A Comparative Analysis to Determine the Role Demographic and Geographic Variables Play in the Assessed/Sale Ratio of Parcels for the City of La Crosse, Wisconsin

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Abstract

Every year local government places a value on all taxable property. These assessments are based on what is known as fair market value and provide a basis from which owner taxes are calculated from. One way to determine if accurate assessment is taking place is through the use of a ratio study based on assessed values of parcels and sale values of parcels. This particular project focused on sales of parcels in La Crosse, Wisconsin from January 2006 through April 2009, and used statistical modeling to determine if particular variables influenced the assessed/sale ratio of those parcels. GIS was incorporated into the project to select spatial locations of parcels meeting predetermined criteria and then mapping the results. Six physical geographic variables were examined along with 14 demographic variables to determine what, if any influence they had on the assessed/sale ratio. The GIS data was obtained from the City Planning Department in La Crosse, Wisconsin. The demographic data was obtained from the U.S. Census Bureau. Statistical analysis was conducted on the variables using correlation and linear regression models. The Student's *t*-test was also used to understand the variability and significance of the variables and their affect on the assessed/sale ratio.

Introduction

Since the 1960s economists and regional planners have devoted time to the study of the proximity effects that social centers such as schools, shopping areas, and key employment centers have had on residential housing values (Foong and Hoong, 2006). Families will often look for housing areas or neighborhoods containing schools that provide a high quality education for their children. As a result of this demand, the housing values in those neighborhoods will often increase (Foong and Hoong).

Din, Binder, and Hoesli (2001) explain that internal physical and external environmental variables also affect the housing market with respect to housing values. Ordinal variables are commonly used as a measurement for the quality of neighborhoods and housing locations inside neighborhoods in respect to the proximity of environmental variables (Din *et al*.). Din *et al*. state that the use of geographical

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information systems (GIS) has made it possible to develop databases containing environmental characteristics of properties, thus allowing for better measurement of the effects environmental variables have on housing values.

Zeng and Zhou (2001) explain that one branch of decision making is optimal spatial decision making (OSDM). GIS makes OSDM in property assessment possible due to its ability to handle substantial amounts of data associated with uncertainties (Zeng and Zhou). Fryrear, Prill, and Worzala (2001) state that the most widely used data types in a GIS for assessment and real estate purposes are demographic databases and site selection data. In addition GIS also allows real estate and assessing companies to "visually" keep track of their properties and parcel locations (Fryrear *et al*.).

The City Assessor's Office in La Crosse, Wisconsin is responsible for assigning a value every year to all real and personal taxable properties within the city limits (City of La Crosse website, 2009). Determining an accurate value for city parcels is important for all departments within a city's government. One way to judge the accuracy of assessment values is by noting the sale prices of specific properties based on large sample sizes. If accuracy is maintained throughout the assessment process, other city governmental departments may confidently base their decisions on that knowledge.

A white paper written by the International Association of Assessors Officers (IAAO, 2007) explains how ratio studies can be used to measure and evaluate the level and uniformity of mass appraisal models. The paper describes that ratio studies use the assessed value divided by the market value to determine a ratio. Since the market value is a concept in economic theory and cannot be directly observed, confirmed sale prices can be used as an accurate substitute (IAAO).

The ratio calculated for this project was derived from the following equation:

$$R = AV/SV$$

Where "AV" is equal to the assessed value and "SV" is equal to the sale value of a home.

If the ratio calculated was below 0.9, the parcel was considered under-assessed. If the ratio calculated was above 1.1, the parcel was considered over-assessed. Parcels with ratio values that fell between 0.9 and 1.1 were considered to be assessed accurately.

Between January 2006 and April 2009, there were 1,862 parcels documented as sold within the city limits of La Crosse. The mean assessed/sale ratio of the sold parcels was calculated to be 0.9796.

