GEOGRAPHY, LAND VALUES, AND MUNICIPAL TAXATION

GEOGRAPHY, LAND VALUES, AND MUNICIPAL TAXATION:
A SPATIAL PARADIGM FOR THE ESTIMATION AND RECLAMATION OF RENT

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ABSTRACT

This dissertation provides an investigation into the confluence of three basic themes; geography, land values, and municipal taxation. This research examines the role of geography as it applies to addressing the inherent structural problems of the municipal property tax system, which result in inequities in municipal tax burdens. These structural problems are caused, in part, because traditional specifications of mass appraisal models are unable to sufficiently incorporate the impact of geography and because the property tax system is based more heavily on the value of capital improvements, such as buildings, than the value of land. Convincing evidence suggests a municipal taxation system based more heavily on the value of land could help mitigate many negative consequences of the property tax; thus, this research examines a spatial paradigm for the estimation of urban land values in order to study the short-run implications of transitioning to a land value tax system.

After reviewing geography's contribution to the professional practice of real estate appraisal, this dissertation describes a spatial decision support system (SDSS) that was used to extract and validate sales of vacant land from the population of real estate transactions that occurred in Hamilton, Ontario between 1995 and 2004. Vacant land transaction prices were used to explore the spatial dynamics of land price appreciation and depreciation rates, investigate the potential for spatial models to improve the accuracy and fairness of mass appraisal, and to simulate the spatial distribution of shifting tax liabilities for residential land uses under the property tax and land value tax systems in order to examine their relationship to area-based deprivation indices. Results suggest there remains much potential for geography to make significant contributions to assessment practice, municipal taxation, and urban planning. Furthermore, there is much potential for land value taxation to contribute to equitable and sustainable cities.

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PREFACE

This dissertation is a compilation of five research papers that have been submitted for publication in peer-reviewed journals. The research papers are as follows:

Chapter 2: Spinney, Jamie E.L. and Kanaroglou, Pavlos S. (2010) What Happened to Geography in Real Estate Appraisal Practice? A Critical Review of "The Appraisal Journal", Submitted to *Journal of Real Estate Literature.*

Chapter 3: Spinney, Jamie E.L., Kanaroglou, Pavlos S. and Millward, Hugh (2009) Improving Access to Land Price Data: A Spatial Decision Support System for Cleansing Land Registry Data, Submitted to *Canadian Journal of Regional Science.*

Chapter 4: Spinney, Jamie E.L., Kanaroglou, Pavlos S. and Scott, Darren M. (no date) Exploring Spatial Dynamics with Land Price Indexes, *Urban Studies*, DOI: 10.1177/0042098009360689.

Chapter 5: Spinney, Jamie E.L. and Kanaroglou, Pavlos S. (2010) Location and Land Values: Comparing the Accuracy and Fairness of Mass Appraisal Models, Submitted to *Urban Geography.*

Chapter 6: Spinney, Jamie E.L. and Kanaroglou, Pavlos S. (2010) Municipal Taxation and Social Exclusion: Examining the Spatial Implications of Taxing Land Instead of Capital, Submitted to *City, Culture and Society.*

It is noteworthy that some repetition of content is to be expected in the different chapters, particularly the descriptions of the study area, because they were compiled as stand-alone manuscripts. The design, analysis, interpretation, and writing of the manuscripts were completed by the author of this dissertation. The contributions of the co-authors, Dr. Pavlos Kanaroglou, Dr. Darren Scott, and Dr. Hugh Millward, included critical appraisal and editorial reviews of the respective manuscripts.

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CHAPTER 1: Introduction

1.1 Justification of Research Topic

The foremost own-source revenue for Canadian municipalities is the property tax, (Bird and Slack, 1983), but the property tax has also been labelled the "worst tax" (Fisher, 1996). One of the criticisms lodged against the property tax is that it discriminates against the owners of the most affordable housing by over-assessing the least expensive properties and under-assessing the most expensive properties (Black, 1972; Paglin and Fogarty, 1972; Thrall, 1979b; Dean, 1980; McCarthy and Ray, 1991; Kuz and Saprovich, 1994; Cox and Studer, 1997; Harris and Lehman, 2001), which, due to the spatial distribution of housing stock in metropolitan areas, typically results in the highest tax burdens for inner-city homeowners (Townsend, 1951; Johnson, 1958; Zimmer, 1958; Oldman and Aaron, 1965; Black, 1972; Peterson, 1973; Bird and Slack, 1978; Thrall, 1979a; Walzer and Fisher, 1981). This discrimination against lower-priced homes and the spatial distribution of inequities has been explored in Hamilton, Ontario on at least three separate occasions (Davies, 1978; Thrall, 1979a; Harris and Lehman, 2001). While spatial models may provide some remedy for the systematic spatial variation of property tax inequities, most of the problems stemming from the property tax system are due to the fact that a tax levied on capital will inevitably discourage its use.

There is, however, an alternative municipal taxation system, referred to as site value or land value taxation, whereby the value of land is taxed proportionately higher than the value of capital. In fact, economists have had a longstanding interest in the taxation of land values as an economically sound and practically viable alternative to the property tax. One of the primary reasons for supporting the land value tax is to provide a mechanism for reducing "the unpleasant consequences of high taxes on land and buildings, both in respect to their regression and to their disincentive effects on the making of improvements"

(Hicks, 1970, p. 9). This disincentive effect of the property tax is echoed by George (1879, rpt. 1958, p. 434)

> *If I have worked harder and built myself a good house while you have been contented to live in a hovel, the tax gatherer now comes annually to make me pay a penalty for my energy and industry, by taxing me more than you.*

Land value taxation is not a new concept in Ontario. In fact, it dates back to Ontario's Assessment Act of 1904, which provided for the separation of land and buildings in the belief that this separation would allow assessors to provide more equitable assessments. Furthermore, a Committee of the Ontario Legislature was appointed in 1909 and 1912 to examine the feasibility of system of property taxation that taxed improvements at a lower rate than the land. However, the Ontario Assessment Act of 1969 ended the separate valuation of land and buildings, which has hindered any subsequent investigation into the potential effects of land value taxation in Ontario.

Unrelenting cries for property tax reform and continued interest in the potential benefits of land value taxation has resulted in a few research projects that evaluated the effect of land value taxation in terms of the degree to which tax burdens would be shifted among different land use classes. For example, tax-shift studies have been performed for Rodney, Ontario (RTTPTC, 1991); Peterborough, Ontario (McCarthy and Ray, 1991); and Montreal, Quebec (CRCT, 1998) to simulate a revenue-neutral shift in tax liability among the different property classes. However, to the best of our knowledge, few studies have examined the spatial distribution of shifting tax burdens among residential land uses and none have examined the relationships between social exclusion and shifting tax burdens under the two municipal tax systems.

The purpose of this dissertation is to investigate the role of geography as it applies to addressing the inherent structural problems of the municipal property tax system; specifically it examines the ability to capture the geography of urban land prices in mass appraisal models as a means of improving accuracy and fairness (i.e. equity) of the estimated (i.e. appraised) value. The lessons learned from this examination were used to estimate urban land values for the City of Hamilton in order to simulate a revenue-neutral shift of tax liabilities for residential land uses under a land value tax system. The simulation provides unique insights into the spatial distribution of shifting tax liabilities plus the relationship between social exclusion and municipal tax burdens for residential properties under both the property tax and land value tax systems.

1.2 Scope of Research Topic

The scope of this dissertation is defined by the prevailing task of comparing tax burdens for residential land uses under the existing property tax system and the simulated tax burdens under a revenue-neutral shift to a land value tax system. Consequently two specific, yet interrelated, prerequisites were identified to complete this task. First, property tax burdens were necessary and they were determined using tax roll data for 2003, which were acquired from the City of Hamilton Finance Department. However, before comparing property tax burdens with land value tax burdens, it was necessary to first estimate urban land values. Accordingly, the second requirement was to acquire vacant land price data so they could be used to generate fair and accurate estimates of urban land values that represent land market conditions for the City of Hamilton in 2003. The estimated land values were used to perform a revenue-neutral comparison of shifting tax liabilities among residential land uses under the existing property tax system with simulated tax burdens under a land value tax system. While tax-shift studies have been performed elsewhere, few have examined the spatial distribution of shifting tax liabilities or used spatial modelling techniques to generate estimates of urban land values. Moreover, this study represents the first to examine the relationship between the property tax and social exclusion, and whether this relationship can be mitigated under a land value tax system.

1.3 Contents of Dissertation

The remainder of this dissertation is organised as follows. Chapter 2 presents the results from a critical review of geography's contribution to the professional practice of real estate appraisal. Based on a search for occurrences of "geography" and geography-related terms over the past four decades in "The Appraisal Journal", the frequency of occurrences was used to provide an objective quantification of geography's impact on the professional practice of real estate appraisal. Additionally, the critical review of all articles containing the term "geography" illustrates its changing use over time, which indicates that geography continues to have a positive, yet limited, influence on the professional practice of real estate appraisal. Moreover, geography's influence appears to be diminishing.

Chapter 3 presents a detailed description of the methods used to cleanse real estate transaction data from the Land Registry office, which, among the limited sources of land price data in Canada, is considered the "dirtiest". For example, they are prone to data quality issues such as data entry errors, a lack of structural and neighbourhood variables, an inability to distinguish between past and present land uses (e.g. residential, commercial), and the presence of non-arm's-length transactions (Pollakowski, 1995). Chapter 3 describes how geographic information system (GIS) techniques were used to develop a spatial decision support system (SDSS) framework in order to (a) extract sales of vacant land, and (b) verify accurate price information.

Using these vacant land transaction prices, Chapter 4 presents an exploration of the within-region spatial dynamics of appreciation and depreciation rates using three different representations of geographic space. Chapter 4 describes how mean value indexing methods are used to construct (i) global land price indices, (ii) submarket land price indices, and (iii) local land price indices for the City of Hamilton, Ontario between 1995 and 2003. After validating the results against Statistics Canada's series of New Housing Price Indices, the relative performance of the three geographic representations of land price indices are compared. The results clearly illustrate the spatial dynamics of annual appreciation and depreciation rates within a metropolitan area, which underscores the need for regular surveillance of urban land markets at a local scale.

Chapter 5 illustrates attempts to incorporate the impact of location into the mass appraisal of urban land values. In contrast to traditional specifications of hedonic price models, which inherently fail to adequately capture the influence of location, Chapter 5 explores the potential for spatial model specifications to improve the accuracy and equity of urban land value estimates by comparing the relative performance of ordinary least squares regression with both spatial autoregressive and ordinary Kriging models. The purpose of this comparison is twofold: investigate (i) the relative out-of-sample predictive accuracy of each model; and (ii) the respective ability of each model to produce fair estimates of urban land values for Hamilton, Ontario. The results indicate that the hedonic price models may provide more accurate estimates of residential urban land values, but spatial interpolation may help promote fairness.

Chapter 6 presents a comparison of shifting tax liabilities among residential land uses under the existing property tax system and simulated revenue-neutral tax burdens under a land value tax system for the City of Hamilton, Ontario. Chapter 6 also describes the methods used to objectively quantify susceptibility to social exclusion in order to evaluate its relationship with the property tax and whether this relationship can be mitigated under a land value tax system. The results illustrate a clear spatial pattern in the distribution of both shifting tax burdens and social exclusion and they also suggest that both forms of municipal taxation contribute to social exclusion, but land value taxation appears to mitigate that contribution.

Finally, Chapter 7 provides a discussion of the major findings of this dissertation and implications for assessment practice and both municipal taxation and planning policies. Chapter 7 also suggests directions for future research.

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CHAPTER 2: What Happened to Geography in Real Estate Appraisal Practice? A Critical Review of "The Appraisal Journal"

2.1 Introduction

The purpose of real estate appraisal, or assessment, is to provide an expert opinion of the market value for real property. Because real estate prices are inherently spatial data and real estate assessments provide the basis for *ad valorem* property taxes, which influence real estate market and lending decisions and affects the social geography of urban areas, it is worth investigating the extent that the real estate appraisal industry has adopted geographic reasoning and techniques as a means of accounting for the impact of geography. Although the impact of location on the value of real estate is well accepted, a fact evidenced by the popular adage "location, location, and location", the professional practice of real estate assessment has traditionally been unable to easily, accurately, and efficiently quantify the impact of location and incorporate it into the appraisal of real estate values.

Over the past few decades, however, new and improved geographic reasoning and spatial analysis techniques are available to help overcome many of the previously cited difficulties for capturing and integrating the impact of location into the professional practice of real estate appraisal. For example, geographic information systems (GIS), which became widely available and accessible in the early 1990's, provide a host of powerful techniques to capture and incorporate the impact of location. In addition, improvements in data availability and data quality provide exciting opportunities for geography to make significant contributions to the professional practice of real estate appraisal. These opportunities are increasingly being exploited by geographers, regional scientists, and real estate academics. On the other hand, and despite evidence that the appraisal industry appears particularly fascinated by the interactive display capabilities of GIS for auditing purposes, we believe there remains considerable untapped potential for geography to improve the accuracy, equity, explainability, and defendability of real estate assessments.

Previous research exploring geography's potential impact on the professional real estate appraisal industry has tended to concentrate, often solely, on GIS applications. In contrast, the purpose of this review is to objectively quantify geography's influence on the professional practice of real estate appraisal. Based on the concept of "brand awareness" from marketing research, which is used to measure the "depth of coverage" and the "reach" of a given brand name, we performed a search for the term "geography" in the Appraisal Institute's (www.appraisalinstitute.org) quarterly publication entitled "The Appraisal Journal" (TAJ). This study explored the changing frequency of occurrences for several geography-related terms in order to measure the "reach" of geography, and also critically reviewed each occurrence of the term "geography" in order to gauge the "depth of coverage". The results provide evidence of geography's influence on the professional real estate appraisal industry, and generate discussion about geography's potential contribution to the accuracy, equity, explainability, and defendability of real estate assessments. In the concluding remarks we suggest that considerable potential appears to remain.

2.2 Methods

In order to systematically and objectively review the general acceptance, or brand awareness, of "geography" by the real estate appraisal industry, several geography-related search terms were used to explore the prevalence of each term in the professional literature. TAJ is described as providing "hands-on information ... written by leading practitioners in the appraisal profession"[1], and was chosen as the primary source of information to investigate the "awareness" of professional real estate appraisers (consumers) about the "brand" called "geography". For this study, a search was performed for the terms (a) geography,

[1] Reference drawn from www.appraisalinstitute.org/taj/Default.aspx

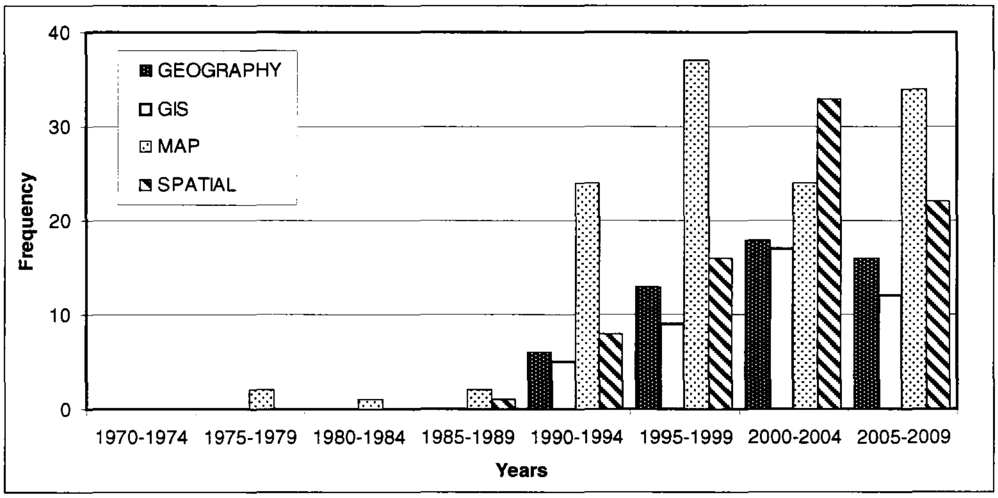
(b) GIS, (c) map, and (d) spatial, using all articles contained in TAJ between 1971 and the end of 2009, which represents more than 38-years of uninterrupted quarterly publications. However, it is noteworthy that "full text" coverage TAJ articles did not begin for the on-line ProQuest® database until Jan 1988, meaning articles before that time would only have the title, key words, author affiliation, and abstract information included in the search. The articles containing geography-related search terms were exported and formatted in a database format, duplicate cases removed, and the date (i.e. year) information was formatted. Each article containing the search term "geography" was subjected to a critical review of the context in which the term was used.

2.3 Results

The occurrences of geography-related terms in TAJ are used to measure the overall reach of geography in the professional real estate appraisal industry. The nonexclusive search, meaning that multiple geography-related terms may appear in a given article, returned 53 articles with the term "geography", "GIS" returned 43, "map" returned 124, and "spatial" returned 80. The frequency distributions for each search term, grouped into five-year categories for display purposes, are depicted in Figure 2-1.

Considering full-text coverage began in 1988, Figure 2-1 illustrates the first mention of geography-related terms was "maps" by Allen and Mudge (1975), who outlined methods to identify impacts of investments in transportation infrastructure at a "local" scale. Other than using maps to illustrate study areas, value maps (e.g. housing values) are rarely discussed, with the exception of Ohno (1985), who described the methods and benefits of land value maps. Despite two years of full text coverage during 1988 and 1989, there were only two occurrences of "map" (Ohno, 1985; Golicz, 1989) and a single occurrence of the term "spatial" (Robbins, 1987). Roughly coinciding with the introduction of commercial desktop GIS software, the reach of geography and related terminology appears to have expanded in the early 1990's.

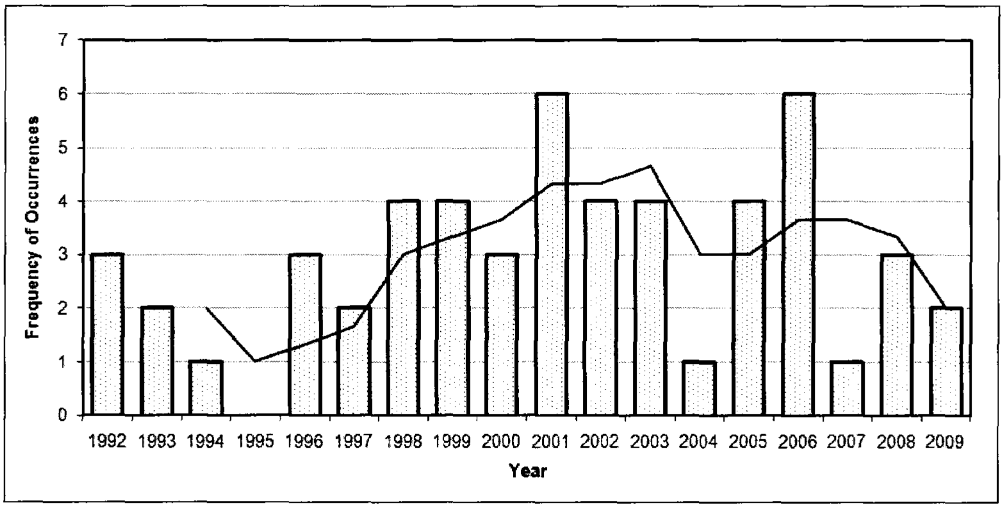
Figure 2-1: Frequencies of Geography-Related Terms in "TAJ"



The past two decades of professional real estate appraisal literature illustrate a general trend, with the exception of "map", of increasing frequencies for each search term that peaked between 2000 and 2004 and subsequently exhibits a trend of levelling off or possibly even decline. In order to further investigate this apparent declining trend, we used a histogram (Figure 2-2) to illustrate the annual occurrences of "geography" in TAJ. We also added a trend line, using a moving average of three data points, in order to smooth out annual variations and illustrate the trend more clearly.

After a sudden appearance of "geography" in the early 1990's, which includes a review by Aalberts and Bible (1992) of many potential benefits of GIS, the occurrences of geography soon decreased to zero occurrences in 1995, which was followed by a precipitous increase in 1996 that continued through the turn of the century. However, there was a dramatic decline in 2004 that appears to have initiated a recent period of steady decline. If the use of "geography" truly reached its peak between 2001 and 2006, and the overall trend continues to exhibit a decline, then it is cause for much concern that warrants further inquiry.

Figure 2-2: Annual Occurrences of "Geography" in TAJ with Trend Line



While the number of occurrences for each geography-related search term provides a measure of the reach of geography in the professional real estate appraisal literature, it provides no information about the depth of coverage. Therefore, all 53 TAJ articles containing the search term "geography" were critically reviewed insofar as the context in which the term was used. Based on the review, five main contexts were identified; (i) distance measures, (ii) market areas, (iii) spatial statistics, (iv) mapping, and (v) other. Unlike previous reviews, we discovered the occurrences of GIS did not warrant a distinct subsection, but any use of GIS technology is mentioned in the following subsections reviewing the usage of the term geography.

2.3.1 Distance

One area that geographic reasoning and techniques can make a significant contribution to the professional practice of real estate appraisal is the ability to provide improved measures of distance. For example, it is common practice to add independent variables that fluctuate over space to regression models in order to account for the impact of geography, such as distance to the central business district (CBD), accessibility, or a variety of other situation-specific variables that are commonly used as surrogate measures of neighbourhood quality. Almost 10%

of the 53 TAJ articles containing the term "geography" described distance measurements, where GIS was used to measure distance to power lines (Kung and Seagle, 1992), an oil spill (Simons *et al.*, 2001), sex offenders (Larsen *et al.*, 2003), nearest coastline (Bourassa *et al.*, 2006), and the CBD (Bourassa *et al.*, 2006; Haughey and Basolo, 2000).

2.3.2 Market Areas

Defining market areas is an important component of both market analysis and market stratification, or market segmentation. Market analysis examines social, economic, land use, and price trends for a single development. Early work by Barnett and Okoruwa (1993) employed GIS to perform location analysis and other aspects of the site selection process for a residential subdivision. Bainbridge (2000) provided instruction on the use of the location quotient for determining market areas for convenience stores, which he follows up again with a related application in 2003. Rabianski (2006) discussed the importance of delineating the geographic boundaries of market areas for apartments and recommends the use of maps for this purpose, but makes no mention of GIS capabilities. Two other articles made tangential mention of market boundaries: Wolverton and Bottemiller (2003) used counties as dummy variables to examine the impact of being adjacent to a high-power transmission line; and, Parli (2008) discusses methods (e.g. 10-mile radius) for defining boundaries for market analysis studies, but he made no mention of spatial techniques or GIS. Notwithstanding Bainbridge's (2000, 2003) use of the location quotient for determining market areas for convenience stores, we found no mention of using GIS to define sub-market boundaries in the TAJ articles containing the term "geography".

2.3.3 Spatial Statistics

The inherent geographic nature of real estate data causes them to exhibit unique characteristics. For example, geographic data often exhibit spatial autocorrelation[2] and spatial heterogeneity[3] and both can cause problems for the most frequently used mass appraisal modelling technique - multiple regression analysis. There are several spatial modelling techniques that explicitly incorporate the spatial configuration of geographic data, but there are few examples of spatial models being used in TAJ. Notably, however, Price (2002) used spatial statistics and maps to illustrate the advantages of continuous surfaces compared to submarkets for commercial real estate appraisal, and more recently, Shultz (2007) used GIS to create continuous surfaces (Kriging) of land prices to compare them with surveys of land values. Other then these two examples, we found no mention of spatial statistics for exploratory data analysis or spatial regression in the TAJ articles containing the term "geography".

