

# **Mass Appraisal Methods**



# Mass Appraisal Methods

*An international perspective for property valuers*

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# Contributors

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**Richard A. Borst** has been engaged in managing the design, development and implementation of computer-based real property information systems since 1973. He was president of North America's largest mass appraisal firm while at the same time maintaining his contributions to the technical aspects of mass appraisal systems. His technical background is evidenced in a number of published articles and conference presentations. He introduced artificial neural networks to the assessment community in 1990. He was appointed to a three-year term in 1997 as a Visiting Research Fellow at the University of Ulster, Belfast, Northern Ireland. During this tenure he collaborated with members of the faculty at the University performing research in the fields of valuation modelling and the application of location effects in the model structuring and calibration process. He obtained a Doctor of Technology from the University of Ulster, Northern Ireland, a Master of Science in Industrial Engineering from the State University of New York at Buffalo and a Bachelor of Engineering Science, with honours, from the Cleveland State University.

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**François Des Rosiers** is an economist and urban planner and holds a PhD degree in Urban and Regional Planning Studies from the London School of Economics, UK (1984). Since 1976, he has been teaching Urban and Real Estate Management at the Faculty of Business Administration, Laval University, where he is a full professor and currently in charge of the Urban & Real Estate Management Program. In addition to his teaching and research tasks, François Des Rosiers has served over the past twenty years as a consultant and adviser for several public, semi-public, institutional and private bodies and organizations, both in Quebec, Canada and abroad and has been involved in various policy issues through numerous committees, commissions, panels, boards, etc., at the national, provincial and local levels. His main research area deals with hedonic price modelling and the measurement of urban externalities. Professor Des Rosiers's academic realizations have earned him several awards and manuscript prizes. In July 2007, he was elected Fellow of the Academy for Social Sciences of the Royal Society of Canada.

**Marc K. Francke** graduated in 1994 in Econometrics at the Vrije Universiteit Amsterdam. Mark Francke worked at the Amsterdam Tax Authorities office during 1994–2000, where he developed models for mass appraisal of real estate. In 2001 he was co-founder of OrtaX, a company that specialized in mass appraisal for local government and housing corporations. In 2006 he defended his PhD dissertation entitled 'Marginal Likelihood in State-space Models, Theory and Applications'. In 2006 he became a part-time Assistant Professor in the Econometrics Department at the Vrije Universiteit Amsterdam. He has published in the *Journal of Property Tax Assessment and Administration*, the *Journal of Business and Economic Statistics*, the *Journal of Real Estate Finance and Economics* and the *Journal of Econometrics*.

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**William J. McCluskey** is presently a Reader in Real Estate and Valuation at the University of Ulster. He has held various international positions including Visiting Professor of Real Estate at the University of Lodz, Poland and Professor of Property Studies at Lincoln University, Christchurch, New Zealand. His main professional and academic interests are in the fields of real estate valuation and more specifically *ad valorem* property tax systems, local government finance, computer assisted mass appraisal (CAMA) modelling and the application of geographic information systems (GIS). Within this context he has been involved in a number of international projects advising on *ad valorem* property tax issues including Jamaica, Northern Ireland, Bermuda, Poland, Kosovo, Tanzania and South Africa.

**Dree Op 't Veld** has been responsible for the design and development of a considerable number of web-based market information and decision support systems in the Netherlands. Throughout his career the emphasis has been on the analysis and modelling of regional economic and demographic phenomena for policy purposes by government officials or firms. Thematically his interest nowadays is in housing and real estate markets and valuation on the one hand, and labour demand and supply on the other. He received his Master's degree in urban geography and planning, specializing in statistical analysis and econometric modelling from the University of Nijmegen, the Netherlands. After a twenty year career at TNO – the Dutch National Organisation for Applied Scientific Research – he started the company Momentum Technologies in 2000 together with a number of colleagues.

