the "assessed" value. "Market" value was used to produce the capital value as at the first of January 1980 of immovable property based on sales evidence of open market transactions and this is the last general valuation. "Assessed" value is the 1909 value based on the experience of Lands and Surveys Department's employees who at the time had no sale record on which to base open market valuations. It can be argued that "assessed" value was only an approximation of the 1909 open market value because it was performed by non qualified valuers based on their profession experience alone and that the evidence of open market sales at that time were very limited. Both values are used as a base for various taxes on landed properties.

Properties belonging to the State, the municipalities and the communities (i.e. villages) are exempt. Additionally churches, places of worship, non-profit-making organisations and properties owned by foreign states for diplomatic purposes are also exempt. It should also be noted that in Cyprus, central government taxes and local authorities rates are mainly payable by those owners whose property is located within municipal, town and improvement board areas. Thus, properties in rural areas are not affected directly by taxation laws. Estate Duty and Capital Gain taxes affect rural areas as well as Immovable Property Tax of the 1980, provided that the owner is not a farmer and total value of an owner's property exceeds £100,000. There are three main reasons for this:

- to motivate people to develop agriculture and farming without the burden of taxes on the landed properties;
- to discourage people from leaving rural areas and moving to towns, by reducing the cost of living in the rural areas;
- the reduction of administrative costs. Generally, land values in rural areas are much lower than values in municipalities and towns, so an economic tax system in rural areas would have relatively high rates of tax, unless some form of complex equalisation of funds was introduced by the State.

General valuation laws

According to the Immovable Property (Tenure, Registration and Valuation) Law, Capital 224, Section 69, the Lands and Surveys Department in Cyprus is required to produce a valuation of landed property for taxation purposes, called a General Valuation, whenever and wherever required by the Council of Ministers for the purposes of securing the up-to-date and uniform valuation of immovable property in any municipal, village or quarter.

According to Section 67, any immovable property can be revalued at the instance of the Director or on the application of the registered owner at any time after five years from the date of the last valuation, provided that a property has been materially changed, causing a substantial increase or decrease in value or if a general valuation has been ordered.

General valuation criteria

According to legal advice given by the General Attorney of the Republic of Cyprus (35/69, dated 20 September 1969), the following legal principles must be applied in a general valuation:

- equal treatment of the taxpayers by the State and the fixing of the tax-paying ability on the basis of objective criteria;
- for general purposes, a revaluation must cover the whole State;
- for specific purposes, the valuation must cover the whole area which is specifically affected; and
- a valuation for specific purposes cannot be used for general purposes.

Under the first principle, the General Attorney requires not only equal treatment of taxpayers but also requires that the tax levied be an amount reasonably payable. Under the third principle, when the Council of Ministers in Cyprus decides to levy a new tax in order to develop a project in a specific area and for specific purpose e.g. construction and maintenance of a sewerage system in Lefkosia, the municipality requires a revaluation, known as a "general valuation for specific purposes". The last principle means that if a revaluation is made for a specific area for a specific purpose e.g. the sewerage system in Lefkosia, it can not be used to levy the Town Rate which is a general purpose. If it is applied in this way, then it will be in conflict with the first criteria of equal treatment of the taxpayers because each valuation is carried out using different criteria e.g. date of valuation. Furthermore according to the Immovable Property Law, Cap.224, 2 of 8/53: "'value' in connection with immovable property, means the amount which the immovable property, if sold in the open market by a willing seller to a willing purchaser, might be expected to realize".

General valuation - historical review

The first General Valuation began in 1909 under the Law 12/907 by which a cadastral survey, registration and valuation to cover the whole island was authorised. The General Valuation was completed some 20 years after it started and the values adopted (1909), known as assessed values were based on the experience of Lands and Surveys Department's employees after visiting the areas e.g. villages, and not always after an inspection of individual properties. The valuers were unable to use sale records because none existed. Nowadays, this assessment is a desk-based exercise and it can be argued that these assessed values are suspect because of the extremely low values of properties in 1909 compare with today's values and the fact that it is not worth applying appropriate valuation methods for such little return. That General Valuation was used for property taxation as soon as it was completed and at present the 1909 assessment is used as the basis for the Towns Tax (previously the Education Tax) and Improvement Rate, since the application of the 1980 General Valuation is a tax base matter depending solely on central Government policy.

The second General Valuation was carried out for a specific purpose and only covered the Sewerage Areas of Lefkosia and Ammochostos at 1971 values in order to levy tax for the establishment of a sewerage system. This is a general valuation for specific purposes and could not be used as a tax base for other taxation purposes. This tax was in fact levied only in Lefkosia because in 1974 Ammochostos was invaded by Turkish troops.

The third General Valuation was carried out for the whole of Cyprus (except the occupied area) at 1980 values and is known as the market (capital) values as of the first of January 1980. It was completed in 1991 and its purpose was to create a record of uniform values all over the country for all purposes e.g. central government taxation, municipalities rating. It is already in use for the Immovable Property Tax, Town Rate (previously the Municipal Tax), Sewerage Charges and Capital Gains Tax but not for the Towns Tax (previously the Education Tax) and Improvement Rate.

General valuation base

The basis of General Valuations in Cyprus has been the capital value since the second General Valuation in 1971 in Lefkosia and Ammochostos and was also used in the third General Valuation in 1980 for the whole of Cyprus (except from the occupied area). Capital value was also used after the establishment of the Immovable Property (Tenure, Registration and Valuation) Law in 1946 for other purposes e.g. compensation on compulsory acquisition. A capital value basis satisfies general valuation criteria and it has fewer practical problems in Cyprus than annual value because of the Rent Control Law (23/83 and the amendment laws) which limits free market rentals and which would be the market evidence for valuing residential and retail properties.

Landed properties are sold in an open market sale by a willing seller to a willing purchaser, and there is a useful volume of open market sales for evidence of comparable transactions. In Cyprus, sale evidence exists, but there is not a large volume of sales, however, it can be argued that these provide strong and sufficient evidence for a capital value tax base with the condition that sales are reliable, genuine and not understated. The capital value basis or Direct Value Comparison is an approach based on the full open market capital value of immovable property in its existing condition, with all developments, improvements, and potentialities (considering the best use of property).

Capital value assessment

The Direct Value Comparison (DVC) method was adopted by Lands and Surveys Department at the last two General Valuations because:

- of the availability of appropriate sales records of immovable properties;
- sales of immovable properties in the open market are the same as "capital value", with the provision that these be reliable and genuine and not understated. Furthermore, if a property sale is much higher than similar property sales in the same area, these may not be included as sale evidence in a general valuation because the sale price may include other assets, e.g. goodwill.
- it is the simplest and most direct method of valuation (Britton et al, 1989).

Britton et al (1989) explained that this method is based on comparing the property to be valued with similar properties and the prices achieved for them and allowing for differences between them, thereby determining the price likely to be achieved for the property in question. However each property is unique and valuers' judgement is essential to analyse transactions in order to reflect the inevitable differences which may affect price and value. The reasons for such differences are mainly:

(i) location;
(ii) physical state of the property;

(iii) tenure and other property legal characteristics;
(iv) market and economic conditions which vary over time.

The Lands and Surveys Department has developed both manual and computerised systems for keeping sales records. The manual system will be abandoned as soon as the Cyprus Land Information System is developed and an integration between the legal and fiscal data of properties and plans is provided for the whole of Cyprus. This will enable valuers to read sale information simultaneously with plan information. The present manual system offers only limited access to this facility. As soon as a contract of sale is deposited or a sale is accepted, Land Clerks write a file number, date and price on the back of a specific set of plans used by valuation section. So, whenever a valuer works on a specific area, sale information is available on the back of the plan. Property sales information (excluding the specific set of plans) are sold to the private sector, to valuers and to real estate agents in hardcopy and in digital form.

Procedure of valuation

According to the Section 70 of the Immovable Property Law, Capital 224, when a general valuation has been ordered under section 69, the following provisions take effect:

(i) the Director of the Lands and Surveys Department publishes a general valuation notice to inform the public that a general valuation will take place;

(ii) when the valuation is completed, the Director prepares a valuation list which is deposited by the Director and the Chairman of the town, village or quarter and also is published in the official Gazette of the Republic. A valuation list is used to inform people about property values.

(iii) Within 60 days from the date of the notice, any person whose property is affected may object in writing to the Director. Nicolaides (1983b) explained that an owner must deposit a fee equal to 1% on the difference between his own valuation and the valuation appearing in the list. The purpose of this limitation is to discourage owners from supplying the Director with inadequate or false information. The Director examines any objections submitted to him with the required fee and notifies the person objecting of his decision. If the owner is not satisfied with the Director's decision, he has the right to appeal to the Court.

Procedure of revaluation

According to the Section 71 of the Immovable Property Law, Capital 224, a revaluation of any individual property can be made at the instance of the Director. The Director may give notice of the proposed valuation or revaluation to the person or persons affected, calling on the owner to supply the valuer with information about the immovable property and if it is necessary to give the valuer the opportunity to inspect the property. When a valuation or a revaluation has been made, the Director gives notice of the value to the owner of the affected property. The owner may object in writing to the Director within thirty days from the date from receipt of such notice. The Director may consider any objection made to him and notify the person objecting of his decision. If finally, the owner is not satisfied with the Director's decision, there is a right to appeal to the Court.