2.3.4 Mapping

Maps are one of the first and most basic communication tools of geography. Maps provide (i) an intuitive and informative means of exploring the spatial pattern of real estate values across the assessment jurisdiction, (ii) an auditing tool for identifying outliers and mistakes, and (iii) an important means of communicating (explaining) results. These benefits were recognised by Aalberts and Bible (1992, p. 484), who used maps in order to examine the spatial distribution of mortgage defaults in Louisiana and suggested "maps are an indispensable tool for understanding and interpreting spatial patterns and relationships" and are also "an important medium for communicating spatial messages". Also capitalizing on the benefits of maps, Bourassa *et al.* (2006) used GIS to map housing sales, while Shultz (2007) used GIS to map land values. Also noteworthy is a recent article by Hoyt and Aalberts (2008) that discussed maps being accepted as part of expert testimony.

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[2] Spatial autocorrelation is the result of the phenomenon that nearby values of a spatial variable are not independent (similar values are clustered in geographic space).

[3] Spatial heterogeneity or non-stationarity occurs because statistical properties of spatial phenomena are rarely independent of their location, so the mean, variance, or the covariance structure tends to vary over the study region (spatial drift).

2.3.5 Other

Other uses of the term "geography" include specific theoretical and technical references to "geography", such as Reed's (2001) introduction to social area analysis. Other uses also includes several perfunctory occurrences, where the usage was in reference to geographic landform features (Wilson, 1996), how water is perceived on the east and west of the Mississippi River (Cohen and Golub, 1996), or real estate asset performance in different countries (Ziobrowski and Curcio, 1992; Ball, 2009). Other usage of the term "geography" is dominated by author's biographies, affiliations, and occasionally referenced material. This final group of occurrences reflects, for the most part, at least some contribution that geography has made to the real estate appraisal industry. For example, of the 22 occurrences of "geography" in either the references or author biographies, 4 mentioned spatial statistics, 3 mentioned maps, 2 mentioned boundaries, and 6 mentioned distance.

2.4 Discussion

Based on a systematic review of the depth of coverage for the term "geography" in a sample of the professional real estate appraisal literature (i.e. TAJ), we take this opportunity to discuss the extent to which geography has reached its full potential insofar as improving the (a) accuracy, (b) equity, and (c) explainability and defendability of real estate assessments. The accuracy of real estate assessments could benefit from geographic reasoning, geomatics technology, and spatial analysis techniques by enhancing the understanding of market processes, improving the ability to measure distance and accessibility, defining markets and their boundaries, and performing an increasing variety of spatial analysis techniques. Indeed, Smith (2001, p. 193) argues that "geographic knowledge and competence are required of an appraiser". However, the apparent lack of references in TAJ to GIS in particular, which is especially troubling in articles that describe methods used to measure distance and create market boundaries, coupled with few examples using spatial analysis techniques, leads us to suspect evidence of untapped potential for geography to improve the accuracy of real estate assessments.

Despite the fact that real estate assessments are now supported by geographic theory, GIS, and spatial statistics, why does research continually discover a spatial pattern (i.e. clustering) of high and low ratio values across the study area, which represent social and geographic inequities of the property tax[4]. The answer stems from the inability to account for the spatial distribution of high value and low value properties. However, we found no mention of tax inequities in the TAJ articles containing the term "geography" or any discussion of the potential for geography to mitigate them, which leads us to suspect evidence of untapped potential for geography to improve the equity of real estate assessments.

Recall that the purpose of real estate assessment is to provide an expert opinion of the market value for real property, and that estimate should be both explainable and defendable. Explainability and defendability are important requirements, because real estate appraisers are often required to defend their estimates of market value or give expert testimony in court. Therefore, the professional practice of real estate appraisal should be particularly interested in geography's potential contribution to improve the defendability of their estimates of market value in court. This issue has received some attention in TAJ from Hoyt and Aalberts (2001), who explains how GIS was used to value wilderness and the method was accepted as expert testimony. Hoyt and Aalberts (2008) also provide a discussion of legal testimony regarding the qualifications of an expert witness where "maps" and "distance" are perfunctorily mentioned[5]. Consequently, we

[4] Studies of property tax equity have found systematic spatial variation across the study area, whereby the cheapest properties tend to be over-assessed and the most expensive properties are under-assessed.
[5] It is noteworthy that the only use of the term "geography" in these two articles relates to the biographical information for Robert J Aalberts, who received his MA in geography from the University of Missouri.

believe there may be some evidence of untapped potential for geography to improve the explainability and defendability of real estate assessments, especially regarding the use of value maps.

2.5 Concluding Remarks

There is a rapidly expanding body of literature that documents the many and varied applications of spatial models and geomatics technology in real estate research, and it is important that the professional practice of real estate assessment benefits from the theory and tools that geography has to offer. In order to gauge the "reach" and "depth of coverage" of geography in a sample of the professional real estate appraisal literature, this study searched 3237 articles spanning almost 4 decades and reviewed each of the consequent 53 articles containing the term "geography". Given this straightforward research design, this research is not without its limitations. Despite the eminence of the journal chosen to review, the sample is limited to a single journal. Furthermore, it is important to consider the sample of occurrences of the search term "geography" (n=53) included several observations in the "other use" category, ranging from a minimum of 14.3% (in 1990 to 1994 period) to a maximum of 42.9% (in 1995 to 1999 period). The results may benefit from a more comprehensive review of each geography-related search term, or the inclusion of additional search terms. Furthermore, the results may also benefit from reviewing additional professional real estate appraisal journals and magazines, including a sample from other parts of the world. However, despite the limitations of this study, we do not believe our conclusions would change significantly regarding the influence of geography on the professional practice of real estate appraisal.

The results of this review indicate that, although geography continues to play a positive role in the professional practice of real estate appraisal, geography does not yet appear to have a significant influence on the appraisal industry and, even worse; its influence appears to be in decline. Roulac (2001, p. 347) reviewed the "Encyclopedia of Real Estate Terms: Based on American & English Practice" (2000) and discovered that "among the notable terms not included in Abbott's encyclopedia definitions are …geography [and] geographic information systems…". These results beg the question; what happened to geography in the professional practice of real estate appraisal? Part of the explanation may lie in the fact that geography as a discipline may be in the middle of an identity crisis, and those with an interest in the "impact of location" may come from widely different academic backgrounds. Additionally, many professionals tend to show allegiance to industry-specific techniques and are resistant to change. This resistance to change is evidenced by Price (2002, p. 261) who described the real estate appraisal industry's relatively slow-paced and unenthusiastic adoption of GIS, suggesting it

> *…has hardly been used in real estate analysis (unlike public planning and land use) because of the complexity and costs of the systems, as well as a lack of data in time intervals and "freshness" suitable for the decisions required. The real estate industry gives low priority to research staff's consistent and reliable data collection, training, and software…* [and] *the most important information is often not amenable to a GIS system.*

Another part of the explanation may be a lack of training in geographic reasoning and geomatics technology. Formal geography training may also help prevent the misuse of geomatics technology and misunderstanding of geographic reasoning, which can result in numerous and dramatic errors. Indeed, Thrall (2003, p. 100) in his response to Wolverton's (2002) critical review of his book, "Business Geography and New Real Estate Market Analysis", argues that

> *…it is long overdue for geography literature to become a core component of the real estate curriculum, particularly that of appraisal. It also is long overdue for real estate, including appraisal, to benefit from advances in geography, … and help to bring geography literature "out of the closet".*

Overall, however, the prognosis for geography's influence on the professional practice of real estate appraisal appears to remain full of potential, but this review has cast some doubt when and whether that potential will be realized. If these results are indicative of the appraisal industry at large, further explanation is warranted to shed light on what happened to geography in the professional practice of real estate appraisal.

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CHAPTER 3: Improving Access to Land Price Data: A Spatial Decision Support System for Cleansing Land Registry Data

3.1 Introduction

Land values represent the economic health of urban areas and regular surveillance of land market behaviour is essential for many private and public sector applications (Cheshire and Sheppard, 2005; Jones *et al.*, 2005). Despite the many and varied potential applications of land price information for land use planning and real estate decision making, there is a dearth of research in Canada using vacant land price data. Contributing to this deficiency is a lack of accessible real estate transaction data, especially vacant land transactions (Clapp, 1990; Wyatt, 1995), and such data may not be in an easily usable form (Thrall, 1998). Furthermore, Feenan and Dixon (1992) suggest that these data accessibility challenges stem from a lack of motivation and a professional environment of secrecy. A simple solution would be to "improve access to, and the dissemination of, property data" (Wyatt, 1995, p. 69). However, based on our experience, and that of many others, the main barrier to land value research in Canada appears to be political rather than technical.

There are at least three sources of vacant land transaction price data in Canada. Among these sources, municipal and provincial assessment agencies have the most accurate datasets available, because they are, or are supposed to be, regularly visited by an inspector to ensure the accuracy of the database. However, these data may not include detailed inventories of vacant land and they are undeniably difficult to acquire. The latter is evidenced by the alleged "habit of secrecy" (Marin, 2006, p. 2) that is prevalent within Ontario's Municipal Property Assessment Corporation (MPAC). Another potential source of vacant land transaction price data is private real estate firms that maintain real estate listings for residential and commercial properties. For example, the largest of these private firms in Canada is the Multiple Listing Service (MLS), which compiles large and detailed datasets of properties that are sold through their listing service. However, MLS data record asking price instead of sale price, are highly skewed towards the residential real estate market, rarely capture vacant land transactions, and are also difficult to acquire due to alleged privacy concerns. The final source of real estate data is Land Registry transaction data obtained from deed transfers, which includes the population of real estate transactions that occurred within the jurisdiction. Beyond access issues, the main problems with using Land Registry data are: they suffer from data quality issues such as data entry errors (e.g. $525,000 vs. $52,500); they contain "non-arm's-length transactions in which reported prices are significantly below market levels because of a relationship between buyer and seller" (Pollakowski, 1995, p. 380); and, they lack land use (e.g. residential, commercial, vacant) and neighbourhood (e.g. median income, accessibility to parks) information.

Not surprisingly, since Land Registry data have recently been made accessible in the UK, they have been regularly used to study housing prices (Leishman and Watkins, 2002; Lim and Pavlou, 2007). Land Registry transaction data have also been widely used in the United States, partly due to data value-added resellers (DVARs), who mitigate the impediments to public access and usability (Thrall, 1998) by cleansing and adding contextual or value-added information to the Land Registry data. However, such DVARs are not widely available in Canada and there is currently no mechanism for public access or data cleansing, so Land Registry data are used less often in Canada[6]. Therefore, in order to mitigate the obstacles surrounding data quality, this research seeks to develop a mechanism to cleanse Land Registry data. Spatial Decision Support Systems (SDSS) provide interactive systems designed to assist decision making for a semi-structured spatial problem (Densham, 1991; Geertman and Stillwell, 2003). Similarly, GIS have a long history of being used to support spatial decision making, because decision makers are particularly attracted by GIS capabilities to

[6] A notable recent exception is Provost *et al.* (2006), who examined changes in land values by geomorphology and land use in the Haut-St-Laurent region of south-western Québec

combine numerous diverse datasets plus the ability to interactively display multiple data themes (Longley *et al.*, 2005).

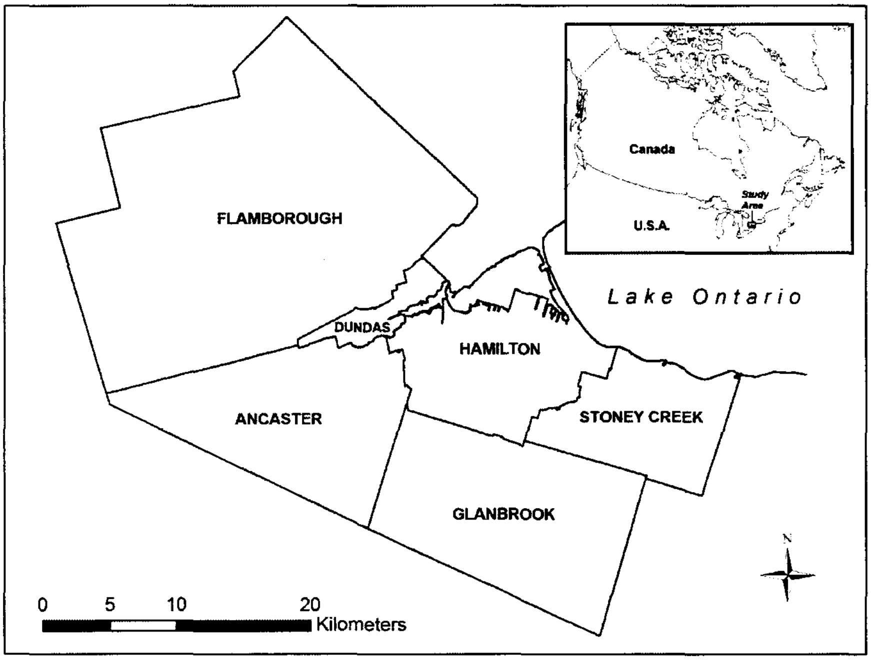
The objective of this research is to use GIS technology to develop an SDSS framework to fuse geospatial information, perform spatial analysis, and provide interactive visualization capabilities in order to cleanse Land Registry data. The purpose of the SDSS framework illustrated here is (i) to apply land use and neighbourhood information to Land Registry data, (ii) to extract vacant land sales from the population of real estate transactions, and (iii) to provide a mechanism to identify and remove erroneous prices. The SDSS framework uses GIS software to build a geo-referenced database by fusing Land Registry data with municipal tax rolls, municipal building permits, and high-resolution imagery. An illustration using Land Registry data for the City of Hamilton, Ontario indicates the SDSS framework was successful in applying land use and neighbourhood information, extracting vacant land sales, and verifying transaction prices, thereby improving access to vacant land price data. The concluding discussion examines the strengths and weaknesses of the SDSS framework and also discusses potential future developments. Descriptions of the digital geospatial data are presented following a brief introduction to the study area.

3.2 Study Area

The study area for this research is the amalgamated City of Hamilton, which is located at the south-western tip of Lake Ontario. Hamilton was amalgamated with five other municipalities in 2001, which include Ancaster, Dundas, Flamborough, Glanbrook, and Stoney Creek (see Figure 3-1).

The amalgamated City of Hamilton's total population exceeded 490,000 people in 2001 (Statistics Canada, 2002), making it the ninth largest city in Canada. The municipality of Hamilton is completely urban and its traditional economic engine has been steel and heavy manufacturing industries located along the waterfront, but within the last decade the economy has been shifting towards the service sector. The municipalities surrounding Hamilton are historically agricultural centres, but are increasingly experiencing urban development due to the outward growth (sprawl) of Hamilton. Consequently, Hamilton may be described as exhibiting a typical pattern of urban development for a mid-sized industrial North American city.

Figure 3-1: Location and Municipalities of the Amalgamated City of Hamilton



3.3 Data Description

The City of Hamilton, along with every other municipal government in Canada has access to the digital data required to contextualise the local land market conditions surrounding each real estate transaction. The spatial-temporal digital data used to illustrate this SDSS framework are: (i) Land Registry transaction data; (ii) municipal tax rolls; (iii) municipal building permits; and, (iii) remotely sensed imagery.

3.3.1 Land Registry Transaction Data

Land Registry transaction data represent the population of real estate transactions, because they are based on deed transfers. Land Registry data were obtained from Teranet Inc. (www.teranet.ca), which manages the deed transfers recorded by Ontario's Land Registry Office. A total of 107,793 transactions of real property were acquired for this research and they represent the population of real property sales that occurred in Hamilton between January 1995 and mid-September 2004. These data include details of the transaction, such as the registration date and consideration value (i.e. sale price), and parcel details, such as area, perimeter, length, and ownership type.

3.3.2 Municipal Tax Rolls

The major own-source revenue for Canadian municipalities is the property tax. Annual property tax information is available from every municipal government across Canada, and is becoming increasingly accessible over the internet through distributed geographic information services. Municipal tax rolls for 1996 through 2003 were acquired from the City of Hamilton Finance Department and included three types of information. The first type of information relates to property identification, and included a tax roll number, a civic address, and the school board to which each property belongs. The second type of information refers to the assessed value of each property, and included both total assessed market value and assessed market value by property class. The third type of information concerns land use: there are different sub-classes within the broader land use categories of residential, commercial, industrial, farm, and managed forests.

3.3.3 Municipal Building Permits

A building permit is the basic administrative device used by municipal governments to enforce the laws that relate to the construction, demolition, alteration, addition (e.g. signs, swimming pool, fence), or renovation on a property. Monthly building permit data were acquired from the City of Hamilton's Planning Department spanning the period from January 1999 to September 2004, and were concatenated into a single database. Building permit data provide information about the location, type, and total costs associated with new construction, alterations, additions, and demolitions.

3.3.4 Remotely Sensed Imagery

Given the widespread availability of high-resolution imagery freely displayed for most Canadian cities on Google Maps, especially Street View, plus increasingly affordable pricing from an increasing number of vendors, most researchers and practitioners can afford access to high-resolution terrestrial or aerial imagery. High-resolution aerial imagery was obtained for Hamilton in the form of colour digital orthophotos, which were acquired in 1999 and again in 2002. The 1999 mosaic of colour digital orthophotos had a spatial resolution of 12.5 cm and a spatial coverage of only the built-up (i.e. urban) areas of Hamilton. The 2002 mosaic of colour digital orthophotos had a spatial resolution of 20 centimetres and a complete spatial coverage of the amalgamated city of Hamilton.

3.4 Methods

This research employs GIS techniques in order to develop an SDSS framework in order to (i) apply land use and neighbourhood information to Land Registry data, (ii) extract vacant land sales from the population of real estate transactions, and (iii) identify and remove erroneous transaction prices.

3.4.1 Spatial Decision Support System (SDSS) Framework

A geo-referenced database was built within an object-oriented geographic information system (GIS) in order to enable the required functions of the SDSS framework, which include data entry, data processing, data fusion, spatial analysis, and interactive visualization and query capabilities.

3.4.1.1 *Data Entry*

The SDSS framework begins with entry of geo-referenced digital data into a common software environment. The Land Registry transaction data, municipal tax rolls, municipal building permits, and remotely sensed imagery were each imported into the SDSS framework, which is currently built within an ArcGIS 9.3 software environment.

3.4.1.2 *Data Processing*

Once the data were entered, data processing was used to prepare the data for fusion with the other geo-referenced data. The first data processing operation involved the application of a common geographic projection. Processing the Land Registry data involved stratifying the real estate transactions by the type of ownership, which includes private (84%), condominium (15%), and freehold (< 1%). The remainder of this research is illustrated using only private real estate transactions (N=90,639) that occurred in the City of Hamilton between 1995 and 2004. Processing the municipal tax rolls involved dividing the assessed market value for each property class by the property's total assessed value, thus generating a series of new variables that reflect the percent of market value for each property class (e.g. percent residential, percent commercial, percent industrial), which is especially useful for highlighting mixed land use properties. Processing the municipal building permits involved converting the work type variable from a text variable (with many spelling mistakes) to a numeric categorical variable. After processing operations were complete, the next step in the SDSS framework is data fusion.

3.4.1.3 *Data Fusion*

Data fusion is defined as the process of combining datasets from multiple sources in order to infer information that would not otherwise be available. Data fusion is used here in order to spatially join the Land Registry data with annual tax rolls and building permit data, based on the corresponding location in both space (i.e. address) and time (i.e. month and year), in order to make decisions about land-use and local land market conditions for each transaction. It is important to note that a small percent of private real estate transactions (2.6%) had incomplete address information and did not join with the tax rolls. These transactions were consequently excluded from the following illustration of the SDSS framework, leaving a total of 88,294 private real estate transactions.

3.4.1.4 *Spatial Analysis*

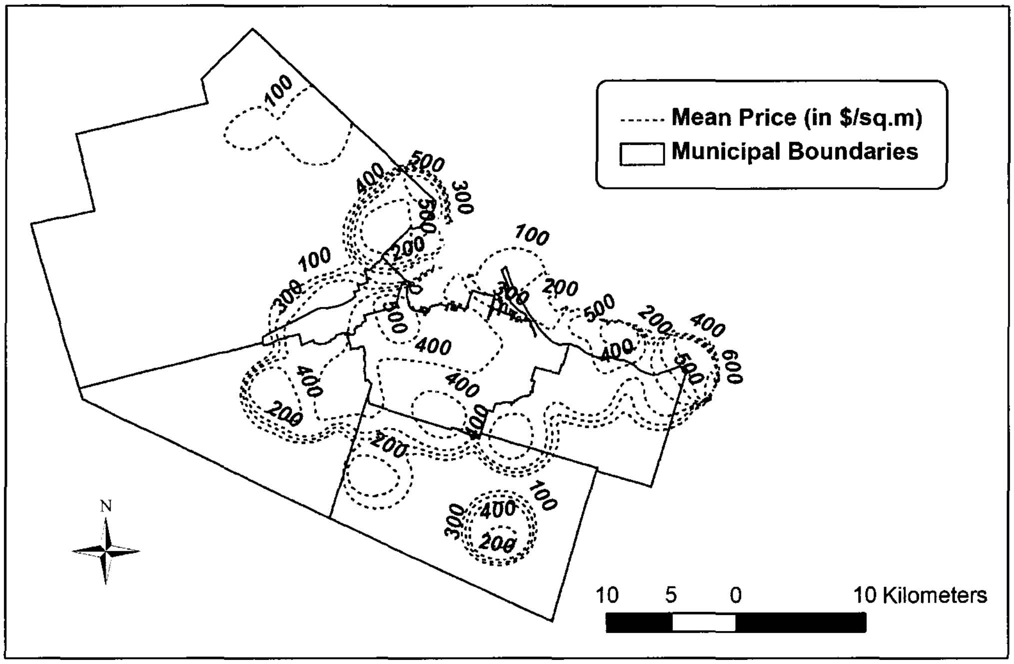
Spatial analysis of the fused datasets was used to generate a series of annual spatially continuous surfaces of mean sale prices per square metre for each property class, which, despite known diminishing returns to lot size (Colwell and Sirmans, 1978), is based on the assumption of a direct linear relationship between property values and lot size. A kernel interpolation technique was used to calculate a distance-weighted average sale price at a given location (using x and y coordinates) based on the prices of other properties that sold within the search radius (called bandwidth) of the kernel. There are two types of kernels; the first uses a fixed distance for the search radius, and the second uses a fixed number of nearest neighbours (Bailey and Gatrell, 1995). The latter type is known as an adaptive kernel and has the advantage of providing greater detail in areas with dense sales without compromising the estimates in areas with less dense sales. An adaptive kernel was chosen because the spatial distribution of real estate transactions had an obvious clustering in rapidly developing suburban areas and a more dispersed distribution in both rural and densely developed areas.