A key factor for accurate assessing is the ability to predict what variables affect the assessed/sale ratio. Incorporating statistical procedures and geostatistical analysis allows this prediction to take place. By comparing data from a 3.3 year period, precision and accuracy is believed to have been achieved throughout this analysis.

Geographic and Demographic Variables

A combination of sources was used to determine which variables would be used in the statistical testing portion of the project. The La Crosse City Assessor's office was the primary source for determining which variables would be tested. A list of potential variables was first established through the review of the literature where prior studies had been documented. This list was then narrowed by the City Assessor's Office in order to fit their needs.

Geographic variables included in a one-sample Student's *t*-test were as follows: open spaces (parks, golf courses, and cemeteries), colleges (universities and technical schools), public schools (grade, middle, and high schools), major roads (county and state highways, and interstates), railroads, and open water. If a sold parcel fell within a predetermined distance from one of the above variables it was included into the statistical testing portion of the project.

Demographic variables tested using correlation and linear regression were as follows: total population, household occupants, household income, poverty level, total housing units, average travel time to work, and educational status. Additional classifications on demographic variables included examples such as 'travel time to work is 15 minutes or less' and 'travel time to work is greater than 15 minutes.'

Purpose

This project was not intended to judge the quality of work performed by the City Assessor's Office. Instead, the results were intended to help the City Assessor's Office understand fluctuations in the assessed/sale ratio. If there is a higher level of understanding, changes can be made if needed to benefit the city of La Crosse as a whole.

The City Assessor's Office divides the city of La Crosse into 53 sales areas in order to better define specific geographical areas (Figure 1).

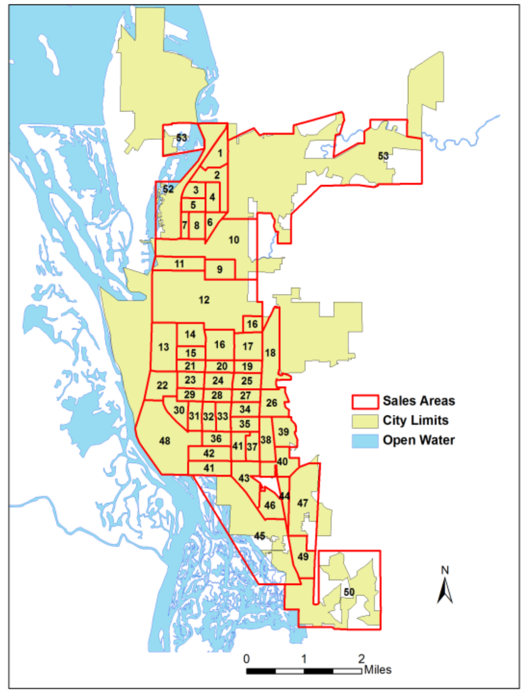

Figure 1. Sales areas in La Crosse, WI. Set by the City Assessor's Office.

These sales areas were mapped on a per-year basis to visually represent areas of under- and over-assessment ratios. This allows the city to locate areas of concern (Appendix A).

Other stakeholders involved in this project, including city government, local businesses, and the citizens of La Crosse, can use the conclusions of this analysis to alleviate questions regarding future assessment changes and to predict future market trends.

Methods

Data Acquisition

The datasets utilized in this project were acquired from three different sources. The City Assessor's Office provided an Excel spreadsheet that contained all city parcels attributed by a parcel identification number (PIN), the parcels assessed value, the parcels last sold value and date, and the sales area. The La Crosse City Planning Department provided shapefiles for parcel and city boundaries, transportation, open water, schools, and open spaces.

Demographic data was downloaded in a Summary File 3 (SF 3) format from the U.S. Census Bureau American Fact Finder website (http://factfinder.census.gov/). SF 3 data was selected because of its ability to describe demographics down to the census block group level.

The block group TIGER/line shapefile for La Crosse County was downloaded from the U.S. Census Bureau's Website (http://www2.census.gov/cgi-bin/shapefiles/national-files).

Determining Distances

In order to select parcels that fell within a predetermined distance from a physical geographical variable, a suitable researched distance was decided upon.