Taxation of immovable property in Cyprus

Ioannou (1990) and Markides (1991) explained that the property tax system in Cyprus dates back to the Ottoman Empire. The Turks were the first to introduce a system of property tax during the period 1850-1878 and this system has been altered through the years to accommodate the subsequent administrators and social changes. The taxes and rates levied by the Government of Cyprus on immovable property are: Immovable Property Tax of the 1980, Town Rate, Improvement Rate, Towns Tax, Estate Duty Taxation, Capital Gain Tax, Betterment Charge and Sewerage Charges.

1. ***The Immovable Property Tax of the 1980 (Law 24/1980 amended by the Laws 60/80, 68/80, 25/81 and 10/84).***

This is levied by the State on the open market capital value as at the first of January 1980, on all of the owners' property. Owner may be either a legal body or private individual who is registered in the Lands and Surveys Department records or is entitled to be registered according to sections 9 and 10 of the Immovable Property Law, Capital 224. According to section 9, no title to immovable property shall be acquired by any person by adverse possession against the Republic or a registered owner. According to section 10, subject to the provisions of section 9, if a person can provide proof of undisputed and uninterrupted adverse possession for a period of thirty years, that person shall be entitled to be registered as the owner. Properties belonging to the State, the municipalities and the communities (i.e. villages) are exempt as are churches, worship places, non-profit making organisations institutions, properties owned by farmers in rural areas and properties owned by foreign states for diplomatic purposes. Markides (1991) explained that the current law replaced the old laws 30/77, 38/78 and 93/79 under which the tax was levied on 1909 (assessed) values of properties. The tax is payable to the State on 30th of September of each year. The rates are as follows:

Total value of an owner's properties in Cyprus	Rate on 1980 Market Value
up to £100,000	0.2% for legal bodies and 0% for individuals
from £100,001 to 250,000	0.2%
from £250,001 to 500,000	0.3%
from £500,001	0.35%

Delays on tax payment are fined with 9% interest on the payment amount.

2. The Town Rate (Capital 240 and Laws 64/1964, 15/1966)

This is paid to the municipalities on all immovable property of legal bodies or individuals, according to the Municipality Law 111/85 (and amendment laws), within the administrative limits of any municipal corporation. Properties belonging to the State and the municipalities are exempt as are churches, worship places, charitable institutions and properties owned by foreign states for diplomatic purposes. The 1995 rate was 0.05% on the market value of such property as at the first of January 1980, as is registered or recorded in the books of District Lands Office (see administration). The tax is payable to the Municipality on the 30 June. A fine of 5% is levied on payments made after the 30 of September.

3. The Improvement Rate (Law Capital 243 and the amendment Laws 46/61, 58/62, 4/66, 31/69, 7/79, 49/79, 65/79, 7/80, 27/82, 42/83, 72/83, 38/84, 72/87 and 66/89).

This tax is levied on all immovable properties within the geographical limits of any improvement area. According to the Villages (Administration and Improvement) Law, Capital 243, an improvement area is any area declared by the Council of Ministers as an "improvement area", for improvement purposes (i.e. construction of roads, national parks).

Properties belonging to the State and the Improvement Boards are exempt as are churches, charitable institutions and properties owned by foreign states for diplomatic purposes. The tax rate, decided by the Improvement Board, is up to 1.5% on the 1909 assessed value of such property as registered or recorded in the books of the District Lands Offices. This tax is payable to the State by the owner on the 30 June each year and is given directly to the Improvement Boards by the State in order to support improvements and local services. A fine of 5% is levied on payments made after the 30 of September.

4. The Immovable Property (Towns) Tax (Laws 89/1962 and 73/1965)

This is levied on immovable property in towns or other areas defined by the Council of Ministers as "Towns", according to section 3. The tax rate is 1.5% on the 1909 assessed value of property as registered or recorded in the books of the District Lands Offices. Properties belonging to the State, municipalities, communities are exempt as are churches, charitable institutions and properties owned by foreign states for diplomatic purposes. It is payable on 30 June of each year. Payments after the 30 of September are fined by 5% on the amount payable. This tax is collected by the State and is given to the Ministry of Education. (It has replaced the Education Tax.)

5. The Estate Duty Taxation (Law 67/62 and the amendment Laws 71/68, 3/76, 13/85, 93/86, 138/86).

This is levied on immovable properties left by a deceased and is collected by the State. The properties are valued at their open market capital value as at the date of death. For deaths before the first of December 1942, Estate Duty is not levied. According to the amendment

Law 138/86, inheritances due on deaths after the 17 October 1986 incur the following level of relief:

£50,000	for husband or wife surviving;
£75,000	for every child under 21 years old at the date of death;
£75,000	for every disabled child surviving;
£50,000	for a 21 years old child;
£50,000	for all the children surviving.

Furthermore, there are rebates in cases where the heir is a non-profit making organisation or religious organisation. These cases are examined by the State individually. The rates of tax are as follows:

Evaluated Immovable Property	Rate
up to £20,000	0%
from £20,001 to £25,000	20%
from £25,001 to £35,000	25%
from £35,001 to £55,000	30%
from £55,001 to £80,000	35%
from £80,001 to £105,000	40%
from £105,001	45%

The above rates are valid from the first of July 1995 to the first of April 1997. Estate Duty taxation is likely to be abolished after the April 1997 because collection expenses exceed the revenue. One of the main reasons for this is that with the application of Law 138/86 which gives so many reliefs, the number of taxable cases are reduced significantly. Another reason is that the assessment and collection expenses are high because estate duty cases are managed by a separate office, the Estate Duty Office, with the collaboration of Lands and Surveys Department both of which currently use mainly manual systems.

6. The Capital Gains Tax (Law 52/1980 and 135/1990)

Capital Gains Tax applies to both individuals and companies. Owners are charged at 20% on gains arising from the disposal of immovable property and shares in a company which owns immovable property. Gains are based on the open market capital values as at the first of January 1980 (or actual cost if acquired later) adjusted for the increase in the Consumer Price Index (C.P.I.) up to the date of sale. Tax is paid to the State, and the main exemptions include:

- Immovable properties left by a deceased (which is liable to Estate Duty);
- Immovable properties given as a gift:
    - from parents to children
    - from husband to wife and vice versa
    - from relatives up to 2nd grade relatives (e.g. grandfather to grandchild).

7. Betterment Charge (Law 90/1972 Section 80)

The enforcement of the provisions of the Town and Country Planning Law 1972 may cause an increase in value of immovable property. Such an increase may result either from a change to a more profitable use, or a higher density, or it may come about after the carrying out of development by a public authority in an area. Nicolaides (1983a) commented that in the same way as it is "fair" to pay compensation to owners whose property rights are being materially adversely affected, it could be argued that it would also be fair to ask from those owners whose properties are being benefited by public activities to pay back at least some part of their gain. One way for the State to collect betterment is the levying of a Betterment Charge. Betterment Charge is levied on the increase in value which is attributable to the scheme. The Betterment is ascertained by the carrying out of two open market capital valuations, one at the date prior to the scheme and a second one at a date falling within the period starting two years after the date of the decision and finishing two years after the date of completion of the scheme. The difference between the two valuations after deducting any increase which is not attributable to the scheme, is the "Betterment" which is subject to the Charge. Betterment Charge has been fixed up to a maximum of 30% on the Betterment, and is payable to the State in 20 annual instalments.

8. Sewerage Charges (Law 1/1971)

The aim of this Law is the establishment, construction, control and the administration of sewerage systems, including the processing and the disposal of waste. The Sewerage Council, according to section 30 of the Law, has the right to levy tax and fees. The tax is levied on open market capital value as at the first of January 1980 and is payable on 30 of September each year.

Administration

Republic of Cyprus, for administration purposes is divided into six districts (Lefkosia (or Nicosia), Ammochostos (or Famagusta), Larnaka, Lemesos (or Limassol), Kerinia (or Kyrenia) and Pafos). The island's capital and seat of Government is Lefkosia. Each district is headed by the District Officer who is essentially the local representative of the Central Government. The District Officer acts as the Chief co-ordinator and liaison for the activities of all Ministries. The administrative power in Cyprus is a two tier system, but the structure is rather centralised, delegating limited power to the local authorities from central government. There are three types of local authorities: Municipalities, Improvement Board areas, and the Villages. Municipalities have more power and more population than the other local authorities. According to the 111/1985 law, one of the limits of an area to be a Municipality is its population which must not be less than 5,000.

The Lands and Surveys Department for administration purposes is divided into six District Offices and a Headquarters. Because Turkish troops occupy Kerinia and part of Ammochostos, their District Offices are situated in Lefkosia and in Larnaka respectively.

Property taxes levied by local authorities afford some financial independence from central government, thus reducing central government's burden of providing local services. The central government is a recipient of the revenues from the Immovable Property Tax of the 1980, Improvement Rate, Towns Tax, Estate Duty, Capital Gain and Betterment Charge. Municipalities are the recipients of the Town Rate. The Sewerage Charges are received by the local Sewerage Councils.

Harvey (1989a) explained that local property taxes are generally accepted by people living in a local authority area and that " an old tax is no tax". He also explained that in form local property taxes are simple, easily understood and appear to be equitable, in that those occupying the largest properties are benefiting most. Furthermore, local property taxes have administrative advantages in that once capital values have been determined, the rate is easily calculated and can be adjusted when additional revenue is required. In addition, the costs of collecting the tax are relatively economic. However, Harvey (1989a) explained that local property taxes are generally subject to considerable criticism, because these taxes are taxes on a particular good. There is a loss of income compared with direct taxes which raise the same amount of revenue by leaving people free to choose the value of their house or landed property. For example, agricultural land in Cyprus is not taxed compared to land in other uses. The main reasons are: firstly the State tries to encourage agriculture which is an important factor to the growing economy of Cyprus. To exempt agricultural land is effectively to give a cash incentive to farmers to continue agricultural operations, secondly it discourages people from leaving rural areas and thirdly it reduces administrative costs. An alternative would be to tax everyone and to give a range of State cash benefits to selected (or all rural) taxpayers which would be administratively expensive.