After temporarily removing repeat sales (keeping the most recent), an adaptive kernel was specified using 30 nearest neighbours and applied to all private real estate transaction prices that occurred in Hamilton between 1995 and

2004. The result was a spatially continuous surface of mean sale price per square metre (Figure 3-2), which clearly illustrates a polycentric distribution of transaction prices. The urbanized areas have higher transaction prices than the rural communities, with the exception of "prestige" suburban subdivisions.

The spatially continuous mean sale prices were subsequently fused with the transaction data in order to enable the computation of the spatial price filter ratio (SPFR). The SPFR is the quotient of the local mean price per square metre divided by the sale price of the property in price per square metre. A tax filter ratio (TFR) was also computed by dividing the sale price of each transaction by the assessed value of the property. Both the TFR and SPFR provided valuable contextual information, especially when combined with the remotely sensed imagery, for the interactive processes of vacant land extraction and verification of an arm's length transaction.

Figure 3-2: Contour Representation of Spatially Continuous Surface of Mean Residential Transaction Prices



3.4.1.5 *Interactive Visualization and Query*

The conventional solution for verifying land use information is to physically visit the site of each transaction and record the land use information. It has been suggested that

> *...it is in no way obsolete to go to the location of the study with the purpose of verifying that the structure of the problem and analysis and any conclusions make sense. This has at times been known as "muddy boots" and today more exotically referred to as "ground truthing"* (Thrall, 1998, p. 52).

In response to the exorbitant costs associated with physically visiting each parcel of land in the study area and the inability to contact the representative actors in each real estate transaction, this paper uses an SDSS framework in order to virtually visit each site to (a) verify land-use information for each transaction and (b) select only transactions with sale prices that appear to reflect arm's length transactions.

3.4.2 Assigning Land Use and Neighbourhood Information

In addition to land use (i.e. property class) information assigned to the Land Registry data by fusing them with the municipal tax rolls, a wide variety of neighbourhood quality information can be used to contextualize the Land Registry data. For example, Statistics Canada's census data, available to the education community through its E-STAT website (http://estat.statcan.ca), can be fused with the Land Registry data to contextualize the social and economic conditions at several different geographic scales. When using census data or any other data that are spatially aggregated into zones, however, it is important to bear in mind that such data are subject to the modifiable areal unit problem (MAUP). MAUP is defined as "the imposition of artificial units of spatial reporting on continuous geographical phenomena [which] result[s] in the generation of artificial spatial patterns" (Heywood *et al.*, 1998, p. 193). Additionally, there is a wide variety of other point, area, or spatially continuous data sources that can be imported into the

SDSS framework to provide valuable contextual information.

3.4.3 Extracting Vacant Land Transactions

Several methods were developed in order to highlight, evaluate, and extract vacant land sales. A small number of commercial and industrial vacant land sales were extracted using property class information garnered from the tax rolls, but the property class information does not permit the extraction of vacant residential land, because all residential properties are, unfortunately, assigned the same tax code regardless of whether they are developed or not. The land registry data were used to extract vacant land sales by querying repeat sales for a dramatic increase in value between successive sales, which indicates there has been development during the intervening period. The land registry data were also used to extract vacant land sales by querying SPFR values less than 0.4, based on the fact that the cost of housing construction is typically at least three times the cost of serviced land. The municipal building permit data were used to extract vacant land sales by querying for demolitions, because demolitions provide the best evidence of vacant land prices in completely developed neighbourhoods. However, it is important to note that the cost of the demolition needs to be added to the transaction price in order to accurately reflect the price paid for *vacant* land.

All extracted vacant land sales were verified using the colour digital orthophotos to provide visual clues whether to support or contest that the parcel of land was indeed vacant at the time of sale. For example, properties that were developed, demolished, or remained vacant between 1999 and 2002 were quickly and easily identified. For the purposes of this analysis, *developed* properties were defined as those with a building or structure that is not slated for demolition. The aerial imagery was not as effective for transactions that occurred either before 1999 or after 2002, but there was sufficient contextual information afforded by the assessment rolls, approximate age of nearby construction, and nearby sale prices for similar properties to verify that each extracted transaction was indeed vacant at the time of sale. After all vacant land sales were extracted from the population of real estate transactions they were subsequently assigned neighbourhood information.

3.4.4 Verifying Arm's Length Transactions

The conditions of a fair price (i.e. arm's length) transaction are met when a willing buyer and seller make informed decisions under the conditions of a fair sale. The best method of verifying that transaction prices are representative of a fair market conditions is to contact the representative actors. Unfortunately, due to privacy concerns, the names and contact information for the actors in the transaction are suppressed due to privacy concerns. Therefore, an alternative approach was developed that considers the transaction price, the transaction date, the assessed value, and land use information in order to decide whether each sale price is representative of an arm's length transaction. It is important to bear in mind that the price people pay for property is occasionally ill-advised (Skaburskis, 2002), which results in market prices that are well above or below market value. The distinction between market price and market value is an important one. Market *price* is the amount actually paid in a particular transaction, while market *value* is a hypothetical or estimated sale price that would result from careful consideration by the buyer and seller of all data, with primary reliance on those data that reflect the actions of responsible, prudent buyers and sellers under conditions of a fair sale (UBC, 2001).

Market prices are reflected by the Land Registry transaction data, while market values are reflected by the total assessed values in the municipal tax rolls. Consequently, a SPFR value near 1.0 provides some support for an arm's length transaction, because it is based on an average of surrounding market prices, but a TFR value reasonably close to 1.0, meaning that the sale price was close to the property's assessed value, provides compelling evidence of an arm's length transaction. The interactive visualization and query capabilities of the SDSS framework also permit detailed inspection of the property in relation to surrounding properties. For example, repeat sales were used to provide contextual information about the *reasonableness* of each successive sale price, especially given any alterations or additions listed in the building permit data. The final decision of whether each sale price was representative of an arm's length transaction was based on an evaluation of the contextual information available.

3.5 Results and Discussion

The results of the SDSS framework are presented for stratifying and validating land use information, assigning neighbourhood information, and verifying arm's length transactions. The SDSS framework, however, as previously discussed in section 4.4, has limited capability for assigning structural information to the Land Registry data and the results have, therefore, been omitted.

3.5.1 Extracting Vacant Land Transactions

Using the SPFR and from the building permit data, coupled with colour digital orthophotos for two snapshots in time, the SDSS framework was successful in the identification and validation of 2,524 vacant land sales. This represents 2.9% of all private real estate transactions that occurred in Hamilton between 1995 and 2004. The distribution of both the number and total area (in hectares) for extracted and validated vacant land sales is illustrated in Table 3-1 by year of sale and land use category.

Results in Table 3-1 indicate that the number of residential sales appears to be steadily increasing between 1995 and 2002. Only the first four months of 2004 are represented by the transaction data, which explains that year's remarkably lower number of sales. The distributions for other land uses, despite being overshadowed by vacant land for residential use, display a relatively stable number of transactions from one year to the next. Most cities have about 35% of their total area in residential uses (streets excluded), and about 45% of their developed area is residential (Hartshorn, 1992, pp. 220-224). Since residential parcels tend to be much smaller than those for other land uses, however, about three-quarters of all urban lots are typically residential. This helps to explain why the large numbers of vacant lots which become residential (79.4%) only comprise a small percent (7.8%) of the total area. It is important to note that the total area of vacant land in each of the other land use categories shows a very different distribution. In contrast, the small group of farm and managed forest properties (5.6%) has a very large total area (76.1%), and those in the industrial and commercial categories are also typically large.

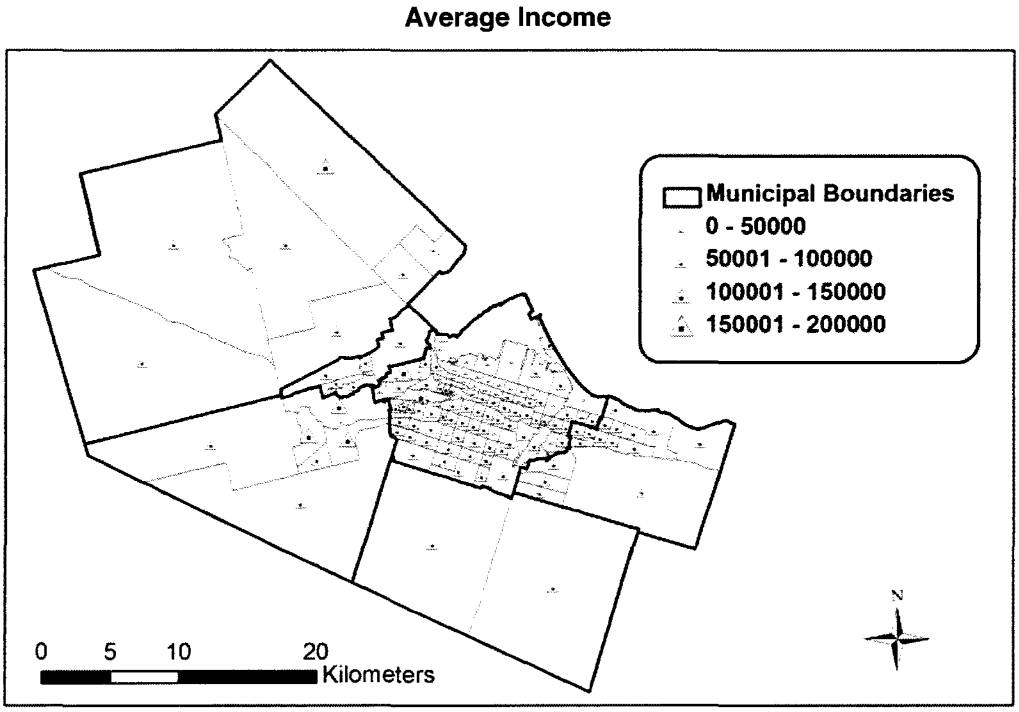
Table 3-1: Temporal Distribution of Vacant Land Sales by Land Use Category

	Residential		Commercial		Industrial		Farm/Managed Forest	
Year	***N***	***Area (ha)***	***N***	***Area (ha)***	***N***	***Area (ha)***	***N***	***Area (ha)***
1995	67	10.8	14	10.2	4	2.7	7	168.4
1996	88	15.0	20	17.5	2	0.6	12	186.5
1997	177	19.1	22	81.1	14	23.7	12	390.1
1998	209	32.6	35	37.8	10	8.6	17	402.9
1999	269	29.5	36	10.0	14	13.0	11	225.1
2000	230	44.0	36	37.1	15	11.0	20	427.0
2001	269	23.7	25	6.55	21	34.4	13	327.2
2002	381	49.6	30	13.6	11	5.4	6	164.8
2003	235	40.5	31	17.6	16	11.0	29	264.3
2004	78	20.5	20	7.2	4	2.9	14	234.8
Total	2003	285.3	269	238.7	111	113.2	141	2791.3
Percent	**79.4**	**7.8**	**10.6**	**6.5**	**4.4**	**3.1**	**5.6**	**76.1**

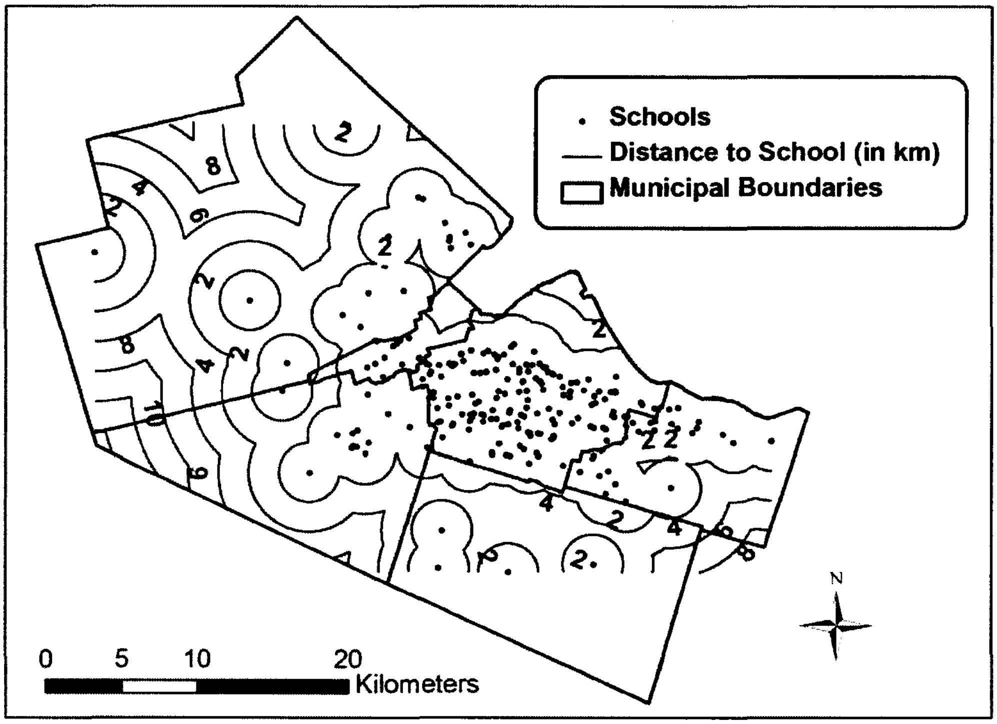
3.5.2 Assigning Neighbourhood Information

Neighbourhood quality information can be fused with Land Registry data in order to provide valuable contextual information for subsequent analysis and modelling efforts. There are a variety of potential variables that can be used to implicitly value neighbourhood attributes (for a review see Cheshire and Sheppard, 1995). Despite the inherent difficulties of quantifying the value of neighbourhood amenities, specific benefits are derived from developing the SDSS framework within a GIS software environment, because of its ability to create location- and distance-related variables "that would be otherwise difficult or time-consuming to create" (Rodriguez *et al.*, 1995, p. 170). For example, distance to school in Figure 3-3 is measured using straight-line distances, but a GIS can also compute network distances, network travel times, and even network travel costs could be used to measure the relative and absolute distance to any service.

Figure 3-3: Examples of Neighbourhood Information



Distance from School

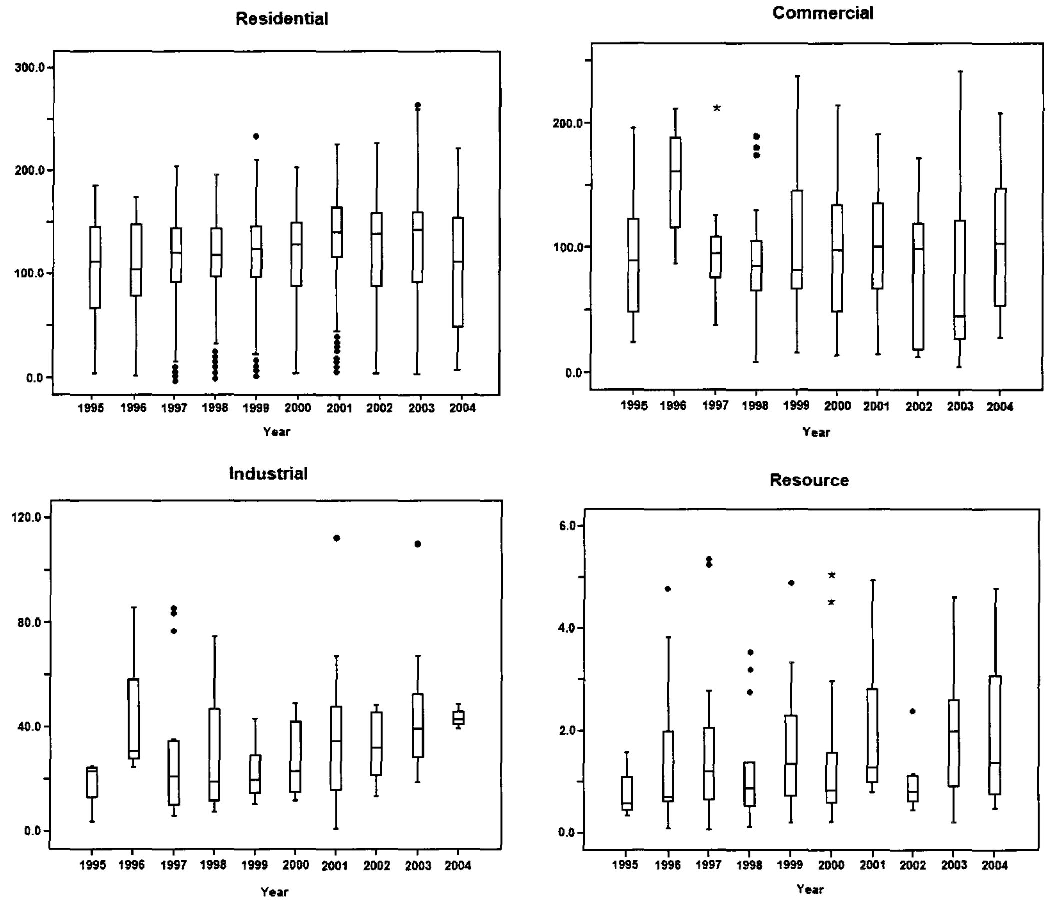


Distance to a school, although often not as important as the quality of the school, acts as a proxy for residential density and approximates the distribution of mean real estate prices in Figure 3-2. Mean real estate prices in Figure 3-3 indicate a polycentric pattern of decreasing prices with increasing distance from the city centre. Conversely, median family income exhibits a general increase with distance from the city center. The paradox "that has intrigued students of American cities since the turn of the century"... "is, then, the well-to-do live on cheap land while the poor live on expensive land" (Alonso, 1964, p. 227). These and other research questions can be explored by adding contextual information to the Land Registry data, but only after validation of sale price information.

3.5.3 Verifying Arm's Length Transactions

The objective of verifying that each sale price represents an arms' length transaction is to eliminate erroneous, and often extreme, values. Based on location and land use it was possible to make a well-informed decision whether or not the sale price appears representative of an arm's length transaction. In fact, the SDSS framework was successful in identifying and removing many erroneous prices, of which many appeared to be typographical but were not altered. The distributions of sale prices that were verified as arms' length transactions are illustrated in Figure 3-4 using box plot (i.e. box-and-whisker) diagrams for the main land use categories.

Figure 3-4: Distributions of Vacant Land Prices per Square Metre by Land Use Category



These diagrams graphically represent the distribution of the data and are especially useful for identifying outliers and skew. The top and bottom of the box generally correspond to the upper and lower quartile, while the median is represented by a thick line that dissects the box. The vertical lines, or whiskers, are capped with horizontal lines, called adjacent values, and encompass about 99% of the distribution between them. Beyond the adjacent values are outliers, represented by a circle, and extreme outliers, represented by an asterisk.

The mean vacant residential and industrial land prices per square metre in Figure 3-4 indicate a general trend of increasing land prices over time. The distributions in Figure 3-4 also suggest that sale prices for vacant land in Hamilton appear particularly "noisy", especially for residential land. However, it is important to consider that vacant land prices vary considerably based on location within the study area (e.g. urban, suburban, and rural). For example, there is a general pattern of decreasing land values with increasing distance from the city centre, which helps explain the apparently large standard deviations indicated in Figure 3-4. Furthermore, there are small-area effects on land prices as well, such as "prestige" subdivisions, where land prices can far exceed land prices in relatively close proximity, but in a different subdivision. Despite the apparent "noisy" data, it is important to bear in mind that the end-user is likely to apply their own removal of outliers.

3.6 Conclusions

Appreciation and depreciation rates for vacant land prices reflect changes in the economic health (i.e. demand) of urban neighbourhoods. Such information is required for land use zoning, eminent domain, and fiscal planning, and for real estate investment and lending decisions. The study of changes in land prices is severely hampered by a lack of access to transaction price data for vacant land. This paper has utilized data management, spatial analysis, and interactive visualization capabilities afforded by GIS in order to develop an SDSS framework that was used to (i) apply land use and neighbourhood information, (ii) extract vacant land sales, and (iii) identify and remove erroneous prices. The SDSS framework is straightforward and easy to implement for any jurisdiction using most commercial GIS software. The illustration in Hamilton provides convincing evidence that the SDSS framework was successful in effectively cleansing Land Registry data. Until DVARs become more widespread in Canada, the SDSS framework provides a mechanism for improving access to vacant land price data.

While vacant land prices are essential for understanding and monitoring land market behaviour, there is also considerable interest in the most active sector of the real estate market – the residential housing market. While the sale prices can be effectively verified, and the required land use and neighbourhood information can be applied using the data and methods described herein, most residential housing price research applications, with the possible exception of repeat-sales house price index construction, require structural information, such as number of bedrooms and bathrooms. Detailed inventories of structural information are maintained by the provincial property assessment authority, but in the absence these inventories there are alternate approaches that can be used, with varying success, to apply structural information to the Land Registry transaction data. One approach is to use building permit data, not because they provide detailed structural information, but because they do provide geo-referenced time-stamped total price information for new construction. That is, total price information can be used as a proxy for structural attributes by representing the total cost of the structure as opposed to seeking the marginal prices for each attribute. This approach should work well for structures of any size, regardless of their use.

An alternative approach is to infer exterior structural attributes, such as the type, size, and approximate age, from the digital imagery; an approach that can be applied to all land uses. For example, techniques exist for the automated extraction of building footprints using high resolution imagery (e.g. Mayer, 1999; Lee *et al.*, 2003). With keen interpretation, the imagery can also be used to gather subjective structural information, such as the "quality" of the structure and surrounding properties. Structural *quantity* (e.g. square footage, number of bedrooms, number of bathrooms) has been well researched, but research into the impact of structural *quality* has been relatively ignored. Seminal work by Kain and Quigley (1970) used structural quality attributes (e.g. condition of exterior structure, windows, and driveway) to study housing prices and found and they explained as much as structural quantities (e.g. number of rooms, number of bathroom). This approach should work well for single-family residential properties, but not as well for multi-tenant residential, commercial, and industrial properties.

3.7 References

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CHAPTER 4: Exploring Spatial Dynamics with Land Price Indices

4.1 Introduction

Regular surveillance of land prices is required for many private sector applications, such as real estate investment and lending decisions, and for municipal government applications (Clapp, 1990; Pollakowski, 1995; Meese and Wallace, 1997; Clapp, 2004; Cheshire and Sheppard, 2005; Jones *et al.*, 2005) such as land use zoning, eminent domain, and fiscal planning. Unfortunately, most traditional specifications of land price indices ignore the spatial distribution of appreciation and depreciation rates, by publishing a single price index value for the entire region (i.e. *global* scale). However, the appreciation and depreciation of land prices within a given region is a function of dynamic social, economic, legal, and environmental processes continuously interacting over time and across space (Grigsby *et al.*, 1985). As a result, there is a widely recognised need for price indices at a local, or neighbourhood, scale (Gatzlaff and Ling, 1994; Leishman and Watkins, 2002; Jones, 2002; Jones *et al.*, 2005), because municipal policies and programs need to be more temporally and spatially-specific (Mark and Goldberg, 1984).