**Małgorzata Renigier** (aka Renigier-Biłozor) has been Assistant Professor in the Department of Real Estate Management and Regional Development at the University of Warmia and Mazury, Olsztyn, Poland since 2005. Her major fields of research interest comprise systems of real estate management, value forecasting, non-linear analysis in modelling of real estate value, influence analysis of stochastic factors on the real estate value, and application

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**Marius Thériault** is a geographer and Professor at the Graduate School of Land Planning and Regional Development, Laval University, Quebec, Canada, where he has been teaching GIS, spatial analysis, applied statistics, applied computing and climatology since 1979. His research activities are about combining GIS, spatial statistics, GPS and spatio-temporal modelling to further studies related to real estate markets, mobility behaviour, accessibility to urban amenities, environmental impacts assessment and urban planning. From 2000 to 2006 he was Director of the Land Planning and Regional Development Research Centre at Laval University. He is currently involved in several research networks and peer reviewed journals in Canada and Europe. Findings of his research are published in more than 40 journals relating to urban economics, housing, geography, geographical information science, transportation planning, computer science, environment, health and regional development.

**John F. Thompson, Jr** has over 30 years of experience in designing, developing and implementing computer-assisted mass appraisal (CAMA) systems. He has been responsible for numerous systems development and application projects, including management and direction of the Company's systems

activities on CAMA implementation projects in 25 states in the USA and several provinces in Canada. His background includes computerization of a variety of valuation manuals, including state manuals in 10 states, and experience in modelling and valuation analysis in scores of communities. In addition, he has provided training and consulting services to assessment staff throughout the USA. He has also written articles for various International Association of Assessing Officers (IAAO) publications and contributed several chapters to the IAAO Property Valuation Assessment textbook, edited CAMA newsletters, and presented papers on a variety of topics at assessment conferences. His academic training includes applied mathematics, computer software, operations research, and environmental engineering. He received both a BS and an MS in mathematics from Rensselaer Polytechnic Institute in 1973.

**Paulien van de Hoef** studied econometrics at the University of Groningen, the Netherlands. After graduating, she specialized in the development of computer systems for decision support in a number of fields, amongst them marketing and media. Since 2004 she has worked at Momentum Technologies, where she plays an important role in the analysis of the housing market and the development of web-based market information and valuation systems.



# Foreword

This book provides an authoritative outline of current mass appraisal techniques being used internationally and in-depth research into state-of-the-art developments that are likely to permeate the industry over the next decade. The editors indicate that the 'book explores the possibilities for developing mass appraisal methods, following two different arguments: firstly, that the performance and feasibility of appraisal methods be compared and evaluated with regard to a set of technical criteria, and secondly, that differences in the suitability of methods also have to do with the particular context where application takes place.'

Each chapter's author(s) select a particular aspect of mass appraisal and provide empirical analysis on a variety of modelling techniques. The research published within the various chapters has addressed the book's three core objectives: firstly, to understand the problem of advancing mass appraisal methods/expertise from both the perspective of scientific debate and the practical feasibility; secondly, to evaluate a set of heretic and orthodox methods based on a set of specific criteria, partly technical/practical and partly institutional; and finally, to establish an international platform for broader networking within this realm. The research has clearly met the objectives and has taken this area of 'mass valuation/appraisal' to the next level in terms of international significance. The various chapters provide a rigorous analytical framework within which various modelling paradigms are developed.

In the first chapter, Kauko and d'Amato set out to explore the possibilities within this under-theorized problem area. In essence, mass appraisal may be defined as a systematic appraisal of groups of properties using standardized procedures where the methodologies normally being applied refer to large groups of properties rather than to a single property. Currently, two related modelling traditions exist, both of which deploy multiple regression analysis (MRA) for estimation, the model-driven hedonic approach, and the data-driven statistical approach. The authors contend that MRA-based hedonic price models may not be suitable for capturing all the necessary information involved in the value formation process, and the literature on how to develop the value modelling tools further is at best evolving. On the other hand, there are property markets where data are not available, or, even if such data are available, it may not be organized into a property data bank. In this case, other types of automated valuation methods (AVMs) with a less deterministic relation between property value and property attributes may be of assistance. Although the problems are highlighted, MRA remains currently the most important theoretical framework in mass appraisal.

The authors suggest that when examining current trends of valuation modelling research, a likely scenario would be that price research is going towards spatial tools on one hand, and on the other hand towards pragmatic tools. In terms of this trend, according to the authors, there are two different arguments concerning advancement: firstly, following the orthodox view, to remain within equilibrium modelling and sophisticated econometric techniques in order to align with the academic tradition, and secondly, following a more heretic/heterodox view, to only consider the practical aspects of accuracy and feasibility which would permit looking beyond hedonic modelling extensions towards computer simulation, artificial intelligence and machine learning paradigms.