A property tax known as "malieh" had been used to tax agricultural land on assessed (1909) values, but it was abolished in 1961 because cost exceeded the revenue because of the low value of land compared with those in towns and because of the use of a manual system of administration. Harvey (1989a) explained that local property taxes tend to be regressive and inequitable. Not only do the "poor" people tend to spend a relatively high proportion of their income on housing, but the tax levied may be unrelated to the ability to pay. This can be alleviated if local authority adopt a rebate scheme for those on low incomes.

Local property taxes may accentuate relative differences in local authorities resources unless the State gets involved in equalising resources. A local authority with a low tax value may have to spend more on new infrastructure, roads, sewerage, education and other services than other authorities and thus is forced to levy a high tax rate in order to meet the needs of its area and thereby makes its inhabitants relatively poorer. The improved local services in municipalities should not increase the property values significantly because basic local services have already been developed. Also, some essential services e.g. hospitals and police stations are not needed for each municipality because of the small size of the local authority's area.

Today, these services may cover more than one local authority and are under the jurisdiction of central government. However, the improved local services in improvement areas and villages resulting from the construction of roads, schools and other services so that people can enjoy the countryside and other services will increase property values significantly, provided that people stop moving from rural areas and start moving from municipalities to countryside. It seems that municipalities are not planned in a sophisticated way e.g. the existence of national parks is very limited, car parks in some areas are confined and traffic jams at peak hours are common. It is worth noting that the Town and Country Planning law was enacted for first time only in 1972 and is one of the main laws dealing with environment.

Rates should vary between one municipality and another. International experience indicates that it may affect the performance of local economies e.g. employment generation. In Cyprus because tax rates are so similar, they have no appreciable effect on employment generation and location. Moreover, local authorities are supported financially by central government and there is no opportunity for extremely high taxation. Only in the improvements areas do the rates vary from 0.6% to 1.5% but the difference is still relatively small.

Principles of ideal tax system

Harvey (1989b) explained that governments may themselves provide goods and services. Economic reasons for this direct provision are often community goods, collective goods, public goods, merit goods and external costs and benefits. Taxation is one method to raise money to finance public goods and services. Governments can expand aggregate demand (the sum total of all planned expenditures in the economy) through its purchases of goods and services. Similarly, they can reduce aggregate demand by decreasing their own spending or by increasing taxation or both. Further, taxation can be used as a measure of reducing the rate of inflation as real income falls and the money supply in the market is restricted. Moreover, Maunder and others (1987a) explained that taxes may be regarded as a leakage from the flow of income of the economy because they reduce the level of disposable income and therefore the level of personal consumption.

In order to achieve an equitable and efficient tax system, it is necessary to analyse the parameters that affect each individual tax system. The system is also influenced by the policies of the State relative to its objectives. Beardshaw (1986) explained that Adam Smith laid down four criteria for a good tax system which should have the following characteristics:

- Equitable - a good tax should be based upon the ability to pay;
- Economical - a good tax should not be expensive to administer and the greatest possible proportion of it should accrue to the government as revenue;
- Convenient - this means that the method and frequency of the payment should be convenient to the taxpayer;
- Certain - the tax should be formulated so that the taxpayer is certain of how much has to be paid and when.

Maunder and others (1987b) explained that there are three types of taxation systems:

(i) In a proportional tax system, taxpayers at all income levels end up paying the same percentage of their income in taxes. Such taxes in Cyprus are the Town Rate and Capital Gain Tax.

(ii) A progressive tax system removes a larger percentage of peoples' incomes as income increases. Such a tax, it can be argued, is more equitable than a proportional tax because it produces a closer relationship to the ability to pay. Cyprus' Immovable property tax and Estate Duty are progressive taxes.

(iii) A regressive tax systems removes a greater proportion of income as the amount of income decreases. Taxes of this type can place a relatively greater burden on the lower income groups. VAT tax, it can be argued tends to be regressive in Cyprus. A low income family with many children pays more VAT tax than single adult living alone because it spends more for everyday living.

Eckert (1995) explained that the general guideline for choosing the criteria for the tax base is to choose the criteria which will maximise equity at affordable administration and compliance costs. He also considered that international experience indicates that an ad valorem (annual value or capital value or site value) property tax system which is based on real market transactions will improve taxpayer equity (ability to pay tax) and revenue buoyancy.

Problems

Cyprus' 1909 and 1980 capital General Valuations are used as the base for a number of taxes. The basis of assessment should be a single valuation base, since uniformity of property values is one of the general valuation purposes and it conforms to the legal principle of the General Attorney i.e. equal treatment of taxpayers. Furthermore, property taxes e.g. the Immovable Property tax, the Town rate, the Improvement rate and the Towns tax should be a single tax paid to a single authority because it would be easier for owners to pay one tax to one authority instead of paying many taxes to many authorities. Additionally, Central Government's and local authorities's administration expenses would be reduced significantly.

If capital values of a general valuation are kept updated at regular intervals, every two or three years or whenever after an assessment ratio study (IAAO 1978) indicates that reassessment is needed, the assessment of tax will be based on what actually exists on the land, including buildings at the date of taxation. It can be argued that this is an equitable system since the capital value reflects all the valuable characteristics of the property. It increases the social equity of the tax because it reflects to up-to-date values and up-to-date relativities of "wealth" (assuming "wealth" equates to tax paying income). Examples of an out-of-date assessment tax system are the Town Tax and the Improvement Rate, because 1909 assessed values are used as the basis of taxation even though these values have no relationship to the actual values of the properties being taxed.

If an owner's properties are located in Strovolos Municipality only, in the part of the area affected by Towns Tax, they are:

	evaluated at 1980 Capital Values	evaluated at 1909 General Valuation
a building site	£15,000	£50
a house	£30,000	£250
an apartment	£20,000	£200
Total	£65,000	£500

Every year the owner pays the following taxes:

- Immovable Property tax of 1980. Since the total value of the owner's property is less than £100,000 and if the owner is not a legal body then the individual is exempted from paying this tax.

- Town rate. The rate is 0.05% on the total value of the property in the Municipality; so at 1980 values, the owner will pay £32.50 (£65,000 multiplied by 0.05%).

- Towns tax. The rate is 1.5% on the total value of the property in the Municipality; so at 1909 values, the owner will pays £7.50 (£500 multiplied by 1.5%).

The Town rate is £32.50 because the basis of assessment is 1980 values. An up-to-date valuation base should ensure that taxpayers pay according to an update liability in proportion with their current relative liabilities i.e. if someone's property is worth £30,000, he should pay half the tax of his neighbour, whose property is worth £60,000, even if properties were worth £15,000 in 1980.

In order to have an estimate of the effect of an updated revaluation on tax liability, an analysis of 90 apartment sales was carried out. The sales took place in the Strovolos Municipality from January 1995 to October 1995 and at the analysis stage, the sale (declared) price was compared with the 1980 values. This sample does not include all the sales of apartments in Strovolos municipality but includes only the sales for which 1980 values were stored in computer records. The 1980's values are not stored immediately for every record because of the difficulties in finding them from the manual records. The mean percentage increase is calculated as follows:

$$\sum_{i=1}^{90} (\text{SALEPRICEi} - \text{1980CAP.VALi}) \times 100 \div \text{1980CAP.VALi} \qquad (1)$$

the "SALEPRICE" is the actual sale price, "1980CAP.VAL" is the 1980 capital value. The result of equation (1), is divided by the number of samples, that is 90.

The mean percentage increase is estimated at 134.14%, so it can be argued that the above owner's apartment may roughly be valued for £46,800 at 1995 values and an estimate can be made of the owner's tax liability assuming a similar level of revenue is to be raised. Sale price is also called "declared price" because it is the price declared by the vendor and purchaser in the Lands and Surveys Department for transfer fees purposes. Sometimes the price declared is understated illegally in an effort for the purchaser to pay to the Lands and Surveys Department lower transfer fees and the vendor to pay less Capital Gains Tax.

The ratio of the sum of 1980 open market capital value and the sum of the sale price (referred to the whole share) is 0.44. This is an indication that 1980 values do not represent today's values.

Furthermore, Figure 1 give us a descriptive summary of the ratio of 1980 capital value and sale price over the month of sale. It can be observed that the points are away from the unit, that is, there is great difference between 1980 capital values and sale prices. Most of the ratio values are found to be between 0.4 and 0.5, that is most of the 1995 sale prices of this set of apartments in Strovolos are more than the double of 1980 capital value.