Unfortunately, the academic and professional literature is sparse insofar as the spatial analysis of appreciation and depreciation rates for real estate prices; a problem also recognised by Clapp (1990), Case and Mayer (1996), Abelson (1997), Orford (2000), Smith (2004), and Coulson and McMillen (2007). Notable exceptions include Clapp (1990), who provides some initial insights into the integration of local spatial dynamics into the construction of vacant land price indices. Locally weighted regression was used by Meese and Wallace (1991) to construct a spatially varying house price index for the San Francisco Bay area and by McMillen (1996) to study land values in Chicago. Clapp (2004) incorporated both the spatial and temporal dynamics into an autoregressive model to calculate *local* house price indices for Fairfax County, Virginia. Bourassa *et al.* (2008)

compared alternative submarket definitions and geo-statistical techniques to predict house prices for Louisville, Kentucky. However, there are few examples of spatial analysis using *land* price indices.

This research exploits Geographic Information Systems (GIS) in order to build upon past research and provide new insights into the incorporation of the spatial dynamics of residential land prices into the construction of land price indices. It makes use of nominal sale prices for vacant residential land within the City of Hamilton, Ontario between 1995 and 2003. Mean value indexing methods are used to construct annual land price indices using three different geographic representations: a (i) global mean, (ii) submarket mean, and (iii) local mean, each validated against Statistics Canada's New Housing Price Index series. The methodological consistencies used in their construction enable a comparison of the relative performance of the alternative geographic representations of the spatial dynamics of land prices. The results are used to examine the spatial distribution of land price appreciation and depreciation rates, and provide important conceptual insights into the spatial dynamics of urban land markets in Canada. Furthermore, they provide important practical insights into best practices for representing the spatial dynamics of vacant land prices.

4.2 Background

A price index is simply an average (normally weighted) value of market prices for a specified good or service during a specified period of time for a specified region. A price index is used to measure the change in nominal average prices for goods within a given region between two periods of time. Thus, a land price index is defined as an average value that is used to measure the temporal changes in the average price of land for a given region. Land is defined in the field of economics, and especially in political economy, as the entire material universe (e.g. sunshine, air, land, plants, animals) outside of people and the products of their labour. Land is defined more restrictively here and is limited to urban ground, irrespective of fertility and capital improvements (e.g. buildings, drainage, or terracing). The economic return to urban land is called ground rent or, to economists, simply rent (Ricardo, 1817). Ground rent is an important economic concept because land values are the result of ground rent capitalized (Hurd, 1924).

Modern price theory distinguishes between value and price, whereby market *value* is an estimated sale price, while market *price* is the amount actually paid in a transaction. The market price for land is based on an actor's willingness to pay, which is dependent upon several factors that include the size and shape of the parcel, intended land use, permitted land use (e.g. zoning), local property taxes, owners' income, financing terms, and a wide variety of spatially-dependent neighbourhood amenities; such as type of buildings present, quality of schools, accessibility, and neighbourhood character (Can, 1990; Case, 1992; Dubin, 1992; Colwell and Munneke, 1997; Cheshire and Sheppard, 1998; Ding *et al.*, 2000; Din *et al.*, 2001). Changes in the quality or quantity of neighbourhood amenities affect land prices either positively (i.e. appreciation) or negatively (i.e. depreciation). However, the measurement of these neighbourhood characteristics is often challenging (Gallimore *et al.*, 1996), which makes the analysis of the urban land market rather complicated (Koomen and Buurman, 2002).

Given that changes in house prices is primarily a function of changes in construction costs plus changes in residential land prices (Davis and Heathcote, 2004), much can be learned about the effects of changing neighbourhood amenities from the rich literature on house price index construction. Research into house price indices has focussed on either hedonic price regression, repeat-sales regression, or a hybrid of the two (Bailey *et al.*, 1963; Haurin and Hendershott, 1991; Crone and Voith, 1992; Meese and Wallace, 1997; Colwell, 1998; Goodman and Thibodeau, 1998; Leishman and Watkins, 2002). However, Bourassa *et al.* (2008, p. 3) warn that caution "should be exercised when devising hedonic models", while Gatzlaff and Ling (1994) suggest neither the standard hedonic price model nor the repeat-sales model seem feasible for constructing house price indices at the local level. Despite the method used, the objective of each indexing method is the same; to create an efficient and unbiased indicator of appreciation and depreciation of prices.

The majority of research into different indexing methods for residential house prices (e.g. Mark and Goldberg, 1984; Clapp *et al.*, 1991; Case *et al.*, 1991; Clapp and Giacotto, 1992; Meese and Wallace, 1997) has focused on the reduction of "the bias thought to be introduced to indices by the established estimation methods" (Leishman and Watkins, 2002, p. 38). While research has concentrated on the reduction of sample selection bias caused by structural "relatives" (e.g. McMillen and MacDonald, 1991; Haurin and Hendershott, 1991), there has been little progress in accounting for neighbourhood "relatives" (Jones, 2002).

Part of the challenge accounting for neighbourhood "relatives" is that real estate data (including vacant land prices) pertain to inherently spatial phenomena, which is evidenced by the spatial grouping of similar sizes, accessibility to value-affecting amenities, and consequent prices for nearby lots. The spatial dynamics of land prices have acquired significant attention in real estate research (e.g. Can, 1992; Dubin, 1992; Chica-Olmo, 1995; Pace and Gilley, 1997; Griffith and Layne, 1999; Dubin *et al.*, 1999; Orford, 2000; Mulligan *et al.*, 2002; Tse, 2002; Páez *et al.*, 2001; Pace and LeSage, 2004; Kestens *et al.*, 2006; Bourassa *et al.*, 2008). However, these issues have only begun to be addressed in the construction of hedonic house price indices (Meese and Wallace, 1991; Can and Megbolugbe, 1997; Clapp, 2004), and have received even less attention in the construction of land price indices.

Research into spatial processes and spatial modelling is enabled by Geographic Information Systems (GIS) technology, which has its storage and analysis capabilities designed around discrete points, lines, and polygons. Consequently, the use of GIS requires the subdivision of real-world areas and the representation of abstract spatial processes with discrete structural elements, which "ranks among the central and most difficult tasks of building a GIS" (Ott and Swiaczny, 2001, pp. 20-21). Given that a land price index is used to measure changes in the average price of land for a given region, it is necessary to first abstract geographic space into regions (i.e. functional markets) for analysis.

Urban economists have been pragmatic in their definition of functional markets (Ratcliff, 1949), whereby the market is the whole region in which buyers and sellers interact. In practice, functional markets are "generally assumed to be conterminous with city boundaries" (Jones *et al.*, 2005, p. 218). However, different goods have different markets, thus the housing market is segmented into a series of submarkets (see Rapkin *et al.*, 1953; Grigsby, 1963). Market segmentation is a procedure that subdivides functional markets into relatively homogeneous discrete structural elements (i.e. submarkets or neighbourhoods). There is an extensive literature on defining and applying submarkets for research into housing prices (e.g. Schnare and Struyk, 1976; Palm, 1978; Goodman, 1981; Rothenberg *et al.*, 1991; Cano-Guervós *et al.*, 2003; Thibodeau, 2003), but few examples for land price index construction. Besides, defining submarkets is only one conceptual approach for abstracting the spatial dynamics of land prices into discrete structural elements.

While market segmentation provides a "useful conceptual framework for modelling spatial dependence" (Bourassa *et al.*, 2008, p. 3), and the spatial dynamics are, in fact, the main reason explaining why submarkets matter (Bourassa *et al.*, 2003), an alternative approach is to conceptualize the abstract spatial dynamics of land prices as a function of local variations (i.e. spatial heterogeneity) and spatially continuous variations (i.e. spatial autocorrelation). The theory behind all spatial interpolation techniques is that observations closer together in space are more likely to have similar values than observations farther apart (Tobler, 1970). There are a variety of different mean-value spatial interpolation techniques[7] available in GIS software, including the kernel interpolation technique (see Lam, 1983; Mitas and Mitasova, 1999; Haining, 2003; Kyriakidis and Yoo, 2005).

Kernel estimation is designed as an exploratory spatial interpolation method that is effective when there is uncertainty (i.e. errors) in the recorded values that requires smoothing to reduce the effects of these errors. A kernel estimator calculates a distance-weighted mean transaction price at a given location (i.e. x and y coordinates) based on other transaction prices within the search radius of the kernel. The search radius (called bandwidth) is used to distinguish between two types of kernels; the first uses a fixed distance bandwidth, and the second uses a fixed number of nearest neighbours for the search radius. The latter type is known as an adaptive kernel and captures "local" changes in mean prices within areas that have a high density of vacant land transactions (e.g. suburban areas) without compromising the ability to produce estimates of mean prices in areas with significantly fewer observations (e.g. rural areas).

Unlike kriging and other moving window models that use cross validation (e.g. Fotheringham *et al.*, 2002; Páez *et al.*, 2008), kernel estimation is an exploratory technique and the number of nearest neighbour observations (i.e. window size) is a function of the "degree of smoothness" desired without compromising our understanding of the underlying spatial processes. Although Bailey and Gattrell (1995, pp. 84-88) discuss general methods for choosing the appropriate cell size and number of neighbours, the optimal size of the kernel represents a trade-off between being small to measure a locally stationary process affecting changes in land prices (e.g. parks, bus stops) but large enough to measure processes with a larger range of influence (e.g. recreation centres, subway stations, or schools).

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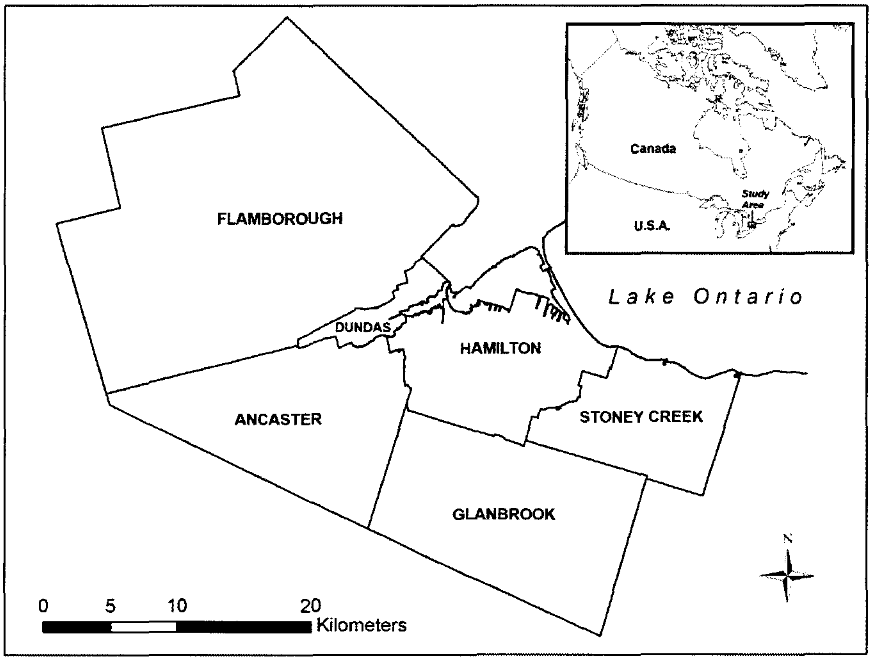
[7] The two most commonly cited mean value spatial interpolation techniques in real estate research include trend surface analysis (Hembd and Infanger, 1981; Parker, 1981; Eichenbaum, 1995; Pavlov, 2000; Fik *et al.*, 2003), and kriging (Matheron, 1963: Ripley, 1981; Oliver, 1990; Cressie, 1993; Case *et al.*, 2004; Chica-Olmo, 2007; Páez *et al.*, 2008).

4.3 Study Area

The study area chosen for this research is the amalgamated City of Hamilton, which rests along the Niagara escarpment at the westernmost tip of Lake Ontario, about 75 km southwest of Toronto, Ontario. The City of Hamilton had a total population of more than 490,000 people in 2001 (Statistics Canada, 2002), making it the ninth largest city in Canada. It is an amalgamation of six different communities (see Figure 4-1). The community of Hamilton contains the central business district (CBD), which is completely urbanised. The small community of Dundas is a well-established "west end" neighbourhood, which is also urbanised. The remaining four communities of Flamborough, Ancaster, Glanbrook, and Stoney Creek are historically agricultural, but have been increasingly subject to both urban and suburban development since the 1980s.

Figure 4-1: Location and Municipalities of the City of Hamilton



The main economic engine of the City of Hamilton has historically been the steel and heavy manufacturing industries, but there has been a shift towards the service sector within the last decade. At the same time, there has been suburbanization of residential and commercial land uses, which have resulted in the rapid appreciation of land values in suburban areas and a stabilization or depreciation of land values in aging and deteriorating urban areas, especially in the east-end of Hamilton's downtown. Despite attempts by the Downtown and Community Renewal Division to rejuvenate the central business district, suburbanization of middle and upper-income households and big-box retailing has destabilized the traditional role of the city's downtown, with a consequent impact on the spatial distribution of land prices.

4.4 Data and Methods

4.4.1 Data and Processing

Among the limited sources of real estate data, it is well known that the lowest quality source is transaction data from the Land Registry (i.e. deed transfer) office. The main problem with using land registry data is data errors, which require a considerable amount of cleaning, but they also lack structural, neighbourhood, and land use information. Although others have used land registry data to construct house price indices (Leishman, 2000; Leishman and Watkins, 2002; Lim and Pavlou, 2007), few have used them to construct land price indices. A notable exception is Hoyt (1933) who sifted through decades of transaction data in order to identify sales of vacant land that could be used to construct land price indices for the City of Chicago. This demanding data collection effort was similarly applied to land registry data for the City of Hamilton, which extracted 1,867 transactions of vacant residential land from the population of private real estate transactions (n = 78,119) that spanned a nine-year period between January 1995 and December 2003.

The vacant residential land transaction data include the location, sale date, and sale price information, and the total area (in square metres) of the property. The sale price and total area information was used to compute a sale price per square metre for each transacted parcel of vacant residential land. Despite a strong positive relationship between sale price and lot size, preliminary investigations revealed the distribution for lot sizes was highly positively skewed. Consequently, single family residential lots larger than two acres (approx 8094 m^2) were excluded in order to (a) account for diminishing returns to lot size (see Colwell and Sirmans, 1978), (b) ensure that the lots are not slated for subdivision, (c) provide some measure of constant quality (see Seow *et al.*, 2003; Coulson and McMillen, 2007) among structural (i.e. lot size) "relatives" in order to reduce the impacts of sample selection bias introduced by especially large and irregularly-shaped lots.

In addition to accounting for constant quality among lot sizes, sale prices for vacant residential land in Hamilton are particularly "noisy". For example, error is introduced into sale prices because the price people pay for property is often ill-advised (Mackmin, 1985). Furthermore, Pollakowski (1995, p. 380) warns that land registry data often contain "non-arm's-length transactions in which reported prices are significantly below market levels because of a relationship between buyer and seller". In order to account for constant quality among sale prices, and ensure each sale price represent an arms' length transaction, while at the same time eliminating any extreme values, this study follows Gatzlaff and Ling (1994) and excludes any observations (n=58) with a sale price in excess of three standard deviations from the overall mean.

Attempts to account for constant quality among lot sizes and sale prices produced a sample of 1,832 parcels of vacant residential land that transacted within the City of Hamilton between January 1995 and December 2003. Summary statistics for these nominal transaction prices per square metre are listed in Table 4-1. Given the range and relatively high standard deviations in Table 4-1, vacant residential land prices clearly exhibit within-year variability. This variability is partly explained by distance to the central business district (CBD) ($R = -0.283$ significant at the 0.01 level), which highlights the importance of the within-region spatial dynamics of land prices. Mean and median values are reasonably similar, which highlights the near-normal distribution, but the consistently higher median values illustrate the positively skewed distributions. Median and mean values in Table 4-1 also exhibit a general trend of steadily increasing price per square metre for vacant residential land from 1995 to 2003. In fact, sale price per square metre and year of sale variables are significantly correlated (R = 0.169 significant at the 0.01 level). While this correlation is indicative of the temporal dynamics in urban land market conditions, it ignores the spatial dynamics of urban land markets.

Table 4-1: Summary Statistics for Vacant Residential Land Prices

Year	Count	Minimum	Maximum	Median	Mean	Standard Deviation
	N	*$/m²*	*$/m²*	*$/m²*	*$/m²*	*$/m²*
1995	64	22.0	185.4	117.1	110.7	45.2
1996	83	1.3	174.1	109.2	108.5	45.4
1997	174	10.4	204.6	121.1	115.4	39.3
1998	201	6.2	279.5	121.5	117.5	42.7
1999	260	10.1	656.7	125.6	122.6	58.8
2000	219	12.4	496.7	129.9	123.3	56.1
2001	258	10.1	518.3	141.9	139.7	58.1
2002	361	9.5	412.3	141.1	128.1	50.7
2003	212	11.1	575.4	149.3	143.7	58.5
Overall	**1832**	**1.31**	**656.68**	**134.38**	**126.33**	**53.40**

4.4.2 Constructing Land Price Indices

This research uses mean value indexing methods to construct land price indices. Mean (or median) value indexing methods are based on the stochastic approach to index number theory (Fisher, 1922; Hill, 1988), which suggests that given a sufficient number of independent observations between two time periods, changes are well represented by the average difference. While mean value indexing methods are regularly used to measure the appreciation or depreciation in the price of a variety of different goods and services, they are used less frequently to measure changes in housing and land prices. Peek and Wilcox (1991) summarize the weaknesses of mean value indexing methods for house price index construction, but Gatzlaff and Ling (1994, p. 239) find the "relatively strong performance" of median value indexing methods "somewhat surprising". Furthermore, Mark and Goldberg (1984) suggest that, among the eleven house price indices constructed for two Vancouver neighbourhoods, the mean sale price indices performed well, along with the hedonic price indices.

The objective of this research is not to gauge the performance of the indexing methods, but rather to explore the spatial dynamics of land prices and compare the relative performance of three geographic representations of vacant land prices. As a result, this research seeks to consistently apply a simple yet robust mean value indexing method to annual groups of observations in order to compare three different geographic representations; a global mean land price index (G-LPI), a submarket or community-level mean land price index (S-LPI), and a local mean land price index (L-LPI). These three land price indices are validated against Statistics Canada's NHPI series, and are subsequently examined for their ability to capture the spatial dynamics of the annual appreciation and depreciation rates for residential land prices within Hamilton's land market.

4.4.2.1 *Global Mean Land Price Index*

The G-LPI was constructed by computing the un-weighted nominal mean transaction price for each annual group of observations within the City of Hamilton between 1995 and 2003. The series of annual mean prices was converted into a set of index values using the indexing formula presented in the following equation.

$$xLPI = 100 + \frac{\mu_{t2} - \mu_{t1}}{\mu_{t1}}$$

Where μ_{t1} and μ_{t2} are the mean sale prices per square metre at t_1 and t_2, respectively. This price index construction is based on the chain Laspeyres index formula, because its specification is based exclusively on the use of price data. As a result, the percentage change in mean nominal prices is referenced to its immediately preceding time period (i.e. year), and does not explicitly control for differences in quality over time.

4.4.2.2 *Submarket Mean Land Price Index*

The submarket mean land price index (S-LPI) is used to increase the spatial resolution of the global land price index by dividing the functional market into smaller market areas. There are a variety of methods used to delineate geographic boundaries for different submarkets[8], but existing political boundaries are often used due to the spatial aggregation of many contextual datasets (e.g. census data). For example, political and geographic boundaries have been used by Schnare and Struyk (1976), Goodman and Kawai (1982), and Adair *et al.* (1996). The submarket boundaries for the S-LPI are based on the communities that comprise the amalgamated City of Hamilton (i.e. Hamilton, Dundas, Flamborough, Ancaster, Glanbrook, and Stoney Creek). The series of annual mean nominal prices for each community was converted into a set of index values by taking the ratio of annual mean price for each community to the preceding annual mean price for the same community using the same chain Laspeyres indexing formula (see Formula 1) used for the G-LPI.

4.4.2.3 *Local Land Price Index*

Mean value indexing methods capture changes in the nominal mean (or median) land prices using a sample of observed transaction prices for vacant land for a fixed time period. Similarly, the L-LPI is based on "local" samples of observed transaction prices that are used to compute a spatially continuous surface of annual nominal mean land prices for each year, whereby the x and y-dimensions are latitude and longitude and the z-dimension represents land price per square metre. CrimeStat software (Levine, 2009) was used to generate the

[8] The most popular approach is the use of statistical methods (see Schnare and Struyk 1976), but perceptual techniques (see Menchik 1972; Palm 1978; Nelson and Rabianski 1988) and self-organizing maps (see Kohonen 1995; Kaski et al. 1998) have also been used.

spatially continuous using an *adaptive* kernel that was specified with a Gaussian functional form, using 30 metre output resolution and 20 nearest neighbours. This output resolution approximates the mean parcel size (868 m^2) within the study area. Meanwhile, the 20 nearest-neighbour specification was based on an evaluation of mean prices and consequent index values generated by 5, 10, 15, 20, 25, and 30 nearest neighbours. The evaluation of the optimal nearest neighbour specification considered (a) the number of observations in each year, (b) the spatial distribution of observations in each year (especially those areas with few observations), (c) the mean absolute error of the estimate, and (d) the range of index values generated.

The adaptive kernel was applied to annual samples of vacant residential land transactions within the City of Hamilton in order to produce a series of nine spatially-interpolated surfaces of annual mean nominal land prices from 1995 to 2003. The series of annual mean nominal prices was converted into a series of eight land price index surfaces by taking the ratio of each year's mean price at each location (x and y coordinates) to the preceding year's mean price at the same location (x and y coordinates) using the same chain Laspeyres indexing formula used for the G-LPI and S-LPI. The resulting land price indices are examined in the following section.

4.5 Results

This section (a) validates the G-LPI, S-LPI, and L-LPI against Statistics Canada's NHPI series of published price indices, (b) illustrates the spatial dynamics of appreciation and depreciation rates, and (c) compares the relative performance of the three geographic representations of land price indices.

4.5.1 Validating Land Price Indices

Statistics Canada publishes the New Housing Price Index (NHPI) series based on a monthly survey of building developers, which is independently indexed as total price (NHPI), house price (NHPI-H), and land price (NHPI-L). However, regardless of the efforts made to verify and edit survey information, the data are subject to errors such as respondent bias, especially insofar as separating the total value of a new house into cost of the structure and cost of the land (Statistics Canada, 2009). The NHPI series are also subject to selection bias, because the NHPI reflects only new homes in the "speculative builders" category (see Nourse, 1982), and it typically represents only suburban areas within the functional market.

Despite these known biases, the NHPI data are the only published land price index data available for the City of Hamilton. Therefore, monthly NHPI data covering January 1995 to December 2003 were downloaded from Statistics Canada's E-STAT website (http://estat.statcan.ca). In order to ensure consistency between NHPI values and the land price index values constructed using vacant land transaction data from the City of Hamilton, the monthly NHPI data were converted into annual values and were also adjusted to represent the same base year as the vacant land transaction data (i.e. January, 2003). It is important to note that the NHPI series for 2003 were only available for the first four months of the year.

Statistics Canada's NHPI series of published price indexes was compared with the G-LPI, S-LPI, and L-LPI (Table 4-2) in order to validate the results. The overall mean values for the NHPI and other land price indices in Table 4-2 are remarkably similar. The G-LPI, S-LPI, and L-LPI have overall mean values that are generally higher than the NHPI-L, but lower than both the NHPI and the NHPI-H. These differences may result from different data sources and the inherent heterogeneity in the land market outside the "suburban single family residential home" land market, which is evidenced in downtown and rural areas not covered by the NHPI series. These differences may also stem from the objective measurement of price using vacant land transaction data compared to the subjective separation of building and land prices by building contractors.