Thompson, in Chapter 2, provides a review of property data issues and then develops a mass valuation case study of a jurisdiction in the USA. The author rightly contends that the performance of automated models and valuation methodologies are related to a number of factors, the principal one being the quality of the data and its fitness for use in the modelling/valuation process. This applies not just to the attributes, but also the coding of the sales or market transactions as to their appropriateness for use in the market analysis and valuation processing. Data is crucial to the mass appraisal process and often the sources of data need to be investigated so as to have confidence in their quality, accuracy and applicability. Often agencies (private and government) may have captured information of limited use as it was not collected for valuation purposes and may be incomplete. The author also suggests that the performance of models varies depending upon the nature of the population(s) of property being modelled, the ready availability of market data on property in setting asking prices, the availability of housing (numbers of properties available for purchase) and overall frequency of sales activity. These all feed into the overall uniformity/efficiency of the market and will impact on the performance statistics generated against the sales transaction base to evaluate the performance of the AVM.

Borst and McCluskey in Chapter 3 state that the traditional comparable sales method of valuation (CSM) is widely used in the USA, the UK and indeed many other countries for the valuation of residential properties. In these jurisdictions, there is a clear and identifiable relationship between CSM as practised by mass appraisers and the recent developments in spatially aware valuation models. The authors of this chapter take the position that the CSM and modified comparable sales method (MCSM) are certainly among the best, if not the best, methods for mass appraisal. Other potential techniques for best practice would include the use of a well structured linear or non-linear model calibrated for an entire jurisdiction, market segmentation models, the 'response surface' method, and a collection of advanced modelling techniques including geographically weighted regression (GWR).

This chapter provides a detailed comparative analysis of a selected subset of these techniques to the CSM and MCSM.

In Chapter 4, Op 't Veld, Bijlsma and Van de Hoef explain the characteristics of the Dutch housing market and the role the realtors or estate agents play in the valuation process. Clearly, this is an important role as the agents are involved in the sale of approximately 90% of all dwellings sold in the Netherlands. This system is heavily reliant on quality data which is provided by and shared amongst the participating agents. Through a web-application, an automated valuation of any house can be provided given its underlying data by means of a hedonic price model. The system is designed to allow all member-offices of the Dutch association of realtors, NVM, to share information on the houses they have on offer for sale through the web-based TIARA-communication system. 'MarktPositie' is essentially the valuation framework that is used by realtors to value one house at a time. However, in its present form it cannot readily be used for the automated mass valuation of the entire housing stock of a municipality or region. This is primarily because the data for the entire housing stock of a municipality are not comprehensive. For this system to work within the mass appraisal context for all dwellings, data on properties that have not been sold would need to be collected.

The authors of Chapter 5 (d'Amato and Siniak) consider that the property market is often viewed as inefficient due to its heterogeneity, illiquidity and high transaction costs, and considerably more inefficient in those transitional democracies of Eastern Europe where confidence in property data is relatively low. As a consequence, property valuation techniques need to deal with a higher level of uncertainty than, for example, the stock market. The authors attempt to demonstrate the application of 'fuzzy logic and numbers' to property valuation and property investment appraisal. It is generally accepted that the use of fuzzy logic techniques can assist in deriving a mathematical solution in cases of high levels of uncertainty. This research indicates an interesting comparison between two different approaches in relation to uncertain information; these are, the most probable selling price, and the most possible selling price.

Des Rosiers and Thériault in Chapter 6 provide a detailed exposition of the application of hedonic modelling for estimating the implicit prices of attributes pertaining to heterogeneous goods. The authors take the view that, given the highly complex nature of real estate which consists of buildings, land and neighbourhood characteristics, it soon became a prime target for hedonic price modelling where it was applied for various purposes, among which was the estimation of the marginal contribution of urban externalities – namely environmental ones – to market values. This chapter looks at the rationale and conceptual framework underlying the hedonic approach;

issues around the functional form issue which are addressed with particular reference to the measurement of proximity effects on house values; innovative ways to account for a major determinant of property prices, namely accessibility to urban services; the problems of spatial dependence are investigated and alternate modelling procedures designed at handling spatial autocorrelation are discussed.