Major roads, railroads, and open water were all considered linear geographic variables in the sense that they all could be represented by a line that was not completely contained within the city boundary. Because of this, unique distances were assigned to each based on fieldwork using GPS and GIS.

For the major roads variable, a distance of 60 feet was established. Parcels that were within a distance of 60 feet from a major road were selected.

For the railroads variable, a distance of 175 feet was established. This distance was chosen based on fieldwork using GPS. Sitting in a parked car on a road perpendicular to a set of railroad tracks, setback distances were tested to determine noise levels. With the windows rolled up in the vehicle (representing a house) and the radio turned up to a normal speaking volume, a distance was marked at 175 feet. This was the distance the car was from the intersection of the road and railroad tracks where the train whistle had no effect on the ability to hear the radio.

For the open water variable, a distance of 300 feet was established. This number was chosen based on the La Crosse County Zoning Department's definition of a Shoreland District. It states that property located 300 feet from the ordinary high water mark of navigable rivers or streams is considered part of a Shoreland District (County of La Crosse website, n.d.). Selection results from the linear geographic variables are displayed in Table 1.

Open spaces, colleges, and public schools were not considered linear geographic variables. Instead, these variables extents were contained within the La Crosse city boundary, and could be represented by a point or polygon. Furthermore, the points and polygons all fell within city blocks. Because of this, blocks were measured and an average length was assigned to each variable.

Since city blocks vary in length, tests were conducted to measure blocks to determine a proper length. To satisfy the need for randomness, a random point generator was downloaded from ESRI's scripts webpage and used to generate 15 random points. These points fell on top of a dataset that represented city blocks within La Crosse. The blocks that contained a point were then measured using the measure tool in ArcGIS Desktop. This test was conducted three times resulting in 45 measurements. The measurements were then used to calculate a mean value. 494 feet was the mean distance calculated for a city block in La Crosse.

Table 1. Selection results from the linear geographic variables.

Variable Name	Number of Sold Parcels Selected	Total # of Parcels in Variable Area
Major Roads	188	2,244
Railroads	82	991
Open Water	21	666

*Note: Total number of sold parcels from January 2006 through April 2009 = 1862. Total number of parcels in La Crosse = 17,321

For the open spaces variable, a distance of 494 feet, or one city block, was established. This number was derived from a previous study performed by Lutzenhiser and Netusil (2001). In this case, Weicher and Zerbst (1973) indicate that homes that were within one block from an open space sold for more than similar homes further away. For the colleges variable, a distance of 741, or 1.5 city blocks, was established. This number was the distance determined by the author to be the average distance student vehicles were found to be parked on streets away from the campus boundaries of city college and university facilities. Lastly, 988 feet, or the equivalent of two city blocks, was established for the public schools variable. This is the distance that is considered a school zone as seen by the Wisconsin State Legislative in Senate bill 2 s. 948.61 (1) (1991).

Based on the above distances, a selection process for each variable took place to locate all parcels sold from January 2006 through April 2009. Selection results of the non-linear geographic variables are illustrated in Table 2.

After each selection, the sold parcels shapefile was exported using the selected features tool to create a new shapefile representing all sold parcels in a particular variable testing area.

A custom script was downloaded and altered to allow for the attribute table of each newly-created shapefile to be exported directly into an Excel spreadsheet. The spreadsheet information was then used for statistical testing.

Table 2. Selection results from the non-linear geographic variables.

Variable Name	Number of Sold Parcels Selected	Total # of Parcels in Variable Area
Open Spaces	449	4,091
Colleges	186	1,922
Public Schools	396	3,483

*Note: Total number of sold parcels from January 2006 through April 2009 = 1862. Total number of parcels in La Crosse = 17,321

Block Groups Separation

In order to statistically test social demographic data, U.S. Census block group data were added to the analysis. Since block groups do not necessarily align with city boundaries (case being La Crosse city boundary), only certain block groups were used in the analysis to prevent skewing of the data in the end results. Block groups that were completely contained within the city limits, or at least 95% contained, were used in the analysis. Figure 2 represents the original block group dataset overlaid on the La Crosse city boundary. Figure 3 represents the selected block groups that met the requirements for analysis overlaid on the La Crosse city parcels dataset.