Table 4-2: Comparison of Annual Land Price Index Values

	Index Period								Overall Mean
	1995 - 1996	*1996 - 1997*	*1997 - 1998*	*1998 - 1999*	*1999 - 2000*	*2000 - 2001*	*2001 - 2002*	*2002 - 2003*	*1995 - 2003*
NHPI*	97.80	101.54	104.68	105.77	108.33	110.47	115.16	120.08	**107.98**
NHPI - H*	96.67	102.08	106.43	107.55	111.48	114.23	121.33	128.50	**111.03**
NHPI - L*	100.00	100.00	101.10	102.30	103.06	103.70	104.24	105.45	**102.48**
Global Mean	98.04	106.36	101.81	104.32	100.61	113.24	91.74	112.11	**103.53**
Ancaster	99.72	118.18	124.20	100.02	108.04	107.83	87.31	124.21	**108.69**
Dundas	57.49	127.70	86.69	131.70	99.14	77.61	129.47	121.97	**103.97**
Flamborough	152.64	92.98	82.12	54.02	156.12	76.93	104.10	83.80	**100.34**
Glanbrook	74.91	133.29	88.20	66.62	156.61	95.55	70.36	77.38	**95.36**
Hamilton	103.47	99.99	102.13	101.60	103.87	110.44	87.22	118.48	**103.40**
Stoney Creek	96.00	93.08	95.06	120.98	90.18	122.68	107.86	102.71	**103.57**
Local Mean	99.51	102.66	103.11	102.71	101.28	112.25	92.89	111.67	**103.26**

* *Source: Catalogue Table No. 327-0005, Geography = Hamilton, Ontario [35537].*

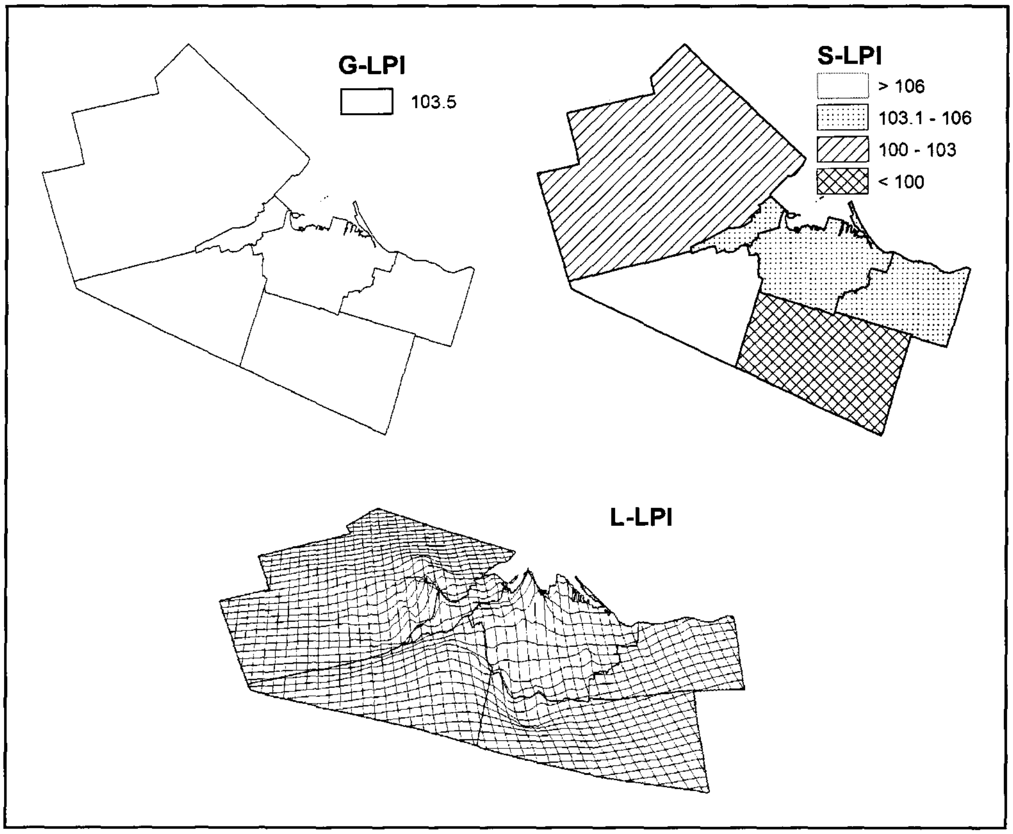
While the annual NHPI index values remain stable and exhibit gradually increasing values from one year to the next, the G-LPI, S-LPI, and L-LPI exhibit volatility between successive indices, with the S-LPI values exhibiting the greatest volatility. The S-LPI is especially prone to sample selection bias due to the low number of observations (i.e. less than ten) within Dundas and Glanbrook for some years, a problem that is compounded by the susceptibility of the mean value indexing method to outliers. The volatility in the G-LPI and L-LPI values appear limited from 2000 to 2002, which is a function of sample selection bias resulting from a few prestige subdivision developments during 2001 and un-serviced farmland conversion development in 2002 coupled with the susceptibility of the mean value indexing methods. It is worth noting that the L-LPI reduces the volatility of land price index values compared to the G-LPI during this period.

Notwithstanding the year to year volatility in the G-LPI, S-LPI, and L-LPI values, the similarities between the NHPI series and the other land price indices, especially the overall mean (i.e. 1995 to 2003), provide sufficient validation to warrant (a) an exploration of the spatial distribution of appreciation and rates, and (b) an examination of the relative performance of the different geographic representations of land price indices.

4.5.2 Spatial Distribution of Appreciation and Depreciation Rates

The spatial distributions of changing land prices for global, submarket, and local representations of geographic space are illustrated using different mapping techniques. For example, the most commonly used mapping technique for submarket representations (i.e. area data) of land prices is the choropleth map (see Bailey and Gatrell, 1995, p. 255). On the other hand, the most popular mapping technique for the local representation of land prices is a continuous surface, which dates back to the social physics tradition in geography (see Stewart, 1947). The G-LPI, S-LPI, and L-LPI are graphically illustrated in Figure 4-2 using the overall mean values (i.e. 1995 to 2003) depicted in Table 4-2.

Figure 4-2: Mean Value Composites (1995-2003) of Land Price Indices



The results in Figure 4-2 clearly illustrate that the G-LPI is failing to capture the spatial dynamics of land price appreciation rates. Both the L-LPI and S-LPI illustrate the existence of within-region spatial dynamics in land price index values for the City of Hamilton. Overall, higher appreciation rates (i.e. index values) are found along the urban-rural fringe in Ancaster and parts of Flamborough, which is illustrated by both the S-LPI and L-LPI. These results approximate the findings of Case and Mayer (1996) for the Boston housing market, whereby the highest land price index values are found on the urban/rural fringe where resource (i.e. agriculture and forestry) land uses are outbid and subsequently converted to residential land uses. The overall pattern of increasing suburban land prices is contrasted by lower appreciation rates (and possibly depreciation rates) highlighted by the L-LPI in west-end, inner-city, neighbourhoods and much of the rural community of Glanbrook. The S-LPI also highlights the community of Glanbrook, but does not provide insights within the community of Hamilton.

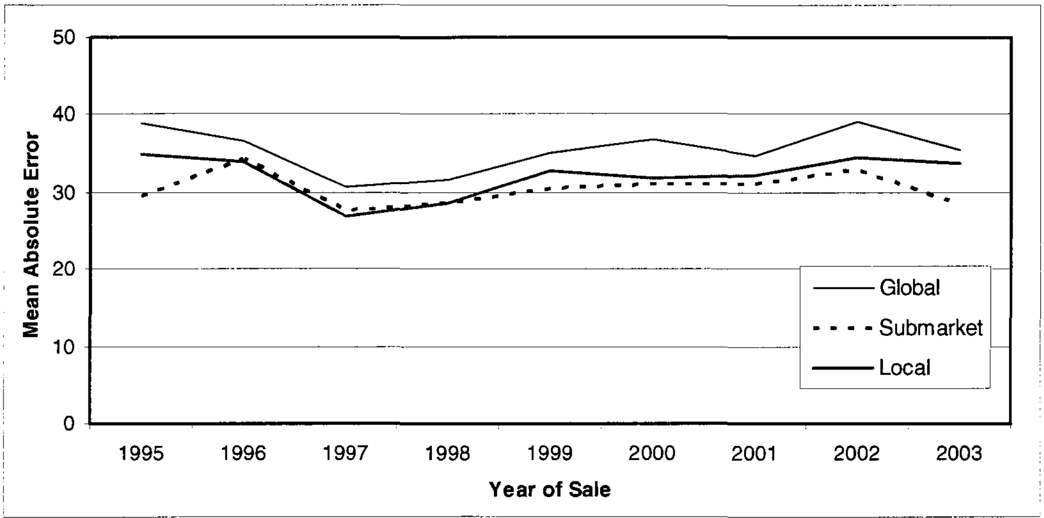
The L-LPI appears to highlight a downtown neighbourhood in the north-western portion of Hamilton with a concentration of high composite land price index values. These findings are supported by McMillen (2003), who reported that house price appreciation rates were higher near the city centre in Chicago. This concentration may be partially explained by the continuing redevelopment (i.e. gentrification and intensification) occurring within the area. However, this interesting concentration of high composite land price index values in the downtown neighbourhood is masked by all the other land price indices. Another neighbourhood highlighted by the L-LPI that is masked by the other indices is within Flamborough where "prestige" subdivisions are being built on land previously used for farming. Given the differences between the level of spatial detail afforded by the G-LPI, S-LPI, and L-LPI, a comparison of the relative accuracy of each geographic representation is described as follows.

4.5.3 Relative Accuracy of Geographic Representations

The relative performance of each geographic representation is examined using its mean absolute error (MAE), defined as the sum of the absolute differences between the estimated annual mean nominal price per square metre and the observed price per square metre in the sample. The annual distribution of MAE values are graphically depicted in Figure 4-3 for the G-LPI, S-LPI, and L-LPI.

The submarket representation has the lowest MAE values, which are due in part to the sample size that often far exceeds the 20 used to generate the local representation. Although the submarket representation is not based on an optimal definition of submarket boundaries, the boundaries used do capture the dichotomy between urban and rural communities (Figure 4-1). Similarly, the community boundaries also tend to stratify the land market into serviced and un-serviced lots, which can significantly affect land prices. Presumably these factors combine to produce the lowest MAE values for the submarket representation for 1995 and 1999 through 2003.

Figure 4-3: Distributions of Annual MAE Values for G-LPI, S-LPI, and L-LPI



Unfortunately, the submarket representation "may mask significant value discontinuities" (Fik *et al.*, 2003, p. 624), thereby failing to address the problem of contextual effects because, in isolating the sub-samples, it takes them out of their natural context as given by surrounding sub-samples; and thus it is inadequate at addressing spatial effects such as spatial autocorrelation and spatial heterogeneity (Páez *et al.*, 2008). Furthermore, the submarket representation is subject to the modifiable areal unit problem (MAUP) (Openshaw and Taylor, 1979; Openshaw and Taylor, 1981; Armhein, 1995; Openshaw and Alvanides, 1999; Nakaya, 2000), which is defined as "the imposition of artificial units of spatial reporting on continuous geographical phenomena [which] result[s] in the generation of artificial spatial patterns" (Heywood *et al.*, 1998, p. 193). MAUP is especially troublesome when using administrative boundaries opposed to functional or empirically derived boundaries.

The annual distributions of MAE values indicate that the submarket estimated mean prices provide the greatest reduction in MAE compared to the other two. However, it is important to note that the MAE values are subject to sample size. For example, increasing the number of nearest neighbours in the L-LPI will increase the degree of smoothing, cause higher MAE values, and result in a smaller range of index values (i.e. appreciation and depreciation rates). Furthermore, the S-LPI values can be altered by simply adjusting the spatial arrangement and number of discrete market segmentation boundaries[9]. However, the reduction of error introduced by sample selection bias must be balanced with the objective of computing robust price index values that represent the spatial dynamics of land prices.

4.6 Conclusion

Space-time variation in land prices reflect changes in the economic health of a region, yet land price indices ignore the spatial distribution of appreciation and depreciation rates within a given region. This research employed advances in GIS analysis to incorporate the spatial dynamics of land prices into the construction of land price indices at the municipal level. The purpose was to explore whether (a) land prices appreciate and depreciate over both time and space, and (b) it is possible to develop a simple yet robust method for exploring the spatial dynamics of the urban land market. Results indicate that the mean value land price indices constructed here are consistent with Statistics Canada's NHPI series, but the NHPI-L exhibits consistently lower values than all other indices. These disparities may suggest that the NHPI-L is underestimating the true changes in land prices within Hamilton, thus casting doubt over NHPI-L values

[9] Insofar as the appropriate number of submarkets, for example, Bourassa et al. (2008) found that the accuracy of house price predictions increased directly with the number of submarkets, but accuracy quickly plateaus once an optimal number of submarkets was reached.

for other jurisdictions as well. However, concerns must be tapered given the nature of mean value indexing methods and data sources, which (i) do not adjust for neighbourhood quality or quality of the lot, (ii) are subject to sample selection bias, and (iii) are especially prone to the impact of outliers.

The annual distributions of MAE values were used to compare the relative performance of three geographic representations of land price indices. Based on the MAE values the submarket representation performed best, but it masked neighbourhood-level changes in land prices. Unfortunately, the comparison of the three geographic representations did not provide conclusive evidence regarding which representation (i.e. global, submarket, or local) is best. The results did, however, clearly indicate that both submarket and local representations outperformed the global representation, which highlights the importance of the spatial dynamics of land prices within the City of Hamilton. The results also highlight the tools and opportunities afforded by GIS, which provide the ability to explore a new spatial paradigm for developing land price indices specifically and for real estate research in general.

This research focused on exploring the spatial dynamics of the urban land market, while relying exclusively on a discrete "annual" temporal resolution. Future research should examine alternate temporal resolutions and the advantages of concurrently incorporating the continuous spatial distribution and continuous temporal distribution of the dynamic urban land market. For example, Clapp (2004) incorporated both the spatial and temporal dynamics into an autoregressive model for Fairfax County, Virginia. Other options include the use of a space-time kernel or space-time Kriging estimation that would enable incorporation of spatial and temporal autocorrelation. The idea of integrating both time and space is not new as evidenced by the famous words of Minkowski (1908) "henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality".

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CHAPTER 5: Location and Land Values: Comparing the Accuracy and Fairness of Mass Appraisal Models

5.1 Introduction

Land values represent the economic health of urban areas and statistical analysis of land values supports research on a variety of social, economic, and planning policies (Clapp, 1990; Cheshire and Sheppard, 2005). The importance and merits of land values have been around for centuries, and in 1826 von Thünen documented "how difficult it is to work out the land rent of any given farm; ...[and] it should not surprise us to find that nearly every such attempt has miserably failed in practice" (Hall, 1966, p. 212). These difficulties become more complex when attempting to work out the land rent of any given urban lot considering the special characteristics of land, public policy controls, the many different and competing land uses, and the wide variety of market participants and financing methods. These difficulties contribute to making the valuation of vacant land one of the most difficult aspects of property assessment (Gloudemans *et al.*, 2002).

Location is clearly an important factor to consider in real estate research, and "land of different situation will command very different rents" (Douglas, 1936, p. 17). The impact of location still manifests itself in the explicit influence of land's location in space on its value. This *inherent geography* of urban land values affords them unique characteristics, such as spatial autocorrelation and spatial heterogeneity. The problem with failing to sufficiently capture the impact of location is that many well-specified appraisal models will violate their statistical assumptions, which may bias and even invalidate the urban land value estimates. Since the assessed value of real estate is the basis for, among other things, calculating property tax burdens, failing to sufficiently capture the impact of location contributes to social and geographic inequities of the property tax (Harris and Lehman, 2001). Consequently, and in addition to the various public and private applications of land price data, it is important to consider the choice of modelling technique used to assess urban land values, because it has economic, planning, and social welfare implications.

The purpose of this research is to explore the inherent geography of urban land values by comparing the traditional ordinary least squares (OLS) regression model with two spatial model specifications. The objective of this comparison primarily concerns each model's relative performance with respect to their (a) predictive accuracy and (b) ability to mitigate geographic inequities in the appraisal of residential urban land values within the City of Hamilton, Ontario, Canada. The spatial modelling techniques employed here include spatial autoregressive (SAR) and ordinary Kriging models. The remainder of this paper continues with some important definitions and theoretical background information, which is followed by a brief description of the study area and the data used to estimate these models. The models are described in the methods section, followed by a comparison of the performance of each modelling technique and concluding remarks.

5.2 Background

Since the dawn of human culture land has held a special place in geographic, environmental, social, and economic thought. Land, in economic parlance, is defined as the entire material universe outside of people and the products of their labour. Within this study the definition of urban land is considerably more restrictive and is limited to urban ground, irrespective of buildings and other capital improvements. The value of urban land is based on modern price theory, which distinguishes between market price and market value. *Market price* is the amount actually paid in a particular transaction, while *market value* is a hypothetical or estimated sale price that would result from careful consideration by the buyer and seller of all data, with primary reliance on those data that reflect the actions of responsible, prudent buyers and sellers under conditions of a fair sale. It is important to note that the price people pay for property is occasionally ill-advised (Mackmin, 1985; Skaburskis, 2002), which affects the amount of error in appraisers' estimates of market value.

An appraisal, or assessment, of land value is essentially an expert opinion of the market value of a parcel of land, and that opinion must be both explainable and defendable, often in court. Many methods and concepts used by assessors of land values stem from the theories and models of economists trying to explain and measure net ground rent. This is an important economic concept because the value of urban land is the result of ground rent capitalized (Hurd, 1924). Therefore, the study of value and its determination have always been a principal concern of economists and assessors. Over time, the assessment industry has developed several methods of estimating land values, such as comparative unit, base lot, abstraction, allocation, cost of development, ground rent capitalization, proportional relationship, land residual technique, and others. However, it has been recognized that all these methods are extremely problematic for jurisdiction-wide assessments (German *et al.*, 2000). Furthermore, the professional practice of property assessment has moved away from the valuation of single properties to mass appraisal techniques.

Mass appraisal is defined as the systematic appraisal of groups of properties for a given date using a set of standardized procedures and statistical tests (Eckert *et al.*, 1990; McCluskey *et al.*, 1997). Computer-assisted mass appraisal (CAMA) models and automated valuation models (AVM) use computers and mathematical models to establish a relationship between property characteristics and sale prices, thereby allowing an estimate of the market value of other properties not subject to a recent sale. Multiple regression analysis (MRA) is internationally recognised as the industry standard modelling technique for CAMA and AVM models. MRA attempts to isolate a set of explanatory variables in order to predict the dependent variable – assessed value. The theoretical basis for using MRA rests in hedonic pricing theory, which was first used by Court

(1939) and later developed by Adelman and Griliches (1961), Lancaster (1966), and Rosen (1974), and is based on the idea that composite goods may be decomposed into the marginal value of each characteristic. These marginal values are represented by each of the *Beta* values in the regression model.

While MRA is a powerful tool and it has several advantages, there are also chronic problems associated with MRA as a mass appraisal technique. Mark and Goldberg (1988) review the issues with MRA and mass appraisal. Some of these problems stem from the simple fact that MRA is a non-spatial model being applied to inherently spatial real estate data. The geographic nature of real estate data causes them to exhibit unique characteristics. One of these characteristics is that both the mean values and the variance around the mean exhibit spatial dependence (i.e. similar values are clustered in geographic space), which is also known as spatial autocorrelation. Research into the influence of spatial autocorrelation on parameter estimates and their level of significance has acquired considerable attention in real estate research (e.g. Dubin, 1992; Pace and Gilley, 1997; Orford, 2000; Mulligan *et al.*, 2002; Kestens *et al.*, 2006). Another unique characteristic of geographic data is that the statistical properties of spatial phenomena are rarely independent of their location. This means that the mean, variance, or the covariance structure vary over the study region (spatial drift), and is referred to as non-stationarity or spatial heterogeneity. The problem with using aspatial econometric models, such as OLS, for estimation of spatial processes is that the models violate their underlying statistical assumptions. This creates problems for estimation, significance testing, and interpretation of models in general (Griffith and Layne, 1999), and in land price models specifically (Páez *et al.*, 2001), while at the same time it has a negative impact on the fairness of the municipal tax system.

Fairness, or equity, is one of the maxims used to evaluate different forms of taxation. The fairness of the property tax is measured in two ways. Horizontal equity is based on the concept of benefits received, and vertical equity is based on the concept of ability to pay. Ratio studies of *market price* to *market value* are the industry standard technique used to quantify fairness, and these studies provide evidence of the tendency of traditional assessment models to over-assess the cheapest properties and under-assess the most expensive properties in Boston (Black, 1972), Winnipeg (Kuz and Saprovich, 1994), and Hamilton (Thrall, 1979a and 1979b; Harris and Lehman, 2001). The systematic spatial variations in ratio values across the study area are caused, in part, because of the mass appraisal model's inability to account for the impact of location.

One method used to account for the impact of location in multiple regression models is to add independent variables that fluctuate over space. For example, the study of urban land values has historically focussed on accessibility to the central business district (CBD), whereby urban land values will decrease accordingly with decreasing accessibility to the CBD in order to offset increased transportation costs (Alonso, 1964). While accessibility continues to play an important role in urban land values, there are a variety of other situation-specific variables that are commonly used as surrogate measures or proxy variables, to explicitly value neighbourhood attributes (e.g. Can, 1990; Case, 1992; Cheshire and Sheppard, 1998). These factors interact in complex ways, are valued differently by different actors in the real estate market, and are often difficult to measure (Gallimore *et al.*, 1996), which makes the analysis of the urban land market rather complicated (Koomen and Buurman, 2002).