In Chapter 7, Renigier claims that residuals are phenomena which fail to be explained by mathematical models because of a lack of the relevant statistical data, incomplete theoretical and practical knowledge about the modelled area and/or because of the dynamic, frequently unforeseeable, tempo of change of the study area. The author has put forward a number of considerations to provide grounds for the claim that integration of geo-deterministic inference (represented by the geostatistical model) and geo-stochastic inference (represented by maps of residuals), linked to space valuation, makes it possible to dynamically diagnose and characterize spatial phenomena and to make rational forecasts (and, consequently, planning) of changes in space and the real estate market.

Francke in Chapter 8 presents a time series model for selling prices of houses, called the hierarchical trend model (HTM). This statistical approach has been successfully used in the Netherlands for the valuation of approximately one million houses for property tax purposes. In essence, a structural time-series model for house prices is described that has proven its value for almost a decade. The author argues that the main strengths of the HTM are the modelling of the time dependence of the selling prices and the sophisticated way of modelling the housing characteristics. In addition, the HTM also addresses the problem of spatial dependence of the selling prices, but in a rather straightforward way with some parameters varying over time and other parameters remaining constant over time.

In Chapter 9, González argues that there are several deficiencies with the use of regression techniques in mass appraisal, for example, real data have several sources of error or imprecision, such as the lack of correct specification of model format, multiple simultaneous relationships among the explanatory variables, and rather imprecise transitions between submarkets. As an alternative, the author has approached the problem by developing more flexible and comprehensive models such as those based on fuzzy systems. Research does, however, conclude that fuzzy systems on their own may not replicate market characteristics and therefore they are applied in association with other techniques, such as artificial neural networks (ANNs) and genetic algorithms (GAs), performing hybrid systems.

In Chapter 10, Kauko deals with two modelling techniques; firstly, the self-organizing map (SOM, also known as the Kohonen Map), and secondly, the analytic hierarchy process (AHP, also known as the Saaty method of elicitation). While being fundamentally different, the two methods potentially

complement more conventional methods of data analysis. The research discussion shows the possibilities and limitations for using the two proposed approaches for 'heretic' mass appraisal. Arguably, the author contends that the approaches put forward are better suited for situations where the market place is affected by frictional factors, monopoly price or other circumstances, when various externalities or simply human behaviour are suspected to have an effect on values, but the extent of which is yet to be comprehended and assessed in monetary terms.

d'Amato in Chapter 11 presents a summary of the application of rough set theory (RST) to mass appraisal. The author has applied the methodology to a small sample of real property transactions in the residential real estate market of Bari, Italy. Essentially, RST's application to property valuation does not require a model or underlying assumptions. The valuation process is directly obtained from observation, in this case the valuation process relies on an internal knowledge only. The chapter then provides a comparison of MRA and RST carried out on a sample of 7107 observations located in the Catawba County in North Carolina. The results of the work demonstrate the potential that RST has in providing relatively accurate predictions of value.

In Chapter 12, the authors (Borst, Des Rosiers, Renigier, González, Kauko and d'Amato) test various modelling paradigms on data with a view to discerning the most 'appropriate' in terms of predictive accuracy. Each researcher has used their own data sets and attempted to evaluate different approaches in terms of measures such as error, absolute error, coefficient of dispersion (COD), etc.

In Chapter 13, d'Amato and Kauko propose a protocol for the application of mass appraisal valuation methodology based on selected criteria. The authors contend from the empirical research so far, it can be concluded that a mass appraisal methodology may be rigorous in itself, but institutionally not suitable for the application in a given property market context. An analysis of market features should therefore be the premise for the application of a specific mass appraisal valuation methodology where MRA may be justified, or the premise for the use of an alternative method in an emerging market.

The final chapter (14) by Kauko provides a critical review with brief synopses of the various chapters. In this chapter, the author suggests that the future direction of research may be towards the use and application of a variety of methods in different property market contexts, in order to better define a paradigm of suitability of a method for each property market.

The contribution that this book provides to the existing body of knowledge lies in its applicability to both industry and academia. The use of mass valuation techniques does not lie exclusively within the domain of property tax assessment departments. The techniques outlined in this book are being aggressively developed by financial institutions in their quest to provide fast and efficient AVM solutions in real time. The book provides an insight into

the traditional/conventional or pragmatic techniques as well as some of the other more 'academic' and cutting edge approaches. The discipline of mass appraisal has been evolving over the last 50 years and clearly, as this book demonstrates, considerable development has already taken place.

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