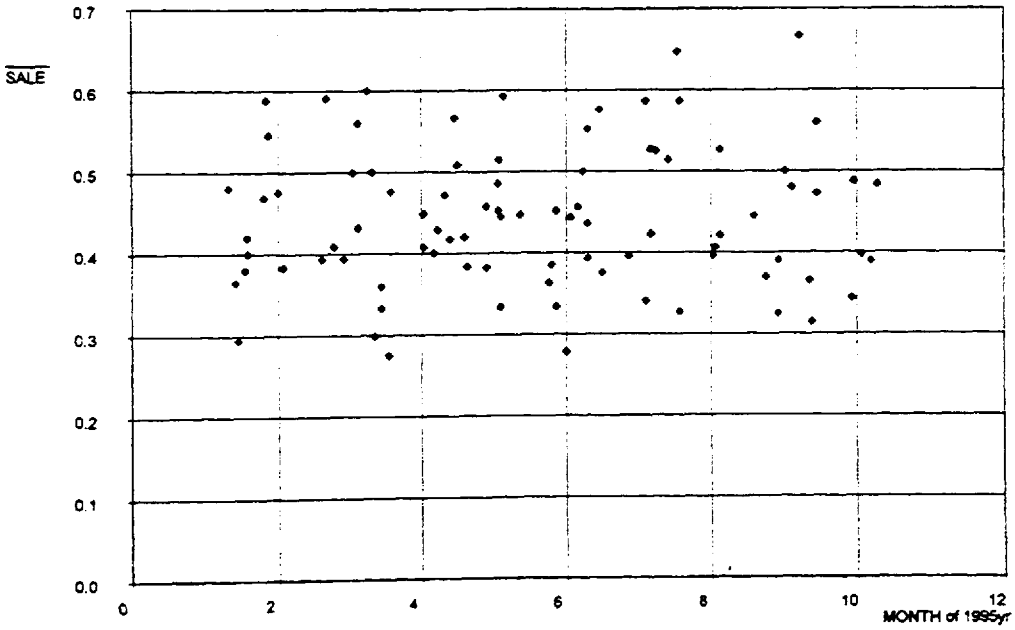


Figure 1

It is also worth noting that land records are not up-dated immediately with landed property changes because manual systems are used at present for the interchange of information between Lands and Surveys Department and local authorities. The Lands and Surveys Department is informed once a year of changes. Additionally, there are deceased owners, whose beneficiaries have not yet registered their claims to the land, especially in certain rural areas where values are low compared with municipalities and taxes are paid by those beneficiaries in order to be registered as owners.

Conclusions

It can be argued that immovable property taxation system in Cyprus is:

- inequitable; because the assessment of taxes are based on old values and the capital value does not reflect all the valuable characteristics at current values;
- inconvenient; because tax payers pay various taxes to various authorities at different dates, especially when owner's properties are located all over Cyprus.
- unfair; because tax systems of the Town Rate, the Improvement Rate and the Towns Tax are proportional and because of this fact people with high valued immovable properties pay at the same rate as every other owner;
- unjust; regarding the contribution between those owners within local authority areas and those outside.
- inconsistent; because properties located outside of municipalities, towns and improvement boards are affected only by one direct tax, the Immovable Property Tax of the 1980, and this only if they are not exempt under this Law.

Recommendations

It is considered that all property-based taxes in Cyprus can be improved both from the tax payers point of view and the tax collectors point of view so that an equitable, convenient, certain, up-to-date system will result and the operative and administrative costs diminish. The following recommendations would provide the means for practical improvement, thereby giving local authorities a strong and stable financial foundation upon which to build the provision of quality services.

(i) The Central Government of Cyprus should adopt an up-to-date capital value basis of assessment, so as to provide consistency throughout the country.

(ii) Up-to-date capital values will not only assist equity and uniformity but also can be a useful tool to discourage purchaser and vendor from declaring a lowerprice. Lands and Surveys Department could present capital values of similar properties in the area, as evidence to support estimated sale prices for transfer fee purposes. As a result of this people would pay more Capital Gain tax and more in transfer fees.

(iii) Once a revaluation has been carried out and implemented, the new values should be adopted for all taxes.

(iv) In order to make revaluations more frequent, i.e. every two or three years, or whenever after an assessment ratio study (IAAO, 1978) indicates that reassessment is needed, it is recommended that the benefits of new technology be utilised. The introduction of Computer Assisted Mass Appraisal (CAMA) systems will assist in estimating property values at a certain date, based on limited sales data, using different techniques for the prediction of a property value e.g. multiple regression analysis and knowledge based systems. The best technique will predict values at a certain date, with minimum acceptable mean error, minimum data, minimum cost, fast respond, minimum human skill and effort.

(v) The Lands and Surveys Department is able to provide digital information on ownership for a number of municipal areas and within five years for the most part of Cyprus (except the occupied area). Tax collectors, including central government, should use computer technology to send separate bills to each owner, where it is possible, as well as reminders, if necessary.

(vi) Even if all ownership records in Cyprus are computerised, it will not be possible to estimate an owner's total property market value because the Lands and Surveys Department has only started to record personal identity numbers and company registration numbers systematically since 1986. This will lead to erroneous results if Lands and Surveys digital records are used for the calculation of Immovable Property 1980 tax. The Department has to adopt methods to find the ID numbers of the owners where that it is possible.

(vii) Rebates for the poorest will make collection more acceptable i.e. recognition that a high property value does not mean and a high income.

(viii) The State should examine the likely effect of merging existing property taxes to a single one, including the resulting procedures of collecting revenues and procedures of appeals against those who refuse to pay taxes. Revenues could be distributed to local authorities in case of collection by central government. Since the administration of income is under local authorities, these will not lose financial control. The procedural cost of property taxation will be minimised and as a result the system will be more efficient, cost effective, time effective and flexible.

(ix) The State should examine the inclusion of rural areas which are not affected directly by taxation laws because of the generally continuing rising of land values, the computerisation of Lands and Surveys Department, the need of local services and the improvement of those areas. Rates can be regulated by local authorities, and specific rebates or cash-back schemes introduced where and when appropriate.

(x) Because taxes are levied on owners and not on occupiers, leaseholders of government land do not pay taxes. Government should examine the likely reforms of property taxes in order to include leaseholders because they enjoy local authority's and central government's services.

(xi) Because of the out of date records of the Lands and Surveys Department, the application of computer assisted mass appraisal techniques cannot operate efficiently as the results would be erroneous. Lands and Surveys Department should re-examine the procedures of up-dating the land records with local authorities and the District Officer. Furthermore, after the last General Valuation in 1980, a new one should be implemented, having in mind the development of an appropriate computer mass appraisal system.

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Property Tax: An International Comparative Review

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8 Immovable property taxation in Cyprus

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Introduction

There are several taxes in Cyprus which are levied on the basis of the value of landed properties. Some of these are paid to the local authority and some are paid to central government. The taxes and rates levied by the Government of Cyprus on immovable property are: Immovable Property Tax of 1980, Town Rate, Improvement Rate, Towns Tax, Estate Duty Taxation, Capital Gains Tax, Betterment Charge and Sewerage Charges.

Property taxes levied by local authorities afford some financial independence from central government, thus reducing central government's burden of providing local services. The central government is a recipient of the revenues from the Immovable Property Tax of 1980, Towns Tax, Estate Duty, Capital Gains Tax and Betterment Charge. Municipalities and Improvement Boards are the recipients of the Town Rate and Improvement Rate respectively. The Sewerage Charges are received by the local Sewerage Councils. Betterment Charge law has not been applied, mainly because of difficulties in defining the area in which betterment has occurred and also in providing the quantum of the betterment.

Overview

The Republic of Cyprus is the third largest island in the Mediterranean with an area of 3,572 square miles (9,251 square kilometres) and a population of approximately 700,000 (see Figure 8.1 for a map of Cyprus). Its open-based economy is relatively poor in natural resources and is thus highly dependent on the import and export of goods and services. The Cypriot Employers and Industrialists Federation (1996) explain that since its independence in 1960, Cyprus's development has been internationally acknowledged as a success story in both the economic and social fields. Despite the acute political problems which emerged in 1974 when Turkey invaded the island, occupying about 38 per cent of its territory, the economy quickly recovered as a result of the concerted efforts of both the public and the private sector.

Kotsonis (1990) explained that after the establishment of the Republic in 1960, agriculture continued to be a backbone of the economy of the island. However, with the post-independence days came the boom of an expanding tourist industry, coupled with an unprecedented residential, commercial and industrial expansion. All this exerted a tremendous pressure on the limited available land resources and the competition of uses became more acute.

Administration

The Republic of Cyprus, for administration purposes, is divided into six districts (Lefkosia (or Nicosia), Ammochostos (or Famagusta), Larnaka, Lemesos (or Limassol), Keryneia (or Kyrenia) and Pafos). The island's capital and seat of Government is Lefkosia. Each district is headed by the District Officer who is essentially the local representative of central government. The District Officer acts as the chief co-ordinator and liaison for the activities of all ministries. The administrative power in Cyprus is a two tier system, but the structure is rather centralized, delegating limited power to the local authorities from central government. There are three types of local authorities: Municipalities, Improvement Board Areas, and the Villages. Municipalities have more power and a larger population than the other local authorities. According to the 111/1985 law, one of the limits of an area to be a municipality is its population, which must not be less than 5,000.

The Lands and Surveys Department for administration purposes is divided into six District Offices and a Headquarters. Because Turkish troops occupy Keryneia and part of Ammochostos, their District Offices are situated in Lefkosia and in Larnaka respectively. According to the Immovable Property (Tenure, Registration and Valuation) Law, Capital 224, 1946, Cyprus's Lands and Surveys Department is entrusted to produce valuations of all taxable landed property for taxation purposes. This is called a general valuation and occurs whenever required by the Council of Ministers, and so far this has occurred only in 1909 and 1980. The basis of tax assessments used in Cyprus today have been the 'market value' and the 'assessed value'. Market values were used to produce the capital value as at 1 January 1980 of immovable property, based on sales evidence of open market transactions: this was the last general valuation. 'Assessed' value is the 1909 value, based on the experience of Lands and Surveys Department's employees who at the time had no sales records on which to base open market valuations. It can be argued that the assessed value was only an approximation of the 1909 open market value because it was performed by non-qualified valuers based on their professional experience alone and that the evidence of open market sales at that time was very limited. Both values are used as a base for various taxes on landed properties.