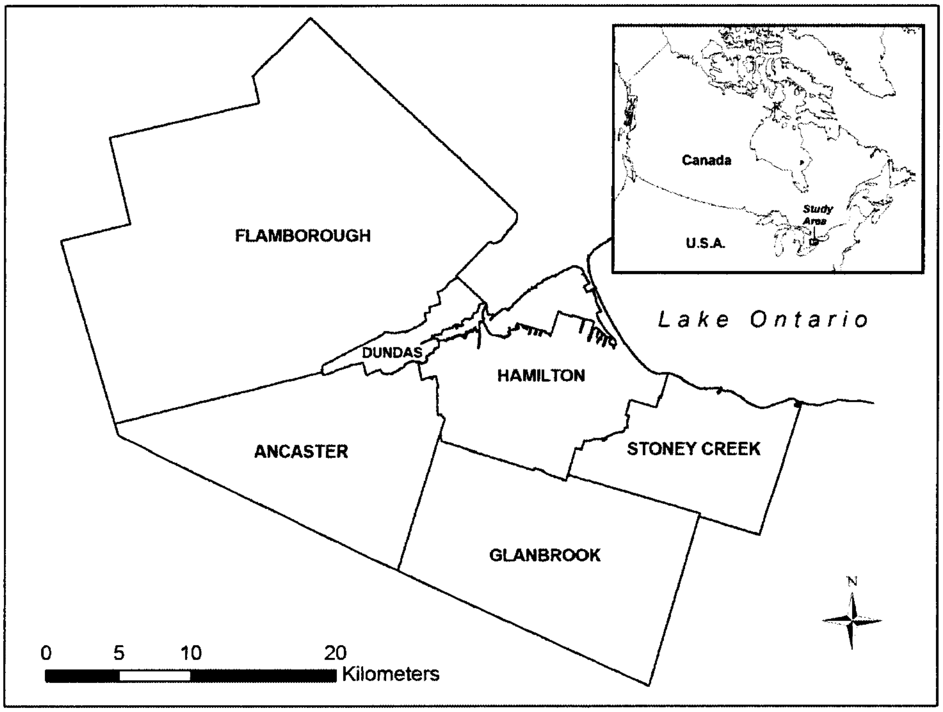
The choice of modelling technique depends, in part, on the manner in which urban land values are conceptualized. For example, if land values are perceived as the transaction price for each discrete parcel of land, there is likely to be considerable heterogeneity among land values due mainly to the size of the lot and its location within the urban spatial structure. Consequently, this discrete view of land values requires a spatial form of multivariate regression (i.e. hedonic price model) to account for these spatially varying site and situation determinants of urban land values. However, if we adjust for site determinants by using land value per unit of areal extent (e.g. square metres, frontage) and conceptualize the situational determinants (i.e. relative location) as spatially continuous processes, much of the heterogeneity in values will be removed and land values can be treated as a regionalised variable. Such variables are assumed to attain values according to a spatial stochastic process whereby every point in space has a value and these values exhibit spatial autocorrelation. The advantage of conceptualizing urban land values as a regionalized variable is that it permits the use of spatial interpolation techniques for estimating spatially continuous surfaces. This paper explores both discrete and continuous views of land value processes and examines their respective ability to improve the accuracy and fairness of urban land value estimates in Hamilton, Ontario.

5.3 Study Area and Data Description

The study area for this research is the amalgamated City of Hamilton, Ontario, Canada. It is located approximately 75 kilometres southwest of the provincial capital of Toronto and had a total population of 693,000 in 2006. Illustrated in Figure 5-1, the municipality of Hamilton is completely urbanised and is surrounded by five, predominantly agricultural, municipalities that collectively comprise the amalgamated city of Hamilton.

Like many other North American cities during the post World War II period, Hamilton experienced substantial economic development and population growth associated with intense urban development. Within the past few decades, Hamilton has been exposed to suburbanization with *greenfield* development of residential and commercial subdivisions. The suburbanization process has destabilized the traditional roles of the countryside and the city's downtown, with a consequent impact on appreciation and depreciation rates in land prices; with the highest values but the lowest appreciation rates in the city's downtown.

Figure 5-1: Municipalities of the amalgamated City of Hamilton



5.3.1 Data Description

The data used to enable the relative performance comparison of three different model specifications within the City of Hamilton can be categorised into price data and contextual data. The transaction price data were acquired from the Land Registry (i.e. deed transfer) office and included information about the location, date of sale, and the nominal sale price for the population of 87,277 private real estate transactions that occurred in Hamilton, Ontario, between January 1995 and May 2004. Using a spatial decision support system[10], a total of 2,524 transactions in vacant land were extracted from the population of private real estate transactions.

Contextual data were acquired to provide independent variables, stratify the vacant land market, and adjust nominal prices. Cadastre (i.e. parcel fabric) data were acquired from Teranet Inc. (www.teranet.ca) and were used to derive

[10] The cleansing process is described in detail within Chapter 3.

information about the total area for each parcel of land within the study area. Land use data were acquired from the municipality (www.hamilton.ca) and provided information primary land use type (e.g. residential, commercial) for each parcel of land within the study area. Using geographic information system (GIS), the location of municipal water and sewer infrastructure, also acquired from the municipality, was used to determine the parcels within the "serviced" area, while the location of public schools was used to determine the distance to each parcel of land in the study area. Statistics Canada's New Housing Price Index (NHPI) includes independently indexed land price (NHPI-L) information and monthly NHPI data for the City of Hamilton between 1995 and 2003 were downloaded from the E-STAT website (http://estat.statcan.ca), and were used to provide information about the dynamic land market conditions. Statistics Canada's 2001 census data were also downloaded from the E-STAT website and were used to represent the social and economic attributes affecting urban land values.

5.3.2 Data Processing

After formatting and concatenating the various datasets, the vacant land sales were stratified into market segments. Market stratification or market segmentation is based on the understanding that different goods will have different markets, whereby consumer preferences and prices are largely diversified (Rapkin *et al.*, 1953; Grigsby, 1963). The concept of a housing submarket is based on the appraisal concept of substitution, and the central notion of a submarket is that properties should be close substitutes and not just located in the same neighbourhood (Goodman and Thibodeau, 2003; Jones *et al.*, 2005). While market segmentation can be used to delineate relatively homogeneous market segments according to either geographical areas (i.e. neighbourhoods) or the physical use of the property (e.g. residential, commercial), it was used in the current study to select relatively homogeneous non-rural residential land uses within the area serviced by municipal water and sewer. Furthermore, residential lots larger than two and a half acres (approx 8,094 m^2), likely planned for subdivision, were excluded in order to improve constant quality among vacant land prices and to account for diminishing returns to lot size (see Colwell and Sirmans, 1978).

Market segmentation resulted in total of 1,751 transactions of urban, serviced, residential, and vacant land parcels within the study area between 1995 and 2003. To enable comparison of land price information from different time periods (and different micro and macro land market conditions) nominal sale prices were multiplied by NHPI-L values for each year required to bring the price information to real prices that represent land market conditions in 2003. For example, transaction prices that occurred in 2001 were multiplied by 2002 and 2003 index values. Using real prices, the next processing operation was to remove price outliers.

In order to account for constant quality among sale prices and to eliminate any extreme values, we first computed a spatially continuous surface of mean land prices per square metre using an adaptive kernel. CrimeStat® III software (Levine, 2009) was used to compute an adaptive kernel using 100 m grid cells with a Gaussian functional form and 30 nearest neighbours, and the mean values were extracted to each sale point. This local mean price per square metre was then divided by the *market price* per square metre to compute local ratio values. Similar to Gatzlaff and Ling (1994) only those transactions with local ratio values within three standard deviations of the overall mean were selected; leaving 1,640 transaction in vacant land to enable the comparison of relative accuracy and fairness of OLS, SAR, and ordinary Kriging models. Before a description and comparison of the various model specifications and their respective abilities to incorporate the impacts of location into the assessment of urban land values, however, the independent variables used in the hedonic price models are examined.

5.3.3 Determinants of Vacant Land Prices

The traditional mantra used to describe the three main factors affecting the value of real estate is "location, location, and location" (Britton *et al.*, 1989). Location may be separated into (i) site factors (e.g. size, shape, slope, drainage), (ii) situation in space factors (i.e. proximity to physical, legal, social, and economic attributes affecting value), and (iii) situation in time factors. The selection of independent variables was partially informed by theory and previous research, but was also based on results from exploratory data analysis (i.e. correlation analysis and multicollinearity tests). Site factors are represented by parcel area, which was measured in square metres. Situation in space factors were represented by two different independent variables: (i) median income in 2001 by census tract (n = 166); and (ii) straight-line distance to the nearest school. Finally, situation in time was accounted for by temporally adjusting nominal sale prices into real prices for vacant land (the dependent variable) that reflect 2003 land market conditions.

5.3.4 Sample Selection

The comparison of model performance is primarily based on each model's predictive ability, so the 1,640 vacant land transactions were divided into two randomly sampled groups; the result is an estimation sample (i.e. in-sample observations) and a validation sample (i.e. out-of-sample observations). The sample used to estimate the different model specifications contains 1,497 observations and the sample used to validate those models has 143 observations. It is important that the comparison of model performance is not inexplicably influenced by a poorly selected validation sample (Case *et al.*, 2004; Páez *et al.*, 2008), so an independent samples t-test was used to ensure the absence of any statistically significant differences between the estimation and validation samples (Table 5-1).

Table 5-1: Summary Statistics of Estimation and Validation Samples

	Estimation Sample (n=1,497)		Validation Sample (n=143)		Comparison of Means	
Variable	**Mean**	**SD**	**Mean**	**SD**	**t**	**Sig. ***
Real Sale Price ($)	74,889.23	52,691.39	73,761.41	36,954.18	0.250	0.803
Parcel Area (m^2)	584.14	516.70	545.78	311.50	0.873	0.383
Median Income ($)	69,596.31	10,981.98	70,329.76	12,029.28	-0.757	0.449
Distance to School (m)	648.07	392.77	611.05	490.95	1.052	0.293

** Two-tailed significance*

The two samples exhibit similar means and standard deviations. For example, the maximum sale price ranges from $10,000 to over $670,000, yet the difference in mean sale prices is only $1,441. The independent samples t-test results provide further evidence that, despite any apparent differences in mean values, none are significant. Table 5-1 provides convincing evidence that the estimation and validation samples are reasonably similar over all the dependent and independent variables used to estimate the different model specifications.

5.4 Methods

The purpose of this section is to describe the different models used to estimate residential land values and the methods used to compare their relative performance. Analysis of each model's predictive ability will follow in the results section along with a comparison of the accuracy and fairness of each modelling technique.

5.4.1 Ordinary Least Squares

As previously mentioned, MRA is the most frequently used model for CAMA and AVM, and OLS is the most commonly used parameter estimation method. The OLS model may be represented using matrix notation as

$$Y = X\beta + \square$$

where Y is a (n x 1) vector of observed sale prices on n parcels of land; X is a (n x k) vector of site and situation characteristics for parcels of land; β is a (k x 1) vector of unknown coefficients; and $\square$ is a (n x 1) vector of all the other factors affecting sale prices but omitted from the model (Bowen *et al.*, 2001). The unknown coefficients are estimated by OLS as

$$\beta = (X^T X)^{-1} X^T Y$$

Linear multiple regression of sale prices was initially carried out in SPSS using a simple additive model and served as the benchmark against which the following models will be evaluated.

5.4.2 Spatial Autoregressive Models

In order to mitigate the negative impacts of spatial effects, they can be incorporated into multiple regression models using *spatial lags*. For example, a SAR model can be fitted to explanatory variables in order to capture both global and local variations in the mean value (Brunsdon *et al.*, 1998; Griffith, 1998). SAR models have been used in real estate research to address methodological issues, such as appropriate estimation strategy, and testing for spatial dependence and heterogeneity (e.g. Can, 1992; Pace and Barry, 1997; Kelejian and Ingmar, 1998; Kim *et al.*, 2003). The explanatory variables include a spatial lag for the dependent variable, which is calculated as a weighted average of neighbouring values (Bailey and Gattrell, 1995):

$$Y = X\beta + \rho WY + \square$$

Here ρ is the spatial autocorrelation parameter and W is the (n x n) neighbourhood matrix of spatial dependence. All other symbols are as in the OLS model. The spatial autocorrelation term ρWY is added to the linear regression model in order to capture the strength of the spatial dependence among the observations of the dependent variable Y. The rows of the neighbourhood matrix W sum to 1, which means that *W* is row-standardized. GeoDa^{TM} software was used to estimate the spatial error model using the Maximum Likelihood method and asymptotic inference (see Anselin and Bera, 1998; Smirnov and Anselin, 2001).

5.4.3 Kriging

Kriging predicts the value of a variable at a point in space on the basis of observed values for the variable. Observations closer to the prediction point are assigned higher weights than those further away (Ripley, 1981; Oliver, 1990; Cressie, 1993). Kriging is based on the assumption that the variable being interpolated can be treated as a regionalized variable, meaning it is spread out in space and/or time (Krige, 1951; Matheron, 1963). A regionalized variable varies continuously from one location to the next and, therefore, values that correspond to points that are near each other have a higher degree of similarity than those that are widely separated (Davis, 1986). There are relatively few applications of Kriging in real estate research (Basu and Thibodeau, 1998; Dubin, 1998; Case *et al.*, 2004; Chica-Olmo, 2007; Páez *et al.*, 2008) and even fewer applications of Kriging models to land prices. A notable exception is Shultz (2007), who used Kriging to estimate agricultural land values and compared them with survey estimates of land values. The practical difficulties using Kriging to predict heterogeneous house prices should be mitigated in land valuation, due to higher homogeneity in land values relative to housing values.

Recall that the impact of location on land values may be separated into absolute location in space, relative location in space, and relative location in time. It is possible to incorporate the absolute location in space (i.e. parcel area) into the dependent variable by using sale price per square metre. It is important to note that this specification of the dependent variable assumes the price of land is directly proportional to the size of the lot. Meanwhile, the relative location in time has already been incorporated into the dependent variable by using the NHPI-L to temporally adjust nominal prices of historical transactions into real land prices that represent 2003 land market conditions. The remaining impact of location is the relative location in space, which is embodied in the sale price, and is thus captured by the Kriging model.

Kriging is a linear model that makes use of the covariance structure (dependency) of the observations in space. The covariance structure is obtained *a priori* through the estimation of a variogram. There are several variations of the Kriging model that differ in the assumptions about the nature of the observed variation on the surface. The two most common are universal and ordinary Kriging. Universal Kriging, also known as Kriging with a trend, assumes that there is an overriding spatial trend in the data that can be modelled using a deterministic function, such as a polynomial. Alternatively, ordinary Kriging, the simpler of the two, is the most widely used and assumes that the trend is represented by a constant value across the study area. Based on analysis of trends and the presence of local stationarity exhibited in the variograms (covariance models), we chose ordinary Kriging with local variograms (see Haas, 1990) for spatial prediction of urban land values. The software used to perform Kriging with local variograms is called VESPER, which is an acronym for Variogram Estimation and Spatial Prediction with Error, and was developed by the Australian Centre for Precision Agriculture (Minasny *et al.*, 2005). The advantage of fitting of a local variogram model stems from the ability of the Kriging model to adapt to differences in local spatial structure over the study area, which should produce more accurate predictions than a global variogram.

5.4.4 Model Evaluation

Evaluating the relative performance of models begins with a comparison of parameter estimates for the OLS and SAR models, followed by an evaluation of the predictive accuracy of each model, including the Kriging model. Predictive accuracy is assessed by comparing predicted values with the observed values in the validation sample. The predictive accuracy of each model specification is also evaluated using sales ratios, which provide a statistical measure of how close the *market value* is to *market price*. Standard sales ratio study metrics are used to evaluate the accuracy and fairness of the land value estimates from the three different model specifications, while the spatial distributions of sales ratio values are illustrated using spatially continuous surfaces of mean ratio values to examine the different patterns of "fairness" associated with each model.

5.5 Results

The purpose of this section is to compare the results of the benchmark OLS model with the SAR and Kriging models. It is important to reiterate that the objective of this research is to compare the relative performance of three parsimonious models. The comparison first examines the model parameters then examines the performance of the different model specifications in terms of out-of-sample predictive accuracy.

5.5.1 Comparison of Model Parameters

A comparison of model parameters for the OLS and maximum likelihood SAR parameter estimation methods is provided in Table 5-2, and illustrates relatively stable coefficients for the independent variables used to explain vacant land prices. While all coefficients are significant in the OLS model, the coefficient for median income has become insignificant in the SAR model, which illustrates the effect that spatial error autocorrelation can have on OLS estimates (see Anselin, 2004). The R-squared values, although not directly comparable due to the manner in which they are calculated, represent the proportion of the variation of vacant land sale prices that is accounted for by each model and are remarkably similar and relatively high. The standard error of the estimate indicates the extent to which the estimated sale prices vary from their actual values, and the values are remarkably similar across the three models, but slightly improved for the SAR model.

Table 5-2: Comparison of Model Parameters for OLS and SAR

	Ordinary Least Squares		**Spatial Autoregressive**	
Variable	***β***	***Sig.***	***β***	***Sig.***
Constant	99.01	0.983	1094.85	0.000
Area	84.07	0.000	80.86	0.000
Median Income	0.30	0.000	0.33	0.994
Distance to School	7.82	0.000	7.01	0.000
Rho			0.565	0.977
R^2	0.736		0.763	
Standard Error	27,125.4		25,632.8	

The similarities between the OLS and SAR models stems from the general lack of spatial autocorrelation in sale prices, which is confirmed by the positive yet insignificant spatial autoregressive coefficient (ρ = 0.565). This however represents a characteristic of the data used in this study and in general one should expect to find significant differences between the two models. Although the SAR model indicates lack of autocorrelation at the study area (global) scale, also verified by global Moran's I tests, examination at the local scale through Anselin's Locan Moran's I test indicates the presence of significant clusters of high and low values.

5.5.2 Comparison of Predictive Accuracy

The performance of these models is illustrated in Table 5-3 using summary statistics and comparative analysis of predictive accuracy that are based on the difference between predicted values from the estimation sample and the observed values of the validation sample.

Table 5-3: Summary Statistics and Comparison of Model Prediction Performance

Model	Mean Absolute Error	Median Absolute Error	R^2	Predictions within 30% of validation price	Predictions within 20% of validation price	Predictions within 10% of validation price
OLS	12,499.9	8,641.6	0.759	81.8	68.5	39.9
SAR	12,712.4	9,478.9	0.764	81.1	66.4	37.8
Kriging	14,965.1	10,562.7	0.757	79.0	61.5	34.3

The mean absolute error (MAE) indicates a slight increase in model performance for the OLS model over the other models, and the Kriging model has the highest MAE. Since the median is less affected by extreme values, the International Association of Assessing Officers (IAAO) generally prefers the median as the measure of central tendency for monitoring appraisal performance. The median absolute error exhibits a similar pattern as the mean absolute error, with OLS exhibiting the lowest median absolute error. The R^2 value represents the squared Pearson correlation coefficients between the predicted and observed sale prices in the validation sample. The SAR model has the highest R^2, while the OLS and Kriging models are only marginally inferior.

The last three columns in Table 5-3 represent the proportion of estimated sale prices that are within 30, 20, and 10 percent of the observed sale prices in the validation sample. For example, 81.8 percent of the prices estimated using the OLS model are within 30 percent of the observed sale prices in the validation sample, compared to 81.1 percent for the SAR model, and 79.0 percent for the Kriging model. Overall, there are only slight differences between the three models with regards to their predictive accuracy. This is partly due to the poorly defined spatial dependency in the vacant residential land price data. In the presence of strong spatial autocorrelation in the dependent variable, it is likely that the SAR model will significantly outperform the OLS model.

5.5.3 Comparison of Sales Ratios

The results from the sales ratio study, which is simply the quotient from *market value* divided by *market price*, using the estimation sample are presented in Table 5-4. The desired sales ratio is 1.00, which means the mass appraisal model was able to accurately predict the within-sample prices. However, a sales ratio of 1.00 is unlikely, so the 2007 Standard on Ratio Studies set by the IAAO (2007) indicate that a sales ratio between 0.90 and 1.10 are considered acceptable. We used assessment ratios, coefficient of dispersion (COD), and price-related differential (PRD) values to evaluate each model's respective ability to produce accurate estimates and mitigate the geographic inequities of the property tax.

Table 5-4: Comparison of Sales Ratios and Fairness

Statistic	OLS	SAR	Kriging
Number of observations	1,497	1,497	1,497
Total appraised value	112,109,179	113,396,826	118,458,760
Total sale price	112,109,179	112,109,179	112,109,179
Mean appraised value	74,889	75,749	79,130
Mean sale price	74,889	74,889	74,889
Mean ratio	1.079	1.099	1.072
Median ratio	1.020	1.042	0.959
Weighted mean ratio	1.000	1.011	1.057
Price-related differential	1.079	1.086	1.015
Coefficient of dispersion	0.208	0.208	0.251

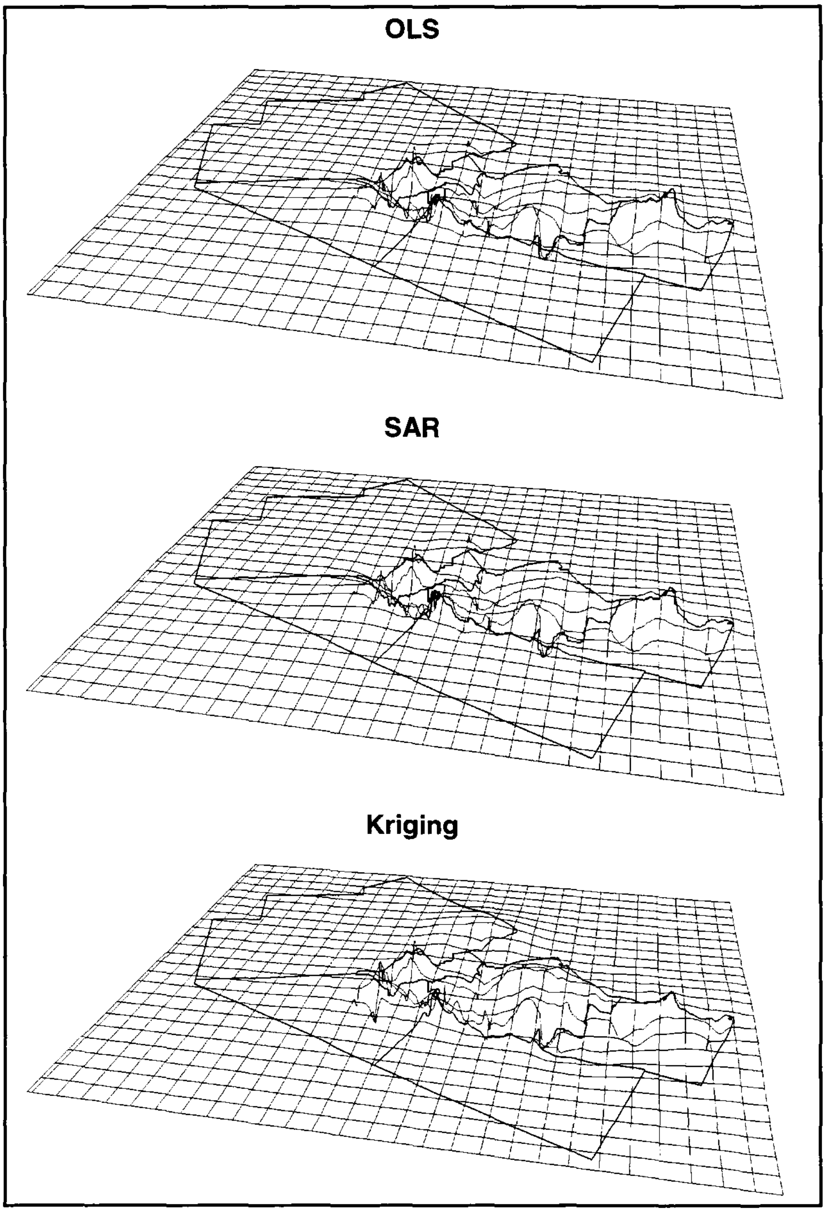
According to the mean, median, and weighted mean ratios listed in Table 5-4, all models generated estimates of vacant land values that are considered "acceptable" by IAAO standards. However, the overall ratios do not provide any indication of uniformity or fairness. The most important measure of assessment uniformity is the COD, which represents the average percentage deviation from the median ratio and can be loosely interpreted as the average error, but it does not depend on the assumption that the ratios are normally distributed. According to IAAO standards, COD values for vacant land should not exceed 20.0. Both the OLS and SAR models are close to meeting IAAO standards for COD. Another measure of uniformity is the price-related differential (PRD), which is used to measure uniformity between high- and low-value properties and should be between 0.98 and 1.03 to demonstrate vertical equity (IAAO, 2007). According to the results in Table 5-4, only the Kriging model was able to produce estimates of vacant land prices that meet IAAO standards for PRD, which suggests that the Kriging model is better able to incorporate the differences between high and low value land parcels.