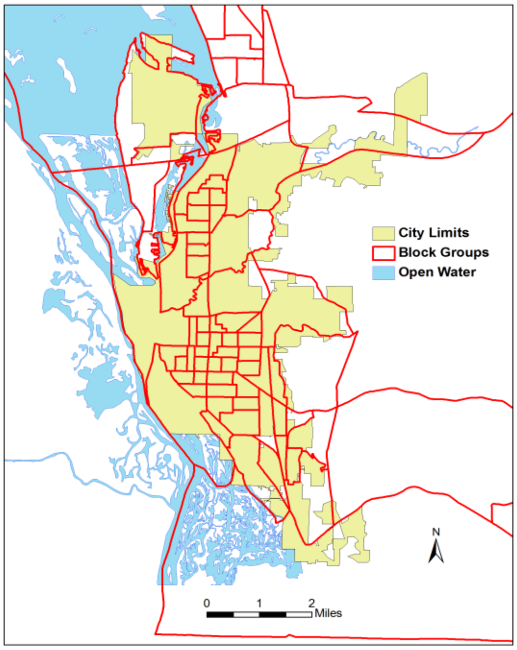

Figure 2. Block groups that intersect the La Crosse city limits. In total, 68 block groups.

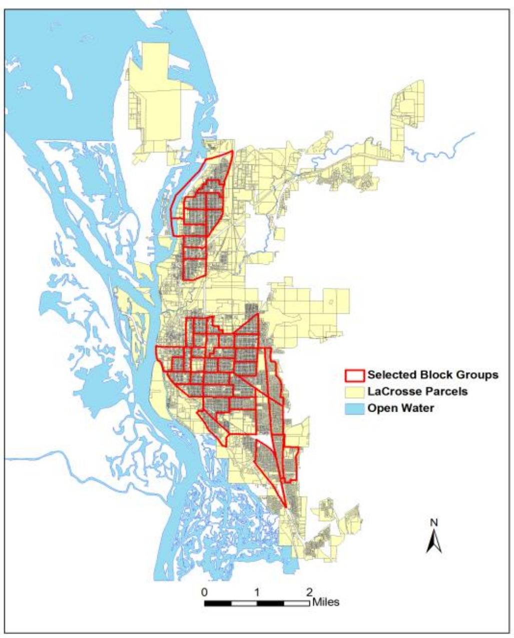

Figure 3. Selected block groups for analytical purposes. 42 blocks groups selected from the original 68 block groups.

The total number of block groups that intersected the La Crosse city limits totaled 68. Of the 68 block groups, 42, or 61.8%, met the analysis requirements. The city of La Crosse has an area of 22.3 mi^2, and the area selected for testing equaled 5.9 mi^2. Most importantly, the total number of sold parcels from January 2006 through April 2009 was 1862. The demographic area that was statistically tested contained 1497, or 80.4%, of the 1862 sold parcels**.**

Statistical Testing

Student's *t*-Test

The Student's *t*-Test was the statistical test used to determine if parcels that were located in proximity to particular physical geographic variables resulted in a higher or lower assessed/sale ratio as compared with the population mean.

For each variable, a table was created with all parcels that had been selected using the aforementioned unique distances. These tables included each parcel's assessed/sale ratio. The resulting tables were imported into SPSS and tested against the population's assessed/sale ratio mean to determine the level of significance. The population assessed/sale ratio mean was calculated to be 0.9796 for the selected block groups utilized in this study.

Correlation Analysis

Correlation analysis was performed to determine if social demographic variables correlated with under-assessed areas and/or over-assessed areas.