Overview of taxes

The Immovable Property Tax of 1980 (Law 24/1980 amended by the Laws 60/80, 68/80, 25/81 and 10/84)

This is levied by the state on the open market capital value as at 1 January 1980, on all of an owner's property. The owner may be either a legal body or private individual who is registered in the Lands and Surveys Department records or who is entitled to be registered, according to sections 9 and 10 of the Immovable Property Law, Capital 224. According to section 9, no title to immovable property shall be acquired by any person by adverse possession against the Republic or a registered owner. According to section 10, subject to the provisions of section 9, if a person can provide proof of undisputed and uninterrupted adverse possession for a period of 30 years, that person shall be entitled to be registered as the owner. Properties belonging to the state, the municipalities and the communities (i.e. villages) are exempt, so are churches, places of worship, non-profit making organizations, properties owned by farmers in rural areas and properties owned by foreign states for diplomatic purposes. Markides (1991) explained that the current law replaced the old laws 30/77, 38/78 and 93/79 under which the tax was levied on 1909 (assessed) values of properties. The tax is payable to the state on 30 September each year. The rates at 1980 market value based on the value of an owner's properties are as follows:

up to £100,000	-	0.2% for legal bodies and 0% for individuals
from £100,001 to 250,000	-	0.2%
from £250,001 to 500,000	-	0.3%
from £500,001	-	0.35%

Delays on tax payment are penalized with 9 per cent interest on the outstanding amount.

The Town Rate (Capital 240 and Laws 64/1964, 15/1966)

This is paid to the municipalities on all immovable property of legal bodies or individuals, according to the municipality Law 111/85 (as amended), within the administrative limits of any municipal corporation. Properties belonging to the state and the municipalities are exempt, as are churches, places of worship, charitable institutions and properties owned by foreign states for diplomatic purposes. The 1995 rate was 0.05 per cent on the market value of such property as at 1 January 1980 as is registered or recorded in the books of the District Lands Office. The tax is payable to the municipality on 30 June. A penalty of 5 per cent is levied on payments made after the 30 September.

The Improvement Rate Law (Capital 243 and the amendment Laws 46/61, 58/62, 4/66, 31/69, 7/79, 49/79, 65/79, 7/80, 27/82, 42/83, 72/83, 38/84, 72/87 and 66/89)

This tax is levied on all immovable properties within the geographical limits of any improvement area. According to the Villages (Administration and Improvement) Law, Capital 243, an improvement area is any area declared by the Council of Ministers as an 'improvement area', for improvement purposes (i.e. construction of roads, national parks). Properties belonging to the state and the Improvement Boards are exempt, as are churches, charitable institutions and properties owned by foreign states for diplomatic purposes. The tax rate, decided by the Improvement Board is subject to the approval of the government. This is up to 1.5 per cent on the 1909 assessed value of such property as registered or recorded in the books of the District Lands Offices. This tax is payable to the Improvement Boards by the owner on the 30 June each year and is used to support improvements and local services. A penalty of 5 per cent is levied on payments made after the 30 September.

The Immovable Property (Towns) Tax (Laws 89/1962 and 73/1965)

This is levied on immovable property in towns or other areas defined by the Council of Ministers as 'Towns', according to section 3. The tax rate is 1.5 per cent on the 1909 assessed value of property as registered or recorded in the books of the District Lands Offices. Properties belonging to the state, municipalities, communities are exempt, as are churches, charitable institutions and properties owned by foreign states for diplomatic purposes. It is payable on 30 June of each year. Payments after the 30 September are fined by 5 per cent on the amount payable. This tax is collected by the state and is allocated to the Ministry of Education (note: it has replaced the Education Tax).

The Estate Duty Taxation (Law 67/62 and the amendment Laws 71/68, 3/76, 13/85, 93/86, 138/86, 323/87, 66(1)/94, 6(1)/96, 78(1)/96, 17(1)/97)

This is levied on immovable properties left by a deceased and is collected by the state. The properties are valued at their open market capital value as at the date of death. For deaths before 1 December 1942, Estate Duty is not levied. According to the amendment Law 138/86, inheritances due on deaths after 17 October 1986 incur the following level of relief:

£50,000	-	for husband or wife surviving;
£75,000	-	for every child under 21 years old at the date of death;
£75,000	-	for every disabled child surviving;
£50,000	-	for a 21 years old child;
£50,000	-	for all the children surviving.

Furthermore, there are rebates in some cases where the heir is a non-profit making organization or religious organization. These cases are examined by the state individually. Additionally, according to the 17(1)/97 amendment law, if the property left by the deceased is a residence used by the deceased or his/her family and the open market capital value at the date of death is less than £150,000 tax is not levied on heirs. The rates of tax on evaluated immovable property are as follows:

up to £20,000	-	0%
from £20,001 to £25,000	-	10%
from £25,001 to £35,000	-	13%
from £35,001 to £55,000	-	15%
from £55,001 to £80,000	-	17%
from £80,001 to £105,000	-	20%
from £105,001 to £150,000	-	23%
from £150,000	-	30%

These rates are valid from March 1997.

The Capital Gains Tax (law 52/1980 and 135/1990)

Capital Gains Tax applies to both individuals and companies. Owners are charged at 20 per cent on gains arising from the disposal of immovable property and shares in a company which owns immovable property. Gains are based on the open market capital values as at 1 January 1980 (or actual cost if acquired later) adjusted for the increase in the Consumer Price Index (CPI) up to the date of sale. Tax is paid to the state, and the main exemptions include:

1 immovable properties left by a deceased (which is liable to Estate Duty);

2 immovable properties given as a gift:

- from parents to children;
- from husband to wife and vice versa;
- from relatives up to second generation relatives (e.g. grandfather to grandchild).

Betterment Charge (Law 90/1972 Section 80)

The enforcement of the provisions of the Town and Country Planning Law, 1972 may cause an increase in value of immovable property. Such an increase may result either from a change to a more profitable use, or a higher density, or it may come about after the carrying out of development by a public authority in an area. Nicolaides et al (1983a) commented that in the same way as it is 'fair' to pay compensation to owners whose property rights are being materially adversely affected, it could be argued that it would also be fair to ask from those owners whose properties are being benefited by public activities to pay back at least some part of their gain. One way for the state to collect betterment is the levying of a Betterment Charge. Betterment Charge is levied on the increase in value which is attributable to the scheme. The betterment is ascertained by the carrying out of two open market capital valuations, one at the date prior to the scheme and a second one at a date falling within the period starting two years after the date of the decision and finishing two years after the date of completion of the scheme. The difference between the two valuations, after deducting any increase which is not attributable to the scheme, is the 'betterment' which is subject to the charge. Betterment Charge has been fixed up to a maximum of 30 per cent on the betterment, and is payable to the state in 20 annual instalments. Betterment Charge has not yet been levied because of:

1 the difficulties in defining the area in which betterment has occurred and also in proving the quantum of the betterment;

2 limited number of staff of the Lands and Surveys Department;

3 the use of manual procedures by the Department; and

4 the political cost.

Sewerage Charges (Law 1/1971)

The aim of this law is the establishment, construction, control and administration of sewerage systems, including the processing and the disposal of waste. The Sewerage Council, according to section 30 of the law, has the right to levy tax and fees. The tax is levied on the open market capital value as at 1 January 1980 and is payable on 30 September each year. Sewerage charges are levied on landed properties in areas where sewerage systems were constructed and are in use. The rates vary depending on the property type e.g. in Larnaka, in 1995, the rates on hotels, hotel apartments and industries was 0.932 per cent and for all other property types was 0.285 per cent. Sewerage charges are also levied on properties in areas where sewerage systems are under construction, e.g. in Larnaka, in 1995, for all property types, the rate was 0.07 per cent. However, charges on landed properties in areas where systems are under-used are likely to be replaced by charges levied on water consumption. The argument for this is that it is a fairer method for those areas, since the greater the water consumption, the greater the use of sewerage systems.

Origins and evolution

Kotsonis (1990) commented that evidence uncovered in a 5th century BC excavation at Dali village revealed that the King of Idalion and the town itself rewarded a physician who had cured those wounded during a siege with the grant of royal lands, to the value of one silver talent in full ownership. Kotsonis explained that this indicated there was then not only royal lands but also land in private ownership, describing the properties donated as neighbouring lands of certain named individuals. The inscription also indicates the existence of land taxation and rights of inheritance even in those early days.

Ioannou (1990) and Markides (1991) explained that the property tax system in Cyprus dates back to the Ottoman Empire. The Turks were the first to introduce a system of property tax during the period 1850-1878, which has been altered through the years to accommodate the subsequent administrators and social changes. The first general valuation began in 1909 under the Law 12/907 by which a cadastral survey, registration and valuation to cover the whole island was authorized. The general valuation was completed some 20 years after it was first started. The values adopted (1909) were known as assessed values and were based on the experience of Lands and Surveys Department's employees after visiting the areas, e.g. villages, and not always after an inspection of individual properties. The valuers were unable to use sale records because they did not exist. Today, the assessment is a desk-based exercise and it can be argued that these assessed values are suspect because of the extremely low values of properties in 1909 compared with today's values and the fact that it is not worth applying appropriate valuation methods for such little return. The general valuation was used for property taxation as soon as it was completed and currently the 1909 assessment is still used as the basis for the Towns Tax (previously the Education Tax) and the Improvement Rate.