5.5.4 Spatial Analysis of Sales Ratios

Similar to the approach used to eliminate any extreme values in Section 3.2, we used CrimeStat® III software to compute a spatially continuous surfaces of sales ratio values for the three models (using 10 nearest neighbours and a Gaussian functional form). The spatially interpolated mean sales ratios in Figure 5-2 are used to illustrate the "geographic inequities" of the land value estimates from the three models.

The differences between the OLS and SAR models appear negligible in the spatial pattern of over-assessed and under-assessed properties, but the spatial distribution of mean sales ratio values from the Kriging model exhibit a much different pattern. In either case, however, there is clear evidence of neighbourhoods that are under-assessed and those that are over-assessed. The areas that are over-assessed may point toward the influence of local outliers, which are created in many cases by the inclusion of demolitions, and may be indicative of developers capitalizing on what Neil Smith (1979) called the "rent gap". These results may also provide an argument for the market segmentation process to also include delineating sub-market boundaries, especially for neighbourhoods that are prone to geographic inequities due to the unique character of the neighbourhood.

Figure 5-2: Spatially interpolated sales ratios for different mass appraisal models



5.6 Conclusion

Land value information is necessary in the private sector for lending and investment decisions, and is required in the public sector for land use zoning, eminent domain, and, of course, property taxes. The objective of this research was to compare the relative performance of OLS, SAR, and ordinary Kriging models insofar as the accuracy and fairness of the estimates of land values produced. The intention was to compare simple model specifications in order to focus on their respective ability to produce accurate and fair estimates of land values, primarily as a function of their ability to incorporate the impact of location. This research is not, however, without its limitations. Firstly, the OLS and SAR models are parsimonious, and are primarily reliant on the size of the lot for their predictive ability. We also recognise the limitations imposed by the land use information that restricted the ability of the market stratification process to distinguish between high-density (e.g. apartments) versus low-density (single family home) zoning for each parcel. Furthermore, a simple linear specification was chosen for the functional form of the OLS and SAR models even though we recognise the relationships are likely more complex. We also included sales data over a nine-year period; although nominal prices were adjusted to real prices representing land market conditions in 2003, markets change and neighbourhoods appreciate and depreciate at different rates within the city.

Despite the limitations, we believe that the Kriging model performed very well, especially considering its specification did not incorporate any neighbourhood attributes. However, results clearly indicate that OLS has significant potential to outperform spatial interpolation of urban land values, and there appears to be some potential for SAR models to improve the accuracy of hedonic price models (Table 5-3). On the other hand, insofar as each model's respective ability to account for differences between high and low-value lots, only the estimates from the Kriging model meet IAAO standards for vertical equity (Table 5-4).

Despite having the poorest predictive accuracy of the models tested, the Kriging model highlighted the advantages of explicitly incorporating local spatial dependence and spatial heterogeneity into the model structure, especially when the dependent variable contains measurement errors. Furthermore, the specification of the Kriging model is hampered by the specification of the dependent variable, because the relationship between price and area is almost certainly not linear. A better specification of the dependent variable in the Kriging model, such as a different specification between price and area, or possibly using price per street frontage, could improve the overall performance of the Kriging model, especially in areas with highly variable lot depths. Furthermore, it is possible to incorporate a covariate into the Kriging model by using cokriging, which would invariably improve model performance. Overall, however, these results suggest that perhaps other spatial analytic techniques need to be adopted, such as generalised least squares or geographically weighted regression, that can take advantage of both the spatial distribution of land prices plus the ability to decompose vacant land values into marginal prices.

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CHAPTER 6: Municipal Taxation and Social Exclusion: Examining the Spatial Implications of Taxing Land Instead of Capital

6.1 Introduction

The *ad valorem* property tax is the major own-source revenue for Canadian municipalities, but "no tax in Canada has been more vilified" (Bird and Slack, 1983, p. 60). In fact, the property tax has been labelled "incredibly bad" (Fisher, 1996, p. 169) and "beyond all doubt one of the worst taxes known in the civilized world" (Bails, 1974, p. 192). Part of the problem, and unbeknownst to many, is that the property tax is really two taxes - one on the value of land and the other on the value of capital improvements (e.g. building, drainage, landscaping). The current municipal property tax system in Ontario, and throughout most of North America, taxes the market value of the entire property, which means the value of capital improvements are taxed more heavily than the value of land. The distinction between land and capital is important, because they are different factors of production and their taxation, therefore, will have very different social and economic outcomes (Becker, 1969; Levine, 1983; Bourassa, 1992; Yang and Means, 1992; Peddle, 1994).

On the other hand, land value taxation, or site value taxation, is an *ad valorem* tax based solely on the value of land, irrespective of buildings and other improvements. It is agued that land value taxation is certainly supportable on purely fiscal grounds, but it is predominantly supported as a means of achieving social justice; it represents compensation to the rest of society for the privilege of monopolizing something the owner did nothing to create (Carter, 1982; Tideman, 1998). Such a levy has been described as "the taking by the community, for the use of the community, of that value which is the creation of the community" (George, 1992, p.421). Inspired by success in other parts of the world, such as parts of the United States (Oates and Schwab, 1997; Plassmann and Tideman, 2000), plus Australia, Denmark, Syria, Spain, and parts of Indonesia (see

Lichfield and Darin-Drabkin, 1980; Youngman and Malme, 1994; McCluskey and Franzsen, 2005) there appears to be numerous potential advantages of increasing the tax imposed on the value of land. These advantages include the discouragement of suburban sprawl (Brueckner and Kim, 2003; Song and Zenou, 2006; Banzhaf and Lavery, 2010), betterment recapture (Bird and Slack, 1983), and, more importantly for the current discussion, the promotion of equity and progressiveness of the municipal tax system (George, 1992; Bird and Slack, 1983; Peddle, 1994).

A municipal policy shift in the direction of land value taxation would inevitably result in a significant redistribution of tax liabilities. The most sensitive issues in the debate about a transition from the current property tax system to the land value tax system focus on questions of equity (Peddle, 1994). Fairness and equity are often used synonymously in tax literature (Woolery, 1989) and represent one of the four maxims most governments use to evaluate different forms of taxation in order to ensure that they provide, "evident justice and utility" (Smith, 1776). Studies of property tax equity normally use ratios, which are based on the quotient of assessed value to market price, and have consistently found that the cheapest properties tend to be over-assessed and the most expensive properties to be under-assessed (Black, 1972; Paglin and Fogarty, 1972; Thrall, 1979b; Dean, 1980; Kuz and Saprovich, 1994; Cox and Studer, 1997; Harris and Lehman, 2001). This discrimination against low-value properties compared to high-value properties has been explored in Hamilton, Ontario on at least three separate occasions in the past (Davies, 1978; Thrall, 1979a; Harris and Lehman, 2001). Interestingly all three of these studies also discovered a tendency for systematic spatial variation in ratio values across the study area. In fact, it has been known for a long time that effective property tax rates are highest in inner city areas (Townsend, 1951; Johnson, 1958; Zimmer, 1958; Oldman and Aaron, 1965; Black, 1972; Peterson, 1973; Bird and Slack, 1978; Thrall, 1979a; Walzer and Fisher, 1981).

The spatial pattern of discrimination by the property tax becomes even more troubling when considering that research has also shown an increasing trend of inequality and polarization of household incomes in Canada, especially in urban areas (MacLachlan and Sawada, 1997; Lee, 2000; Myles *et al.*, 2000). That is, research highlights a disproportionately high concentration of poor households within inner city areas (Broadway, 1992; Klasen, 2002); a phenomenon known as Spatial Concentration of Poverty (SCOP)[11]. Similarly, Klasen (2002) argues that social exclusion is unevenly distributed across communities and the spatial dimension of social exclusion is a neglected policy area. Social exclusion is defined as the alienation or disenfranchisement of certain people within a society. Social exclusion has received considerable attention from social scientists examining the differences and uniqueness compared to traditional concepts of income poverty, multi-dimensional poverty, and income inequality (Atkinson, 1970; Atkinson *et al.*, 2002; Eliadis, 2004). Social exclusion is an important consideration for municipal planners and policy makers given its negative consequences for physical health, mental health, social outcomes, and socio-economic performance of individuals, families and cities (Kawachi *et al.*, 1997; Young, 1999; Ellaway and Macintyre, 2000; Kawachi and Berkman, 2000; Bynner, 2001; Putnam, 2001). Attempts to measure the multidimensional process of social exclusion (e.g. Burchardt *et al.*, 1999; Duclos *et al.*, 2004; Wilson, 2006) have been reviewed by Daly (2006) and Hayes *et al.* (2008). Among these measurement techniques, area-based deprivation indices (ABDIs) have gained wide acceptance for studying the spatial patterns of social exclusion. For example, in the United Kingdom researchers have used the Townsend Material Deprivation Score (Townsend *et al.*, 1988) and the Carstairs Deprivation Index (Carstairs and Morris, 1989). Based on attempts to replicate these indices in the United States (e.g. Eibner and Sturm, 2006), Messer *et al.* (2006) developed a standardised

[11] Hajnal (1995) provided one of the first studies of SCOP in Canada, while Ley and Smith (1997), Murdie (1998), and Kazemipur (2000) provide further evidence of spatial concentration of poverty in Canadian cities.

approach for developing ABDIs using widely available census data.

Despite the prominence of spatial analysis in the study of social exclusion and SCOP, few researchers have considered the spatial distribution of the property tax (Harris and Lehman, 2001), and even fewer have examined the spatial distribution of a municipal tax system based on solely value of land. This paper is, to the best of our knowledge, the first to examine the spatial distribution of shifting residential tax liabilities that would result from a transition from to a property tax system to a land value tax system, and also qualifies as the first to quantify the consequent impacts on objective measures of social exclusion. This research employed geographic information system (GIS) technology to simulate the spatial distribution of a revenue-neutral tax shift from the property tax system to a land tax system and examine the short-run implications of such a transition on social exclusion. The implications for social exclusion were quantified by first constructing an area-based deprivation index using principal component analysis data reduction techniques and subsequently examining the bivariate statistical association with property taxes, land value taxes, and the differences between the two. The results permit the discovery of both the location and extent of shifting tax liabilities and those susceptible to social exclusion in Hamilton, Ontario. The information and knowledge gained from this research will have significant social and economic implications for academic research, assessment practice, and municipal government policy in the realms of both municipal taxation and urban planning.

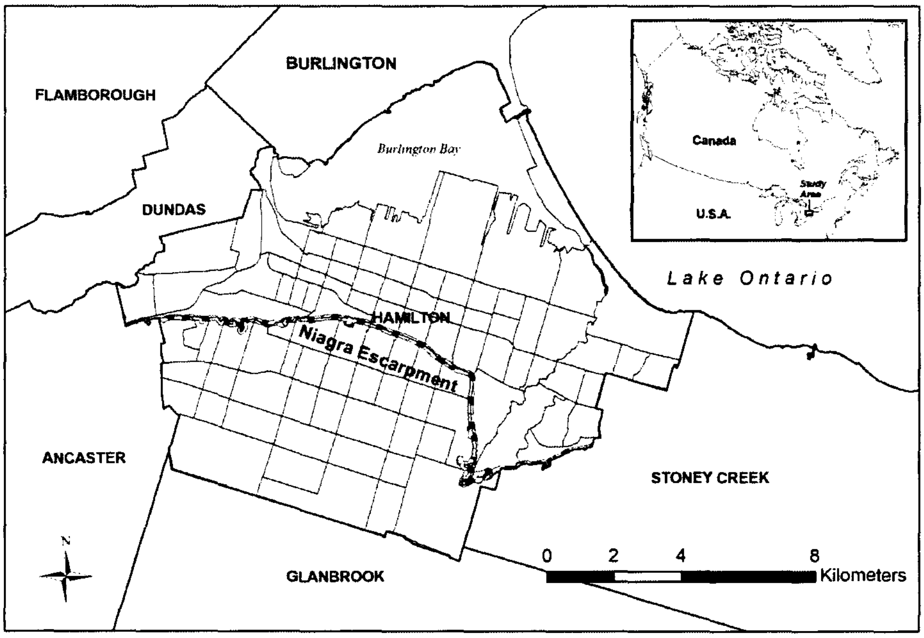
6.2 Methods

This section provides a brief introduction to the study area and describes the data and methods used to (a) quantify social exclusion by constructing area-based deprivation indices, (b) calculate land value tax burdens, (c) determine property tax burdens, and (d) examine the statistical relationship among them.

6.2.1 Study Area

The study area chosen to illustrate the impact of different municipal tax systems on social exclusion at the metropolitan scale is the City of Hamilton, Ontario, Canada, which is located approximately 75 kilometres southwest from the provincial capital of Toronto. The City of Hamilton is surrounded by six municipalities and is dissected by the Niagara Escarpment into what is locally known as "below the mountain" (i.e. north of the Niagara Escarpment) and "on the mountain" (i.e. south of the Niagara Escarpment). According to Statistics Canada, Hamilton had a 2001 population of 355,523 people spread across 100 census tracts (Figure 6-1). This research focuses on Hamilton, because it is the only municipality that entirely urbanised, while, despite the increasing pressures of suburban development, the vast majority of other municipalities, with the exception of Dundas, are considered rural.

Figure 6-1: Map of the City of Hamilton and Surrounding Municipalities



Hamilton is not unlike many other industrial cities in North America and its primary economic engine has historically been the steel and heavy manufacturing industries, which are located along the shores of Burlington Bay. Over the past decade, however, there has been a shift towards the service sector with decentralization of affluent families and retailing to the rapidly developing suburban municipalities surrounding the City of Hamilton. During the same time, Hamilton has experienced a pattern of increased urban blight in the inner-city area, which is located below the mountain. Despite attempts by Hamilton's Downtown and Community Renewal Division[12] to rejuvenate the downtown, the traditional role of the City's downtown has been destabilized; the "west end" of downtown is experiencing some signs of gentrification, while the "east end" appears to remain in a downward spiral of decay. The southern part of the city has also witnessed increasingly segregated and polarized household incomes, with a growing number of homogenous subdivisions of increasing value with increasing distance from the concentrated lower-income and recent immigrant households in Hamilton's downtown.

6.2.2 Area Based Deprivation Indices

We used Statistics Canada's 2001 census data reported at the census tract level to compute an area-based deprivation index. Although shifting tax liabilities were initially calculated at the parcel level, census data are publicly-available at the census tract level, which represents a limitation on the type of analysis that can be undertaken. However, census tract data provide the most comprehensive source of available information to empirically quantify the multiple dimensions of social exclusion and still permit spatial analysis of the relationships with the two municipal tax systems. Based on previous work by Rajaratnam *et al.* (2006), Messer *et al.* (2006), and Bell *et al.* (2007), we used 13 different variables from the 2001 census (Statistics Canada, 2001) to construct area-based deprivation indices for the City of Hamilton. These variables were downloaded from the E-STAT website (http://estat.statcan.ca), and were used to provide information

[12] http://www.hamilton.ca/CityDepartments/PlanningEcDev/Divisions/DowntownRenewal/

about 5 domains of deprivation that can contribute to social exclusion: (i) material wealth; (ii) housing tenure; (iii) education; (iv) employment; and, (v) cultural identity.

The material wealth domain includes average income, proportion of low income households, average dwelling value, and average dwelling age. The housing tenure domain includes percent residing in single family homes, proportion of renters, and percent residing in an apartment. The education domain is represented by the proportion with a university degree. The employment domain is comprised of the proportion of women in the labour force, proportion without an income, and the proportion of elderly people. Finally, the cultural identity domain includes the proportion of non-Canadian citizens, and the percentage whose first spoken language was neither English nor French.

Area-based deprivation indices typically employ either principal components analysis (PCA) or factor analysis to empirically summarize multiple highly-correlated variables. In order to compute area-based deprivation indices, we used SPSS 15.0 software to perform PCA for the 100 census tracts in the City of Hamilton. The PCA was specified with varimax rotation and Kaiser normalization to select principal components whose eigenvalues exceeded a value of one. The resulting rotated principal component coefficients were saved in the census tract data file for subsequent analysis.

6.2.3 Property Taxes

Property taxes for 2003 were acquired from the City of Hamilton Finance Department and provided information about assessed value of each property, which was also broken down into the assessed market value for each property class (e.g. residential, commercial). The total assessed market value of the property was divided by the assessed market value for the residential property class in order to select only those properties that were assessed as 100% residential; meaning that this study omits multi-use buildings. We also eliminated multi-unit residential properties (i.e. apartment buildings) in order to increase homogeneity in the sample. The average property tax liabilities for all single-unit residential properties within each census tract was calculated and appended to the census tract data file.

6.2.4 Land Value Taxes

The Ontario Assessment Act of 1969 ended the separation of valuation for land and buildings in the province, so using transaction data acquired from Teranet Inc. (www.teranet.ca) we applied multiple regression analysis to 268 observations of vacant residential land prices that occurred in the last 6 months of 2002 and throughout 2003. The purpose was to generate estimates of urban land values for the City of Hamilton that represent land market conditions in 2003. The purpose here is not to describe the modelling process, because it has been detailed in Chapter 5. However, it is noteworthy that mean sales ratios, coefficient of dispersion, and price-related differential values are within the IAAO Standards (2007) for uniformity and fairness (see Appendix 6-A). Using only those single-family residential lots previously identified in assigning property tax burdens, the estimated land values were used to compute land value tax burdens for the same parcels of land using a revenue-neutral approach; meaning the city's overall revenue from the sample of residential properties would remain unchanged. Given the total property taxes raised from these 61,118 single-family residential properties in 2003 was $149,975,845.49, we simply divided the total land value of all residential properties (i.e. $3,898,411,063.68) by the total tax revenue to get an effective land tax mill rate of 3.85%. The mill rate was applied to the land value for each property, thus simulating the revenue-neutral tax burdens under the land value tax system. The mean land tax burden for all single-unit residential properties within each census tract was calculated and appended to the census tract data file.

6.2.5 Statistical Analysis

Property tax and land value tax burdens were used to compute the difference between the two by subtracting the property tax from the land value tax at the parcel level. These differences were aggregated in order to compute the average difference for each census tract and the mean differences were subsequently appended to the census tract data file. Given that the rotated principal component scores represent the propensity for social exclusion within each of the 100 census tracts, we used Pearson's correlation coefficient to evaluate the bivariate statistical association between these coefficients and (a) mean property tax burdens, (b) mean land value tax burdens, and (c) mean differences for single-family residential properties.

6.3 Results

This section provides a description of the results from principal component analysis, which were subsequently used to quantify the relationship between social exclusion and both property taxes and land value taxes at the census tract scale. The purpose of examining these relationships is twofold; (a) to evaluate whether the property tax contributes to social exclusion and (b) whether this contribution can be mitigated under an alternative land value tax system. The results from PCA are illustrated in Table 6-1, which illustrates the sorted component loadings for each variable, which represent the partial correlations between each variable and the rotated component. These component loadings provide an indication of the key variables, which are indicated by the large loadings, for each of the four components and are used to help interpret the meaning of each component.

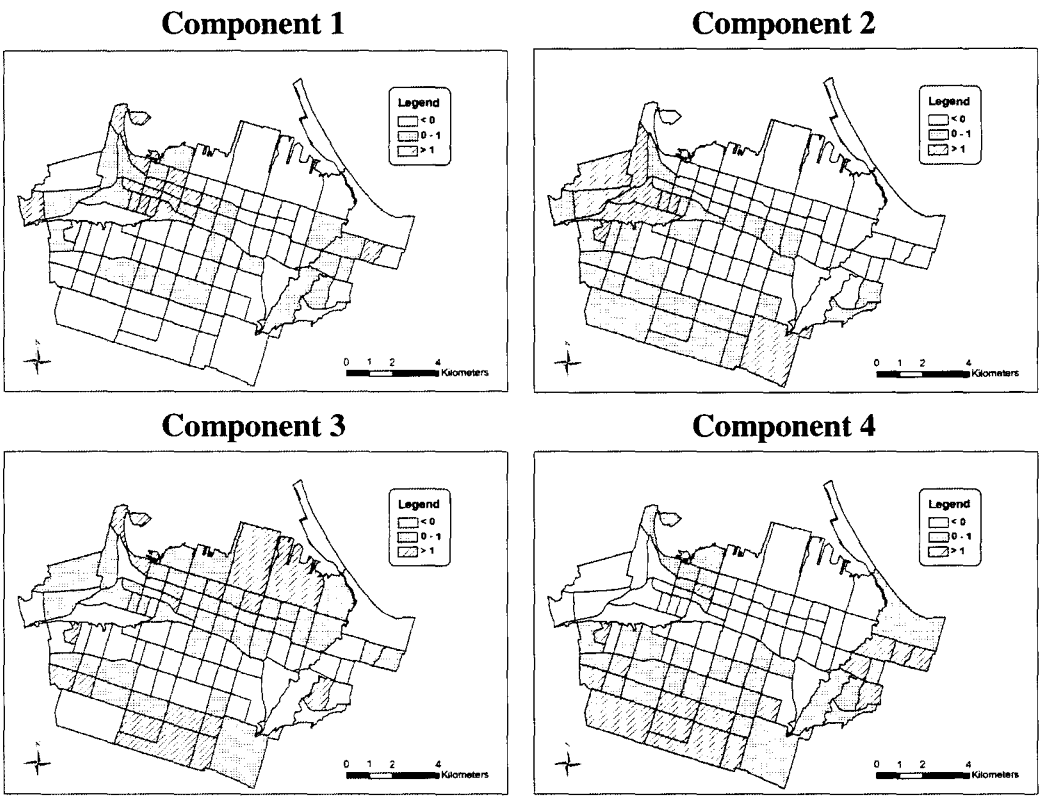
Although not depicted in Table 6-1, the eigenvalues from the four principal components indicate that the rotated solution accounts for 84.6% of the variance in the observed variables relative to the total variance in all the variables: the first principal component accounts for 36.7%, the second accounts for 22.3%, the third accounts for 14.7%, and the fourth accounts for 10.9%. The first principal component includes 6 variables and is dominated by variables from the housing, low income, and cultural identity domains; with strong negative loadings on the number of single family homes and very high positive loadings on apartments and renters, plus high to moderate loadings on immigrants and low income households. The second principal component includes 4 variables and is dominated by the material wealth and education domains and includes positive loadings on the proportion with a university degree, average income, average dwelling value, and prevalence of women in the labour force. The third component includes positive loadings on the proportion of households without an income and negative loadings on the proportion of elderly people. The fourth, and final, component is described exclusively by high positive loadings on the average dwelling age within each census tract.