To begin, all SF 3 demographic tables were merged into one master table using a merge ad-on tool in Excel. The block group's Geo ID field was used as the primary field for the merge. Using ArcMap, a selection was made for each block group to determine the number of under- and over-assessed parcels. This number was added to the master table using two new fields, 'under- assessed' and 'over-assessed'. The master table was imported into SPSS, where correlation modeling took place.

A Bivariate Pearson correlation value was calculated for each demographic variable, once with under-assessed parcels, and once with over-assessed parcels. Variables that correlated highly with both under- and over-assessment counts were recorded for further evaluation.

Stepwise Linear Regression

All of the demographic variables were tested using a stepwise linear regression model to determine the coefficient of determination or R^2. The stepwise method was selected because of its power to predict or explain what demographic variables correlate strongly with under-assessed areas and/or over-assessed areas.

The master table was imported into SPSS and two tests were run. The first test used the number of under-assessed values per block group as the dependent 'Y' variable, and the demographic values per block group as the independent 'X' variables. The second test used the number of over-assessed values per block group as the dependent 'Y' variable, and the demographic values per block groups as the independent 'X' variables.

Results and Discussion

Student's t-Test

Testing geographic variables' assessed/sale ratios against the population mean (0.9796) led to two possible null and alternate hypotheses and which was appropriate depended on whether the sample mean was greater or less than the composite block group mean:

H□: $\mu \geq 0.9796$ H□ : $\mu < 0.9796$

or

H□ : $\mu \leq 0.9796$ H□: $\mu > 0.9796$

Summary statistics for the geographic variables are represented in Table 3. All six geographic variables were tested using a one tailed Student's *t*-test at a 95% confidence interval. Four variables, including open water, public schools, colleges, and open spaces, proved to be statistically lower than the population mean. Railroads and major roads were not statistically different than the population mean. The results from the Students t-tests are shown in Table 4.

Table 3. Summary of geographic variables tested using a Students t-test at a 95% confidence level.

Major Roads	
N =	188.00
Mean	0.97
Lower/Upper Limit	0.92/1.02
Railroads	
N =	82.00
Mean	1.01
Lower/Upper Limit	0.89/1.13
Open Water	
N =	21.00
Mean	0.80
Lower/Upper Limit	0.68/0.92
Open Spaces	
N =	449.00
Mean	0.93
Lower/Upper Limit	0.89/0.97
Colleges	
N =	186.00
Mean	0.88
Lower/Upper Limit	0.83/0.93
Public Schools	
N =	396.00
Mean	0.94

Lower/Upper Limit	0.91/0.97

Table 4. Results from student's t-test for all geographic variables.

	N	Mean diff.	t	Sig. (1-tailed)
Major Roads	188	0.01	0.383	0.351
Railroads	82	0.03	0.552	0.291
Open Water	21	0.18	2.887	0.005
Open Spaces	449	0.05	2.311	0.011
Colleges	186	0.09	3.843	0.000
Public Schools	396	0.04	3.045	0.001

*Note: Variables were tested against a population mean of 0.9796.

The results from the Student's *t*-test did not offer the City Assessor's Office or other researchers a guarantee in prediction. Nonetheless, they represent a statistical difference in means for the four geographic variables listed above. This allows the City Assessor's Office or other researchers to believe that parcels in proximity to open water, public schools, colleges, and open spaces will have an average assessed/sale ratio lower from that of the population mean.

Demographic Variable Correlation

The first correlation test was to determine which demographic variables correlated highly with under-assessed areas. From this test it was determined that the three highest correlation values were as follows: total population whose household income is above $30,000 (0.604), population with Associate or Bachelor degrees (0.562), and population whose income was above poverty level (0.551). Of the 14 demographic variables tested against under-assessment, seven were found to correlate significantly at $\alpha = 0.05$ level, and five were found to correlate significantly at $\alpha = 0.01$ level.