The second general valuation was carried out for a specific purpose and only covered the sewerage areas of Lefkosia and Ammochostos at 1971 values in order to levy tax for the establishment of a sewerage system. This is a general valuation for specific purposes and could not be used as a tax base for other taxation purposes. This tax was in fact levied only in Lefkosia because in 1974 Ammochostos was invaded by Turkish troops.

The third general valuation was carried out for the whole of Cyprus (except the occupied area) at 1980 values and is known as the market (capital) values of 1 January 1980. It was completed in 1991 and its main purpose was to create a record of uniform values all over the country for all purposes e.g. central government taxation, municipalities rating. It is already in use for the Immovable Property Tax, Town Rate (previously the Municipal Tax), Sewerage Charges and Capital Gains Tax, but not for the Towns Tax and Improvement Rate.

The place of the tax within the general tax system

Taxation of landed property has always been a significant financial resource for the socio-economic development of the island because such resources have been extensively used for local authority services, education, sewerage, construction of roads and generally for the improvement of areas.

Statistics on the size of the tax base

Table 8.1
Government ordinary revenue raised by Immovable Property Tax (1980), Towns Tax, Estate Duty and Capital Gains Tax

Year	Im. Pr. Tax 1980 £	Towns Tax £	Estate Duty £	Capital Gains Tax £	Betterment Charge
1991	4,754,000	449,000	1,433,000	5,001,000	-
1992	3,461,000	348,000	2,373,000	4,719,000	-
1993	2,997,000	410,000	2,203,000	5,181,000	-
1994	3,126,000	408,000	2,022,000	5,974,000	-
1995	5,949,000	488,000	2,318,000	9,336,000	-
Total	20,287,000	2,103,000	10,349,000	30,211,000	-

Table 8.2

Calculated Town Rate and Improvement Rate by the Lands and Surveys Department and sewerage revenue from tax levied on landed properties

Year	Town Rate	Improvement Rate	Sewerage Charges
1991	502,796	101,438	2,465,714
1992	761,319	104,502	4,050,446
1993	1,204,970	130,823	5,462,187
1994	1,835,115	114,889	6,520,881
1995	2,013,885	101,260	8,472,102
Total	6,318,085	552,912	26,971,330

Total revenue raised

Table 8.3

Total government ordinary revenue raised by Immovable Property Tax (1980), Towns Tax, Estate Duty and Capital Gains Tax

Year	Total £
1991	11,637,000
1992	10,901,000
1993	10,791,000
1994	11,530,000
1995	18,091,000
Total	62,950,000

Comparison with other taxes

According to the Statistical Abstract (1994) and the Financial Report (1995) the most important sources of government revenue is Income Tax, as a direct tax, and Import Duties, as an indirect tax (see Table 8.4).

Table 8.4
Government ordinary revenue raised by Income Tax, Import Duties and Excise

Year	Income Tax (Direct Tax) £	Import Duties (Indirect Tax) £	Excise (Indirect Tax) £
1991	131,075,000	100,170,000	80,600,000
1992	154,390,000	108,402,000	96,670,000
1993	169,513,000	88,446,000	67,794,000
1994	217,075,000	88,167,000	98,900,000
1995	237,239,000	91,830,000	118,535,000
Total	909,292,000	477,015,000	462,499,000

Table 8.5
Government ordinary revenue raised by Lands and Surveys Fees

Year	Lands & Surveys fees (Direct Tax) £	Lands & Surveys fees (Indirect Tax) £	Lands & Surveys fees (Sale of Goods & Services) £	Total £
1991	3,341,000	6,809,000	3,341,000	13,491,000
1992	4,083,000	8,276,000	4,084,000	16,443,000
1993	4,130,000	8,241,000	4,130,000	16,501,000
1994	5,277,000	10,504,000	5,277,000	21,058,000
1995	6,136,000	12,248,000	6,136,000	24,520,000
Total	22,967,000	46,078,000	22,968,000	92,013,000

The total revenue raised by Immovable Property Tax (1980), Towns Tax, Estate Duty and Capital Gains Tax from 1991 to 1995 is £62,950,000 (see Tables 8.1, 8.2 and 8.3). This means that this revenue is 1.7 per cent of the total government income, (total revenue raised by taxes levied on landed properties divided by total government revenue). Furthermore, this revenue is 10.9 per cent of the total government development expenditure, (total revenue raised by taxes levied on landed properties divided by total government development expenditure).

Both taxes in Table 8.1 and Lands and Surveys Fees in Table 8.5 are government revenue. The total amount raised by those categories is 4.2 per cent of the total government income and 26.8 per cent of the total development expenditures. Income tax provides the greatest contribution to the government revenue. Immovable Property Tax is 2.2 per cent of Income Tax (Immovable Property Tax divided by Income Tax).

Table 8.6
Government total revenue raised, development and ordinary expenditures

Year	Government Total Revenue £	Government Dev Expenditure £	Gorvernment Ord Expenditure £
1991	563,142,000	90,082,000	794,232,000
1992	635,219,000	104,807,000	803,603,000
1993	731,500,000	114,977,000	915,985,000
1994	847,530,000	120,948,000	1,011,108,000
1995	940,475,000	146,325,000	1,112,400,000
Total	3,717,866,000	577,139,000	4,637,268,000

Purpose of the tax

The Immovable Property Tax of 1980, Estate Duty, and Betterment Charge are spent by central government under normal development expenditures. Town Rates and Improvement Rates are collected by municipalities and Improvement Boards respectively. These are incorporated into their budgets for administration and development projects e.g. public works, roads. The Towns Tax is spent by the Ministry of Education for educational purposes and Sewerage Charges are spent by Sewerage Councils for the construction and maintenance of sewerage systems.

Basis of assessment

The unit of assessment for taxation purposes is immovable property, as defined by the Immovable Property Law, 1946, at its highest and best use with all improvements. According to the Immovable Property (Tenure, Registration and Valuation) Law, section 2, 1946, immovable property includes land, buildings, trees, wells, water rights and easements.

According to the Immovable Property Law, Cap. 224, 2 of 8/53: 'value in connection with immovable property, means the amount which the immovable property, if sold in the open market by a willing seller to a willing purchaser, might be expected to realize', i.e. its capital value, based on open market transactions. The basis of general valuations in Cyprus has been capital value since the second general valuation in 1971 in Lefkosia and Ammochostos; it was also used in the third general valuation in 1980 for the whole of the country (except for the occupied area). Capital value was used after the establishment of the Immovable Property (Tenure, Registration and Valuation) Law in 1946 for other purposes such as compensation for compulsory acquisition. A capital value basis satisfies general valuation criteria and has fewer practical problems in Cyprus than annual value because of the Rent Control Law (23/83 and the amendment laws) which limits free market rental information required as market evidence for valuing residential and retail properties.

Landed properties are sold on the open market by a willing seller to a willing purchaser and this represents a useful volume of open market sales as evidence of comparable transactions. In Cyprus, whilst sale evidence exists, there is not a large volume of sales. However, it can be argued that these limited sales transactions provide strong and sufficient evidence for a capital value tax base, with the condition that sales are reliable, genuine and not understated. The capital value basis is an approach based on the full open market capital value of immovable property in its existing condition, with all developments, improvements, and potentialities (considering the best use of property).

Responsibility for making assessments

According to the Immovable Property (Tenure, Registration and Valuation) Law, Capital 224, Section 69, the Lands and Surveys Department in Cyprus is required to produce a valuation of landed property for taxation purposes, called a general valuation, whenever and wherever required by the Council of Ministers for the purposes of securing the up-to-date and uniform valuation of immovable property in any municipality, village or quarter.

According to section 67, any immovable property can be revalued at the instance of the Director or on the application of the registered owner at any time after five years from the date of the last valuation, provided that the property has materially changed, causing a substantial increase or decrease in value or if a general valuation has been ordered.

General valuation criteria

According to legal advice given by the General Attorney of the Republic of Cyprus (35/69, dated 20 September 1969), the following legal principles must be applied in a general valuation:

1 equal treatment of the taxpayers by the state and the fixing of the taxpaying ability on the basis of objective criteria;

2 for general purposes, a revaluation must cover the whole state;

3 for specific purposes, the valuation must cover the whole area which is specifically affected; and

4 a valuation for specific purposes cannot be used for general purposes.

Under the first principle, the Attorney-General requires not only equal treatment of taxpayers but also requires that the tax levied be an amount reasonably payable. Under the third principle, when the Council of Ministers in Cyprus decides to levy a new tax in order to develop a project in a specific area and for specific purpose e.g. construction and maintenance of a sewerage system such as in Lefkosia, the municipality requires a revaluation, known as a 'general valuation for specific purposes'. The last principle means that if a revaluation is made for a specific area for a specific purpose e.g. a sewerage system, it can not be used to levy the Town Rate which is for general purposes. If it is applied in this way, then it will be in conflict with the first criteria of equal treatment of taxpayers because each valuation is carried out using different criteria e.g. date of valuation.

The Lands and Surveys Department has developed both manual and computerized systems for maintaining sales records. The manual system will be abandoned as soon as the Cyprus Land Information System is developed and the integration between the legal and fiscal data of properties and plans is provided for the whole of Cyprus. This will enable valuers to read sales information simultaneously with plan information. The present manual system offers only limited access to this facility. As soon as a contract of sale is deposited or a sale is accepted, land clerks write a file number, date and price on the back of plans used by the valuation section. So whenever a valuer works on a specific area, sales information is available on the back of the plan. Property sales information (excluding the specific set of plans) are sold to the private sector, to valuers and to real estate agents in hardcopy and in digital formats.