Table 6-1: Communalities and Rotated Component Loadings for all Social Exclusion Variables

	Rotated Component Matrix a			
	1	2	3	4
Single Family Houses	-0.952	0.015	0.086	0.175
Apartment Residents	0.950	-0.029	-0.095	-0.174
Home Renters	0.928	-0.161	0.059	-0.131
Non-Canadians	0.842	-0.098	0.280	0.242
Low Income Households	0.647	-0.540	0.358	-0.152
Neither English nor French	0.562	-0.456	0.149	0.280
With University Degree	0.286	0.888	0.041	0.041
Average Income	-0.367	0.803	-0.089	0.226
Average Dwelling Value	-0.230	0.683	-0.161	0.562
Women In Labour Force	-0.447	0.610	0.472	0.098
Elderly	0.085	-0.062	-0.946	-0.007
Without Income	0.422	-0.233	0.704	0.115
Average Dwelling Age	-0.069	0.182	0.108	0.888

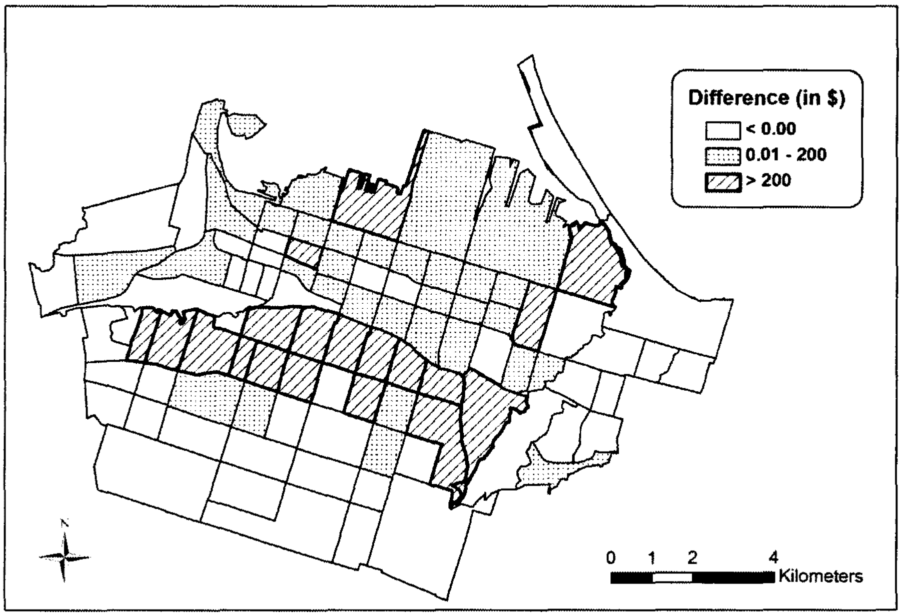
[a] *Rotation converged in 6 iterations.*

Figure 6-2: Spatial Distribution of Component Loadings using Census Tracts



The spatial distribution of the component loadings for the four principal components, that had eigenvalues exceeding a value of one, are presented at the census tract scale in Figure 6-2 using choropleth maps. Overall, the four principal components represent the different domains of social exclusion and exhibit different spatial patterns. For example, the northwest portion of the city exhibits a large concentration of the first principal component loadings, while the easternmost part of the city, below the escarpment, also exhibits high loading values for the first principal component. The second principal component displays high loadings in the westernmost part of the city, which borders the community of Dundas, but also has relatively high component loadings in the south-eastern part of the city bordering the municipalities of Glanbrook and Stoney Creek. The third component is dominated by an absence of the elderly and the presence of those without an income, and exhibit a mottled spatial pattern of high component loadings below the escarpment and along the southernmost border of the study area. The fourth principal component describes the average age of dwellings and illustrates the typical pattern of decreasing age with increasing distance from the city centre, while highlighting the gentrification of the north-western portion of the downtown, near Hess Village.

Figure 6-3: Map of Tax Burden Differences (Land Value Tax - Property Tax)



Before comparing the relationships between the principal component loadings and tax burdens under both the property tax and land value tax systems, it is important to understand the spatial distribution of tax burdens. Toward that end, the differences in tax burdens under the two different systems are graphically illustrated in Figure 6-3, with the property tax subtracted from the land value tax. That is, negative values indicate that there is net savings for residential properties under a land value tax system and positive values indicate increased tax burdens under a land value tax system.

Most single-family residential properties below the escarpment, which includes some of the oldest residential properties in the city, would end up with slightly higher tax burdens ($0 to $250) under a land value tax system. The properties with the highest increases in tax burdens under a land value tax system straddle the top of the escarpment, where there are relatively newer and more expensive homes on rather large lots. On the other hand, single-family residential properties on the periphery of the city would experience a decrease in tax burdens under a land value tax system. Despite being newer homes, they are situated on cheaper land surrounded by predominantly agricultural land uses and are often located on fairly small lots in residential subdivisions.

Table 6-2: Correlations of Principal Component Scores with Property Taxes, Land Value Taxes, and Differences (Land Value Tax - Property Tax)

		Property Taxes	Land Value Taxes	Difference (LVT - PT)
Component 1	Pearson Correlation	-0.097	-0.140	-0.063
	Significance (2-tailed)	*0.338*	*0.164*	*0.531*
Component 2	Pearson Correlation	0.623(**)	0.639(**)	-0.061
	Significance (2-tailed)	*0.000*	*0.000*	*0.547*
Component 3	Pearson Correlation	-0.237(*)	-0.373(**)	-0.209(*)
	Significance (2-tailed)	*0.018*	*0.000*	*0.037*
Component 4	Pearson Correlation	0.539(**)	0.370(**)	-0.381(**)
	Significance (2-tailed)	*0.000*	*0.000*	*0.000*

*** Correlation is significant at the 0.01 level (2-tailed).*
** Correlation is significant at the 0.05 level (2-tailed).*

The results in Table 6-2 illustrate the bivariate Pearson's correlation coefficients between the rotated principal component scores and (a) the mean property tax burdens, (b) mean land value tax burdens, and (c) the mean differences between the two. The results indicate there is negative relationship between the first principal component and all tax burdens, but the relationship is both weak and insignificant. On the other hand, the relationship between the second principal component and both property and land value tax burdens are moderately strong, positive, and highly significant. However, the relationship between the second principal component and the "difference" between the two tax systems is weak and insignificant. The property tax burdens, land tax burdens, and the difference between the two are all significantly associated with the third and fourth principal components, albeit moderate to weak relationships. The relationships are all negative for the third principal component, meaning the higher the component scores (i.e. potential for social exclusion) the lower the tax burdens and the greater savings under the land value tax system. The fourth principal component exhibits a strong positive relationship with the property tax, but weaker with the land value tax, and the negative relationship with the tax difference, thus indicating that the land value tax would result in reduced tax burdens for those census tracts scoring high on the fourth principal component.

6.4 Discussion

This research has shown that it is possible to effectively measure social exclusion using widely available census data and data reduction techniques. Using census data at the census tract scale, 13 individual, and highly correlated, variables were chosen to represent susceptibility to the multi-dimensional process of social exclusion. Principal component analysis was able to reduce these variables into four distinct dimensions that collectively account for nearly 85% of the variance in the 13 variables. These four principal component scores were examined insofar as their spatial distribution and their statistical association with property taxes, land value taxes, and the differences between the two.

Of the four components, the solution was highly loaded on the first component, which also had the largest collection with 46% of the variables; including housing, low income, and cultural identity domains (Table 6-1). Other studies have found that immigrants and refugees are over-represented in the lowest income quintile and under-represented in the highest income quintile (Kunz *et al.*, 2000). Both Yalnizyan (2000) and Galabuzi (2001) found that the gap between racialized groups and other Canadians has grown, while Kazemipur and Halli (2000) refer to this trend as the racialization or ethnicization of poverty. The first principal component has a concentration of high loading values in an increasingly popular neighbourhood in the north-western fringe of the downtown (Figure 6-2) that is experiencing gentrification, thus capitalizing on what Neil Smith (1979) refers to as a "rent gap", where the potential rent exceeds the rent under current land uses and, consequently, many older and low-value single-family homes are being demolished to make way for multi-unit residential and commercial land uses. High loadings for the first principal component were also found in the northwest part of the city (Figure 6-2), which, as noted by Fraser (2004), includes some of the poorest neighbourhoods in the city and is also home to a large proportion of immigrants. The neighbourhoods in the northeast part of the city are dominated by older, working-class homes that border the steel manufacturing industries and thus experience negative spill-over effects such as noise and noxious smells. According to the spatial distribution of shifting tax liabilities depicted in Figure 6-3, many residents in both of these areas should experience considerable savings (an average of up to $500 per year) under a land value tax system. Statistical analysis for the study area as a whole supports this observation, but the correlations between first principal component scores were weak and insignificant with the differences between the property tax and land value tax burdens, but much stronger for the land value tax compared to the property tax (Table 6-2).

The second principal component is dominated by the material wealth and education domains of social exclusion and also includes the percentage of women in the labour force. Bell *et al.* (2007) suggest that educational attainment may act as a proxy for socio-economic status that is independent of income. Educational attainment has been shown to be positively associated with membership in groups (Glaeser *et al.*, 2002), which is an important indicator of social exclusion. The second principal component accounts for 22.3% of the variance in all the variables relative to the total variance, and has high values concentrated in the westernmost part of the city, along the border with Dundas, and in the southern border with Glanbrook, particularly in the east near Stoney Creek. According to Figure 6-3, the former area should also expect to see some savings under a land value tax system, while the latter area should expect to see some of the largest savings within the entire study area under a land value tax system – upwards of $750. The results in Table 6-2 indicate that while the statistical association of the second principal component with the property tax (0.688) and the land value tax (0.658) are both relatively strong and highly significant and will pay similar taxes under both systems, evidenced by the weak and insignificant relationship with the difference between the two. These educated, wealthy and women-inclusive areas of the city expectedly have high positive associations with tax burdens, which provide some evidence of the redistributive effects of both the property tax and land value tax, but a slightly stronger correlation with the land value tax.

The third principal component accounts for almost 15% of the variance relative to the total variance and scores high on prevalence of households without income and the absence of elderly people. The elderly are an important cohort to consider when examining social exclusion and municipal tax systems, especially considering that by the year 2021 about one in five Canadians will be over 65 years old (Statistics Canada, 2003). The problem is exacerbated for the elderly, because they are especially prone to mobility issues with disproportionate access to required destinations and activities, thus making them even more susceptible to social exclusion (Kenyon *et al.*, 2002; Murie and Musterd, 2004; Spinney *et al.*, 2009). The results in Table 6-2 indicate moderate negative associations between the third principal component scores and both forms of property tax, with a stronger association with the land value tax. This means that census tracts with a lower proportion of elderly and higher proportion of no-income households experience a decrease in their property tax burdens, so young and especially poor households live in areas of the city that should benefit from a land value tax system. This brings to mind the work by Lindholm (1972), who suggested the land value tax is a tax on wealth, which is more unequally distributed than income and Plunkett (1976) who suggested the property tax is not an adequate reflection of wealth. Insofar as elderly homeowners often have limited income, their wealth is reflected in their homeownership. Therefore, programs and policies allowing these people to defer their annual municipal taxes until the house is sold may provide some remedy for preventing social exclusion of these vulnerable groups under a transition to a land value tax system.

The fourth principal component accounts for 10.9% of the variance relative to the total variance and is represented solely by the average age of dwellings within each census tract. The fourth principal component exhibits a typical spatial pattern of urban development that is represented by concentric rings of decreasing age of housing stock with increasing distance from the central business district, with the exception of the area experiencing gentrification of the north-western portion of the downtown – an area highlighted by the first principal component as having a large proportion of apartments, renters, low-income households, and immigrants. Although both are significant, the fourth principal component scores are much more strongly associated with property taxes (0.539) than land value tax burdens (0.370), meaning the property tax burdens have stronger associations with newer, and often more expensive, houses, but proportionately not as high for land value taxes. Part of the explanation lies in a paradox that has perplexed students of American cities for the past century; "the well-to-do live on cheap land while the poor live on expensive land" (Alonso, 1964, p. 227). While there are several explanations for this paradox that are based primarily on a trade-off between space and accessibility, it is interesting that newer and often more expensive homes on the periphery of the city will also experience significant savings under the land value tax system (Table 6-2).

This research has shown that the property tax burdens are significantly associated with many groups that are prone to social exclusion and, relatively speaking, these relationships appear to be mitigated under a land value tax system. However, this study is not without its limitations. Although this research has focused exclusively on single family homes, it is important to consider that the poorest members of society, those most susceptible to social exclusion, most often live in apartments, because home ownership is not an affordable option. Based on an understanding that building value to land value ratios largely determine who benefits under a land value tax system, apartment buildings and other intensive land uses would experience the greatest savings under a LVT system. Furthermore, like most ecological studies this research is limited by the use of census data at the census tract scale, with its inherent assumption of internal homogeneity. The list of variables collected by the census also limits our ability to measure social inclusion, while the spatial resolution may have its own impact on the measurement of social exclusion and the consequent results. These results illustrate the immediate, or short-run, impacts of the land value tax, but it is important to consider that in the long-run land value taxes would have an inherent tendency to lower the price of land and, thus, lower the real cost of housing (Rawson, 1961; Peddle, 1994). Moreover, the results suggesting either the property tax or the land value tax promotes social exclusion are confounded by the premise that the ability-to-pay principle should be based on the properties' "highest-and-best use" and the consequent "rent potential" of the parcel of land, opposed to the income or capital assets of people who reside thereupon. This "is a crucial distinction, which, if not made, will forever mire the debate about tax reform in its current debilitating terms of reference" (McCarthy and Ray, 1991).

6.5 Conclusion

With problems as extensive and multidimensional as social exclusion in our cities, there can be no one, simple, or easy solution, thus municipal planners and policy makers need all the tools that academic theory can provide. While deeply rooted in economic theory, the contemporary importance of land values has been neglected in municipal planning research (Clapp, 2004; Cheshire and Sheppard, 2005; Jones *et al.*, 2005) despite the wide-ranging applications such as land use zoning, eminent domain, fiscal planning, and providing the basis for municipal tax burdens. Using the City of Hamilton as a case study, this research has developed objective measures of social exclusion, examined the spatial distribution of shifting municipal tax burdens from the property tax to a land value tax system, and also evaluated the implications of this tax shift for social exclusion. Results indicate a clear spatial distribution of shifting tax burdens and although land value taxation appears to mitigate the contribution to social exclusion, the likelihood of such a transition depends upon convincing municipal and provincial officials. In this vein, Skaburskis and Tomalty (1997) surveyed developers and municipal officials from the Toronto and Ottawa regions about the consequences of replacing the property tax with a land value tax. Their results highlight one of the primary problems of transitioning to a land value tax system; only 25% of the developers and only 48% of municipal officials had even heard of land value taxation, let alone understand the potential strengths and weaknesses. Clearly academic programs and research agendas must shoulder much of the blame for the unawareness by the municipal officials, and maybe it is "time to reestablish the administration of the property tax as a significant issue for the social geography of metropolitan areas" (Harris and Lehman, 2001, p. 882). Moreover, we believe it is time to establish the land value tax as part of the contemporary research agenda and as a viable alternative to the current property tax system.

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Appendix 6-A: Sales Ratio Study Report for Residential Land Values in Hamilton, 2003

Number of observations	268
Total appraised value	16,865,906.29
Total sale price	16,169,739.00
Mean appraised value	62,932.49
Mean sale price	60,334.85
Mean ratio	0.99
Median ratio	1.06
Weighted mean ratio	0.96
Price-related differential	1.03
Coefficient of dispersion	0.20

Based on the industry-standard technique used to evaluate the performance of an appraisal (IAAO, 2007), the sales ratio represents a statistical measure of how close the market value is to market price. For assessment purposes the desired ratio is 1.00, which means the mass appraisal model is able to accurately predict within-sample prices. For example, the IAAO standards indicate that a sales ratio between 0.90 and 1.10 is considered acceptable. The results indicate the mean, median, and weighted mean sales ratios are well within the IAAO standards. However, sales ratios do not provide any indication of uniformity or fairness. The most widely used measure of assessment uniformity is the coefficient of dispersion (COD), which represents the mean deviation from the median ratio (i.e. average error). The IAAO standards state the COD for vacant land should less than 20 percent and the results indicate the assessed values meet acceptable limits. Another measure of uniformity is the price-related differential (PRD), which is used to measure uniformity between high- and low-value properties, and should be between 0.98 and 1.03 to demonstrate vertical equity (IAAO, 2007). The results indicate the PRD meets exceeds the acceptable limits for PRD.

CHAPTER 7: Conclusion

7.1 Contributions of the Dissertation

This dissertation details an investigation into geography's contribution to the appraisal of urban land values of sufficient accuracy and fairness to enable a simulation of an alternative municipal tax system based solely on the value of land. The differences between the property tax and land value tax burdens were used to examine the spatial distribution of shifting tax burdens and, also, to investigate the potential benefits of a land value tax system; specifically whether the association between the property tax and susceptibility to social exclusion can be mitigated under a land value tax system. In doing so, this dissertation has made significant contributions to the academic literature and also has important implications for professional assessment practice and planning policy.

7.1.1 Contributions to the Literature

The research described in this dissertation makes significant contributions to the existing literature that spans several disciplines. Beginning with Chapter 2, a critical review of the reach and depth of coverage of "geography" highlights geography's lackluster penetration into the professional real estate appraisal literature, thus drawing much needed attention to this deficit. The methodological contributions in Chapter 3 illustrate the development of an SDSS framework, using GIS, in order to cleanse "dirty" land registry data, thereby providing a novel mechanism that can be used to improve access to real estate data. The methodological contributions continue in Chapter 4 with one of the few investigations, to date, into the spatial dynamics of appreciation and depreciation rates of land prices within a metropolitan area. Moreover, Chapter 4 distinctly constructed vacant land price indices instead of the much more common housing price indices. The methodological contributions are also illustrated in Chapter 5, which, in contrast to the majority of the research in this field that also concentrates on housing values, describes an investigation into the potential advantages of spatial model specifications for mass appraisal of urban land values. Furthermore, Chapter 5 provides an important contribution to the literature though its investigation into the potential for spatial models to improve the fairness, or equity, of mass appraisal models. Unlike previous tax-shift studies, Chapter 6 represents a unique perspective on the spatial distribution of shifting tax liabilities between the property tax and land value tax systems. Chapter 6 also provides an important contribution the literature by quantifying the relationships between municipal tax burdens and area-based deprivation indices, which act as proxies for social exclusion.

7.1.2 Implications for Planning Policy

By exploring the underpinnings of geography's role in the appraisal of urban land values and the analysis of two different municipal tax systems, this dissertation has several implications, both theoretical and methodological, for assessment practice in addition to policies related directly to both municipal taxation and municipal planning. For example, the use of spatial interpolation as a mean value indexing method, illustrated in Chapter 4, provides a straightforward and creative technique for constructing vacant land price indices within metropolitan areas. Furthermore, Chapter 5 provides one of the few inquiries into the potential advantages of using spatial model specifications for the mass appraisal of urban land values. It is noteworthy that among the OLS, SAR, and Kriging models only the Kriging model was able to meet IAAO standards for vertical equity, which should be of particular relevance to assessment practice and municipal policy. The results of this dissertation also provide important practical insights into best practices for representing the spatial dynamics of vacant land prices at a local, or neighbourhood, scale; information that, if regularly updated, could be used to help guide land-use zoning and public investment decisions.

Although not part of the stated purpose, this dissertation has also shown the relative ease of generating land value maps using GIS and spatial interpolation techniques, which could be used to help integrate land values into municipal taxation and municipal planning policies. The Urban Development Institute of Ontario has indicated the importance of land values and asserts a need for alternative paradigms that link municipal land use policy with tax policy (Rodgers, 2003). Toward that end, Chapter 6 illustrates a simulation of the short-run impacts of implementing a municipal tax system based solely on land values, because a land value tax system would, finally, provide a mechanism to link changes in land values with urban planning policies.

7.2 Direction for Future Research

This ultimate objective of this research was to provide a geographer's perspective on two municipal tax systems. The research presented in this dissertation further develops our understanding of geography's role in the professional practice of real estate assessment, generally, and the construction of land price indices and mass appraisal of urban land values, specifically. This research highlights a sluggish embrace of the potential benefits of geography and GIS by the municipal property assessment industry; meaning there is much opportunity and necessity for additional studies to showcase the potential advantages of spatial analysis and GIS applications in the professional real estate appraisal literature. Future research may alter the search parameters and/or expand the body of literature to gain a better understanding of geography's contribution to the professional practice of real estate assessment.

This research was successful in developing a rich dataset; the data cleaning efforts documented in Chapter 3 represent a considerable amount of effort and the resulting compilation of vacant land transaction price observations span almost a decade. Consequently, these data support a wide range of research applications that extend far beyond the scope of this dissertation. For example, and in addition to continued work on spatial estimation of land values and land price indices, future research should examine alternative methods for representing dynamic land values for communication purposes. Furthermore, regular surveillance of land values requires a mechanism for collection, compilation, and estimation on an on-going basis. Perhaps future research could include efforts to automate the SDSS processes or expand the functionality in order to extract residential properties and/or commercial properties, which would permit an even wider range of research applications.

The results from this dissertation suggest that spatial models may help promote fairness of mass appraisals, because conventional mass appraisal models are unable to sufficiently account for the impact of location, which manifests itself as spatial autocorrelation and spatial heterogeneity. This research suggests that spatial models may help improve the fairness of real estate appraisals and, hence, the fairness of property taxes. Future research may wish to test alternative model specifications including co-Kriging, spatial-temporal autoregressive models, and geographically-weighted regression. It would also be interesting to test alternative methods for constructing market segments (i.e. neighbourhood boundaries) and examine their ability to improve the accuracy and fairness of mass appraisal models. While Chapter 5 focused on serviced urban residential properties, future research could investigate the estimation of land values for other types of land uses and also include suburban and rural properties.

The contribution of the property tax system to social exclusion and other social and economic ills, which are becoming increasingly prevalent in many Canadian cities, remains poorly understood. While this dissertation begins to fill the gap in intelligence surrounding the spatial distribution of shifting tax burdens between the property tax and a land value tax, it would be prudent to validate the results with a comparison to another metropolitan area of similar size, perhaps one that currently has a land value tax system, such as Pittsburg, Pennsylvania. Further research should also explore variations in a split-rate tax whereby various ratios of land value to building value are examined. It would also be an interesting extension of this research to include multi-unit residential properties into the simulation of shifting tax liabilities, especially given that those whom are particularly prone to social exclusion are often unable to afford homeownership and, thus, were not well-represented in our analysis.

While research using land values is rare, spatial analysis of land values and research into their applications to urban planning is even more uncommon, and virtually non-existent in a Canadian context. Consequently, it is hoped that this dissertation provides an impetus for other geographers to continue investigating a spatial paradigm for the estimation of rent and the reclamation of rent through land value taxation.

7.3 References

Rodgers, N. (2003). *Perspectives on land development & smart growth in Ontario*. Retrieved from www.udiontario.com/reports/pdfs/IMApres030609.pdf