The second correlation test was to determine which demographic variables correlated highly with over-assessed areas. From this test it was determined that the three highest correlation values were households with at least one child (0.423), total housing units built before 1970 (0.365), and total population whose household income was above $30,000 (0.358). Of the 14 demographic variables tested against over-assessment, five were found to correlate significantly at $\alpha = 0.05$ level, and three were found to correlate significantly at $\alpha = 0.01$ level.

Total population whose household income was above $30,000 was the only variable in the top three correlation values appearing in both tests. However, it proved to correlate higher with under-assessed areas than over-assessed areas.

Given the number of demographic variables found to be significant, one could conclude that the chosen demographic variables relate better to under-assessed areas than to over-assessed areas. The higher Pearson correlation values found in under-assessed areas help to support that conclusion.

Demographic Linear Regression

All 14 demographic variables were tested in a stepwise linear regression model to determine variability of under- and over-assessed areas. The first regression test used under-assessed areas as the dependent variable and two demographic variables were selected to explain the variability. The two demographic variables were total population whose household income was above $30,000, and total housing units built between 1970 and 2000. 42.8% of the variability in under-assessed areas can be explained by these two demographic variables. Table 5 represents the model summary for the regression test using the dependent variable, under-assessed.

The second regression test used over-assessed areas as the dependent variable and the results produced three demographic variables to explain the variability. The three variables were total households with at least one child, total population with Masters or Doctorate degrees and total housing units built between 1970 and 2000. For this model, 38.2% of the variability in over-assessed areas was explained by the three demographic variables. Table 6 represents the model summary for the regression test using the dependent variable, over-assessed.

For the linear regression analysis, the variable total housing units built between 1970 and 2000 appeared in both tests as a suitable variable to explain variability. However, in both tests the total R^2 value was below 0.45, leaving at least 55% of the variance unexplained and apparently due to variables not suggested in the study. If the unmeasured variables had been tested in the two models, it is possible that the observed variables would not be considered at all using the stepwise approach. Of the 14 demographic variables, 10 did not appear in any model and had low partial correlation values suggesting they were not good choices in predicting variability.

Using the standard error of estimate (represented in Table 5 and Table 6) one can measure the accuracy of the models. Given that the mean for under-assessed parcels in the studied block groups was 15.14, one could say

Table 5. Model summary of stepwise linear regression test using under-assessed as the dependent variable.

Model	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.365	0.349	5.082
2	0.428	0.398	4.887

*Note: Model 1 predictors = total population whose household income is above $30,000. Model 2 predictors = total population whose household income is above $30,000 and total housing units built between 1970 and 2000

Table 6. Model summary of stepwise linear regression test using over-assessed as the dependent variable.

Model	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.179	0.158	3.499
2	0.310	0.275	3.247
3	0.382	0.333	3.113

*Note: Model 1 predictors = total households with at least one child. Model 2 predictors = total households with at least one child and total population with Masters or Doctorates degrees. Model 3 predictors = total households with at least one child, total population with Masters or Doctorates degrees, and total housing units built between 1970 and 2000 they are 95% confident that when using model 2 predictors, observed values of under-assessed parcels for each block group in the study area would be between 5.56 and 24.72 parcels. In the case for over-assessed parcels, the mean was 6.26 per block group in the study area and one could suggest that there is a 95% confidence level that when using model 3 predictors, observed values of over-assessed parcels for each block group in the study area would be between 0.16 and 12.36 parcels. Using this approach for a measure of accuracy shows that the demographic variables chosen for this study were a better fit for under-assessed areas than over-assessed areas. Yet using any of the models for prediction would yield poor results.

Limitations of the Data

One major area of concern during the completion of this project was the fact that demographic variables from the 2000 census were being tested against parcel sales from January 2006 through April 2009. Potentially, census data (collected in 1999) could be 10 years older than a sale of a particular parcel if that parcel was sold in 2009. The 2006-2008 American Community Survey was not chosen as a data source because the smallest geographic type was at a sub-county level. For this project, a geographic type of census block group was needed to perform the analysis. Demographic factors during the years of the study may be different from when they were collected in 1999. Because of this, the results cannot be considered completely accurate. A future study using 2010 census data and the corresponding sales years would be more reliable.