The majority of assessors in the Lands and Surveys Department were trained in courses organized by the Department. Some of the staff are university graduates in real estate management and valuation, law and economics.

Furthermore, some land officers of the Headquarters in Nicosia are members of the Royal Institution of Chartered Surveyors and members of the Scientific and Technical Chamber of Cyprus which is the local professional organization recognized by the Government. Locally trained staff are supervised by the qualified staff at the Headquarters.

Use of private sector assessors

General valuation assessment is the sole responsibility of the Lands and Surveys Department. The private sector may be used by the owners in order to question or appeal the Lands and Surveys' assessments and decisions.

Frequency of valuations

According to the section 70 of the Immovable Property Law, Capital 224, when a general valuation has been ordered under section 69, the following provisions take effect:

1 the Director of the Lands and Surveys Department publishes a general valuation notice to inform the public that a general valuation will take place;

2 when the valuation is completed, the Director prepares a valuation list which is deposited by the Director and the Chairman of the town, village or quarter and is also published in the official Gazette of the Republic. The valuation list is used to inform people about property values.

Within 60 days from the date of the notice, any person whose property is affected may object in writing to the Director. Nicolaides et al (1983b) explained that an owner must deposit a fee equal to 1 per cent of the difference between his own valuation and the valuation appearing in the valuation list. The purpose of this limitation is to discourage owners from supplying the Director with inadequate or false information. The Director examines any objections submitted to him with the required fee and notifies the person objecting of his decision. If the owner is not satisfied with the Director's decision, he has the right to appeal to the Court.

Revaluation of individual properties

According to Section 71 of the Immovable Property Law, Capital 224, a revaluation of any individual property can be made at the instance of the Director. The Director may give notice of the proposed valuation or revaluation to the person or persons affected, requiring the owner to supply the valuer with information about the immovable property and, if it is necessary, to give the valuer the opportunity to inspect the property. When a valuation or a revaluation has been made, the Director gives notice of the value to the owner of the affected property. The owner may object in writing to the Director within 30 days from the date of receipt of such notice. The Director may consider any objection made to him and notify the person objecting of his decision. If the owner is not satisfied with the Director's decision, there is a right of appeal to the court.

Notification of assessed value

Once a year the municipalities or the district officers supply the Lands and Surveys Department with a list of building permits issued in their respective areas. The Director of Lands and Surveys Department orders the revaluation of the properties with the effective date being that of the last general valuation, that is, 1 January 1980. Valuers visit the properties, complete a standard revaluation form and estimate values manually. Because of the great number of revaluation cases, the use of manual methods and the limited number of staff of the Department, valuation lists are not posted, as required by the section 71 of the Law. However, owners are informed of the date of tax payments.

Appeals procedure

For the dates of tax payments, owners are reminded by the mass media. In the case of sewerage charges, notices of property values are sent to taxpayers by mail. Owners may not pay their tax and object in writing to the Director. The Director considers any objection made to him and notifies the person objecting of his decision.

Appeals system

If an owner is not satisfied with the decision of the Director of the Lands and Surveys Department regarding the valuation of a certain property, he has the right to resort to the District Court. The District Court after hearing both parties (the owner and the Department) will give its decision on the market value to be adopted. If either party feels that the decision of the District Court is not correct, an appeal may be made to the High Court. Individuals and legal bodies are represented by attorneys at all appeal cases and may hire expert property valuers and surveyors. An appeal does not postpone the deadline for payment and tax payments are fined with the pre-defined rate of interest on the payment amount.

The number of appeals is generally quite small because owners are normally satisfied with the assessed property values. As values are estimated as at 1 January 1980, owners have the illusion that the taxes are based on underestimated values. The constitution of Cyprus does not allow the use of valuation tribunals.

Methods of assessment

Capital values are achieved using comparisons made by Lands and Surveys Department based on open market transactions of similar properties for the last two general valuations because:

1 of the availability of appropriate sales records of immovable properties;

2 sales of immovable properties in the open market are the same as 'capital value' with the provision that they are reliable and genuine and not understated. Furthermore, if a property sale is much higher than similar property sales in the same area, these may not be included as sales evidence in a general valuation because the sale price may include other assets, e.g. goodwill; and

3 it is the simplest and most direct method of valuation.

The profits and contractor's valuation methods are not widely used because they are not as reliable as the comparative method which, moreover, is accepted by the Cyprus courts.

Use of mass appraisal techniques

Manual appraisal techniques were used for the 1909 and 1980 general valuations. The Lands and Surveys Department is in the process of computerizing and developing the Cyprus Integrated Land Information System (CILIS), with mass appraisal techniques being designed and developed by the CSC Datacentralen A/S, Denmark. Datacentralen is the software and hardware supplier to the Department since it succeeded in an international 'request for tenders' competition in 1995. According to the contract between the government and Datacentralen, CILIS will be delivered by the end of 1998. As soon as the Council of Ministers decide to perform the next general valuation, this will be implemented using the developed mass appraisal techniques.

When it was decided to introduce a fully computerized Land Information and Management System, the Department of Lands and Surveys invited Sagric

International to carry out research and prepare the request for tender documents (RFT) in 1991. The main proposal in the area of computer assisted mass appraisal systems (CAMAS) was to utilize simple multiple regression analysis. The Danish valuation system known as the 'Total Value System' or the 'base home approach' is based on multiple regression analysis.

Exemptions, reliefs and concessions

Properties belonging to the state, the municipalities and the communities (i.e. villages) are exempt. Additionally churches, places of worship, non-profit making organizations and properties owned by foreign states for diplomatic purposes are also exempt. It should also be noted that in Cyprus, central government taxes and local authorities rates are mainly payable by those owners whose property is located within municipal, town and improvement board areas. Thus, properties in rural areas are not affected directly by taxation laws. The Immovable Property Tax of the 1980 affects rural areas, provided that the owner is not a farmer and the total value of the owner's property exceeds £100,000. There are three main reasons for this:

1 to motivate people to develop agriculture and farming without the burden of taxes on the landed properties;

2 to discourage people from leaving rural areas and moving to towns, by reducing the cost of living in the rural areas; and

3 the reduction of administrative costs. Generally, land values in rural areas are much lower than values in towns, so an economic tax system in rural areas would have relatively high rates of tax, unless some form of complex equalization of funds was introduced by the state.

Properties entitled to relief

The following properties are exempt from Towns Tax (S.9, Law 89 of 1962), Town Rate (S.92, Cap. 240) and Improvement Rate (S35 D, Cap. 243):

1 any public burial ground;

2 any church, chapel, mosque, meeting house or premises or such part thereof as shall be exclusively appropriated to public religious worship;

3 any premises used as public hospitals;

4 any immovable property:

- held and registered in the books of the District Lands Office in trust for any school operating under any Law in force for the time being relating to Elementary or Secondary or Higher Education (this last for Towns Tax and Improvement Rate only);
- belonging to the Republic;
- owned or used exclusively for the purposes of any charitable institution of a public character supported mainly by endowments or voluntary contributions in so far as such immovable property is held for such purposes. (Such properties will not be exempt from taxation unless and until local enquiry is held on the application by the institution concerned and on payment of fees for the purpose, and the Director to whom the report of the DLO, is referred signifies his approval for such exemption);

5 'Supply Lines' belonging to the Electricity Authority of Cyprus. 'Supply Line' (S.2 Cap. 171) includes any building or apparatus connected with a conductor, etc., for the purpose of transforming, etc., electricity (S.25, Cap. 171);

6 property owned by any foreign state and used by such state as an embassy or consulate or as an official residence of the diplomatic representative of that state, provided that such state has signed the 1961 Vienna Agreement on Diplomatic Privileges (Art. 23 of the Agreement, Law 40/68).

The following properties are exempt from Towns Tax (S. 9, Law 89 of 1962) and Improvement Rate (S. 35D Cap. 243):

1 property owned by the offices or any other body or authority of any Communal Chamber of the Republic;

2 property registered or recorded in the books of the District Lands Office as common pasture ground;

3 property recorded or assigned *abantiquo* for the common use of the community. (This includes all village domestic water supplies, whether issuing from wells or otherwise (D.L.S. 314/48 of 24.1.1951).

The following properties are exempt from Town Tax (S.9, Law 89/62 as amended by S. 2 of Law 73/65):

Property owned by a municipality or a public utility body. The Council of Ministers must decide on this after recommendations by the Minister of Finance and the Council of Ministers may impose on this such conditions as they may think fit.

Property belonging to the Improvement Board of the area are exempt from Improvement Rate (S.35D, Cap 243)

Reference should be made to the provisions of the Persons who sustained Losses (Exemption from Taxation) Temporary Provisions Law, 62/1975. This is a temporary Law and it affects all immovable property which is situated in the area or is adjacent to the area occupied by Turkish troops. Such properties are temporarily exempt from taxation. On the approval of the Director of Lands and Surveys Department, any tax paid for the year 1974, is refunded to the owners of such property. (S. 2-3, Law 62/75).

Collection procedures

The central government tax collectors are located in each district and are responsible for the collection of Immovable Property Tax of 1980, Towns Tax and Capital Gains Tax. Municipalities and Improvement Boards collect Town Rate and Improvement Rate respectively. Sewerage Boards collect the sewerage charges. Taxes are payable, in one payment, within a specified period of time applicable throughout the country.

Liability for the tax

Generally the payment of taxes in Cyprus is the responsibility of the owner. Where legal ownership records are not updated, usually taxes are paid by those beneficiaries who are entitled to be registered as owners. Frequently leaseholders of government land have not been asked to pay taxes.

Computation of the tax

The rates of the Immovable Property Tax of 1980, Towns Tax, Estate Duty and Capital Gains Tax are determined by the Ministry of Finance and are approved by the House of Representatives. Town Rates and Sewerage Charges are imposed by municipalities and the Sewerage Boards respectively subject to the approval by the government. Improvement Rate is imposed by the government and collected by the respective Improvement Boards. There is no differential taxation on land and buildings since all taxes are levied on property as it stands.

Enforcement procedures

Enforcement procedures for the collection of taxes are provided by law. Late payments generally carry interest and in some cases, penalties. Delays on Immovable Property Tax payment are liable to 9 per cent interest on the payment amount and delays on Town Rate, Improvement Rate and Towns Tax are each fined with 5 per cent interest. It is worth noting that in order for a property to be transferred to another person, the owner must present proof that he has paid all the taxes related to the property. As a consequence the government and the local authorities can be sure that all taxes and interest will have been paid.

Penalties

When the total amount of tax owed by an owner represents a substantial sum, the authority may decide to sue the owner. In that case, the owner may be liable to a fine or imprisonment.

Critical analysis

The 1909 and 1980 general valuations are used as the base for a number of taxes. The basis of assessment should ideally be a single valuation base, since uniformity of property values is one of the general valuation purposes and conforms to the legal principle of the Attorney-General, i.e. equal treatment of taxpayers. Furthermore, property taxes, e.g. the Immovable Property Tax, the Town Rate, the Improvement Rate and the Towns Tax should be a single tax paid to a single authority because it would be easier for owners to pay one tax to one authority instead of paying several taxes to many authorities. Additionally, central government and local authorities' administration expenses would be reduced significantly.

If capital values for a general valuation are kept updated at regular intervals, for example every two or three years or whenever an assessment ratio study indicates that reassessment is needed (IAAO, 1990), the assessment of tax will be based on what actually exists on the land, including buildings, at the date of taxation. It can be argued that this is an equitable system since the capital value reflects all the valuable characteristics of the property. It increases the social equity of the tax because it reflects current values and up-to-date relativities of 'wealth' (assuming 'wealth' equates to capital value and not exclusively to taxpaying income). Examples of an out-of-date assessment tax system are the Town Tax and the Improvement Rate, simply because the 1909 assessed values are used as a basis of taxation even though these values have no relation to the actual values of the properties taxed.

If an owner's properties are located in Strovolos Municipality only, in that part of the area affected by Towns Tax, and the following values apply:

	evaluated at 1980 Capital Values	evaluated at 1909 General Valuation
building site	£15,000	£50
house	£30,000	£250
apartment	£20,000	£200
Total	£65,000	£500

Each year the owner would pay the following taxes:

1 Immovable Property Tax of 1980. As the total value of the owner's property is less than £100,000, and providing the owner is not a legal body then he is exempt from paying this tax.

2 Town Rate. The rate is 0.05 per cent on the total value of the property in the Municipality, so at 1980 values, the owner will pay £32.50 (£65,000 multiplied by 0.05 per cent).

3 Towns Tax. The rate is 1.5 per cent on the total value of the property in the Municipality, so at 1909 values, the owner will pays £7.50 (£500 multiplied by 1.5 per cent).

The Town Rate is £32.50 because the basis of assessment is 1980 values. An up-to-date valuation base would ensure that taxpayers pay according to an updated liability in proportion with their current relative liabilities, i.e. if someone's property is now worth £30,000, he should pay half the tax of his neighbour, whose property is worth £60,000, even if both properties were worth £15,000 in 1980.

Land records are not updated immediately with landed property changes because manual systems are used at present for the interchange of information between the Lands and Surveys Department and the local authorities.

Recommendations

It is considered (Panayiotou et al., 1997) that all property-based taxes in Cyprus could be improved both from the taxpayers' and the tax collectors' point of view so that an equitable, convenient, certain, up-to-date system would result and the operational and administrative costs decrease. The following recommendations would provide the means for practical improvement, thereby giving local authorities a strong and stable financial foundation on which to build the provision of quality services.

1 The central government of Cyprus should adopt an up-to-date capital value basis of assessment, so as to provide consistency throughout the country.

2 Current capital values will not only assist equity and uniformity but also can be a useful tool to discourage purchasers and vendors from declaring a lower price. Lands and Surveys Department could present capital values of similar properties in the area, as evidence to support estimated sale prices for transfer fee purposes. This would result in greater levels of Capital Gains Tax and transfer fees.

3 Once a revaluation has been carried out and implemented, the new values should be adopted for all taxes.

4 In order to make revaluations more frequent, say every two or three years, it is recommended that the benefits of new technology be utilized. The introduction of Computer Assisted Mass Appraisal (CAMA) systems would assist in estimating property values at a certain date, based on limited sales data, using different techniques for the prediction of a property value, e.g. multiple regression analysis and knowledge-based systems. The best technique will predict values at a certain date, with minimum acceptable mean error, minimum data, minimum cost, fast response, minimum human skill and effort.

5 The Lands and Surveys Department is able to provide digital information on ownership for a number of municipal areas and within five years, for most of the country. Tax collectors, including central government, should use computer technology to send separate bills to each owner, where it is possible, as well as reminders, if necessary.

6 Even if all ownership records in Cyprus are computerized, it will not be possible to estimate an owner's total property market value because Lands and Surveys Department has only started to record personal identity numbers and company registration numbers systematically since 1986. It will lead to erroneous results if Lands and Surveys digital records are used for the calculation of Immovable Property Tax 1980. The Department has to adopt methods to find the ID numbers of the owners where that is possible.

7 Rebates for the poor will make collection more acceptable i.e. recognition that a high property value does not mean a high income.

8 The state should examine the likely effect of merging existing property taxes into a single one, including the resulting procedures of collecting revenues and appeal procedures against those who refuse to pay taxes. Revenue could be distributed to local authorities in those cases where collection is by central government. Since the administration of income is by local authorities, they will not lose financial control. The procedural cost of property taxation will be minimized and as a result the system will be more efficient, cost-effective, time-effective and flexible.

9 The state should examine the inclusion of rural areas which are currently not affected directly by taxation laws, because of the continued rise of land values, the computerization of Lands and Surveys Department, the need for local services and the improvement of those areas. Rates can be regulated by local authorities, and specific rebates or cash-back schemes introduced where and when appropriate.

10 Government should clarify its position as to whether leaseholders should pay taxes as they enjoy services provided by local authorities and central government.

11 Because of the dated records held by the Lands and Surveys Department, the application of computer assisted mass appraisal techniques will not operate efficiently and will result in inaccurate assessments. The Lands and Surveys Department should re-examine the procedures of updating the land records with local authorities and the District Officers. Furthermore, since the last general valuation was in 1980, a further revaluation should be implemented.

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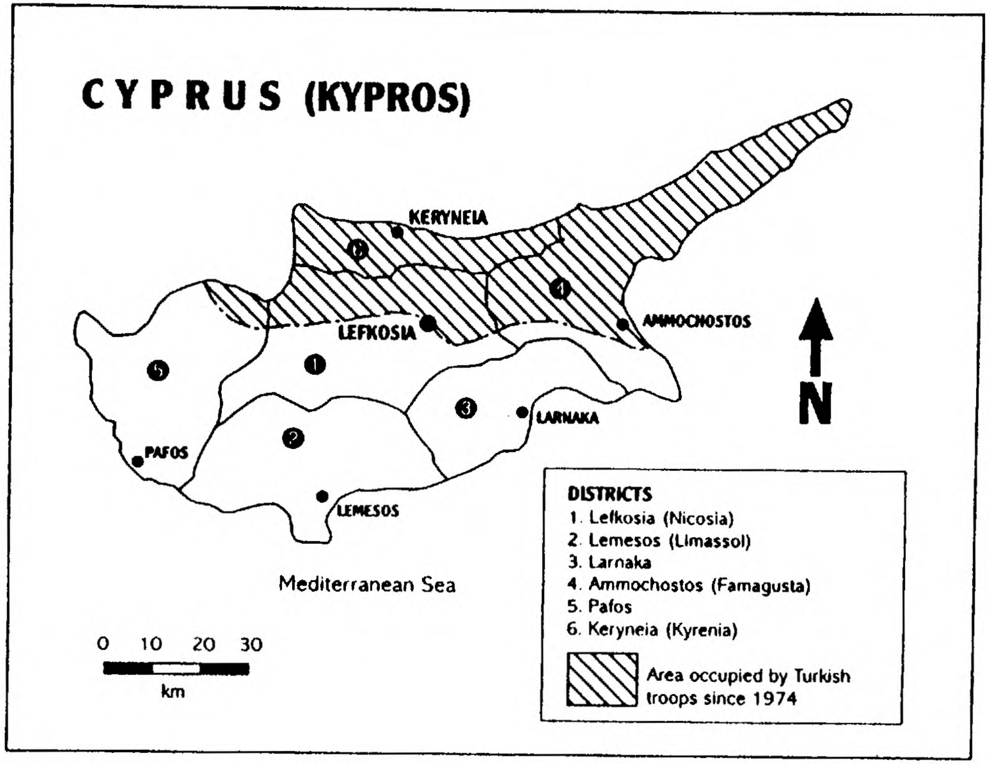

Figure 8.1 Map of Cyprus