The second limitation to the data would be in respect to the demographic analysis using only particular block groups. The block groups used in this study were chosen as a representation of the entire city. Since the majority (more then 80%) of sold parcels in the city of La Crosse were contained completely within these block groups, it is believed that they are an overall representation of all sold parcels within the city. It should be noted the variations in the assessed/sale ratio could exist within parcels found outside the selected block groups. Therefore one should be a bit cautious when drawing conclusions because the results of this study may not completely reflect the true predictability of the demographic variables. This method was chosen so that only demographic data completely within the city limits would be analyzed.

Conclusions

The results from the physical geographic statistical testing indicated that four of the six chosen variables proved to have different assessed/sale ratio means than the population's mean. The four variables were open water, public schools, colleges, and open spaces. The other two, railroads and major roads, did not prove to be significantly different from the population mean. The lowest p-values were observed in colleges and public schools.

A similar study conducted by the same researcher during an undergraduate project looked at sales between the years 2000 through 2005 for the city of La Crosse. Interestingly, the results from that project showed that public schools and colleges assessed/sale ratio means were statistically different from the population mean. Open spaces and railroads were also tested in the previous study but means were not statistically different from the population's mean.

From the correlation analysis, it was determined that total population whose household income was above $30,000, population with Associate or Bachelor degrees, and population whose income was above poverty level correlated the highest with under-assessed areas. The three variables that correlated highly with over-assessed areas were households with at least one child, total housing units built before 1970, and total population whose household income was above $30,000. In both tests there did not appear to be a "standout" variable that correlated highly with either under- or over-assessed areas.

The results from the multiple regression analysis proved to be beneficial in two ways. First, using the stepwise approach, models were created that could be used to explain some of variability observed in the data. Second, it could be looked at in a way that shows the City Assessor's Office which demographic variables could be disregarded when trying to predict variability in the data. This suggests that other demographic variables could be tested in order to achieve results leading to a greater power of prediction.

The findings concluded from this particular study could be generalized for both the government and public sector. The major stakeholders for this study revolve around those in the government sector who could use the results throughout planning decisions. The public sector can use the results to answer their questions about why changes are being made in assessing and planning in the city of La Crosse. Other city governments could see the results and conclude that a similar analysis is needed.

Acknowledgments

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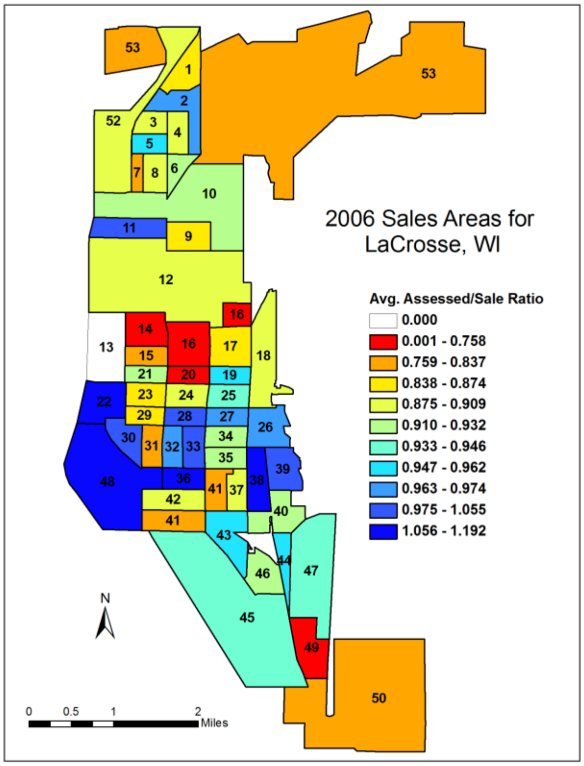
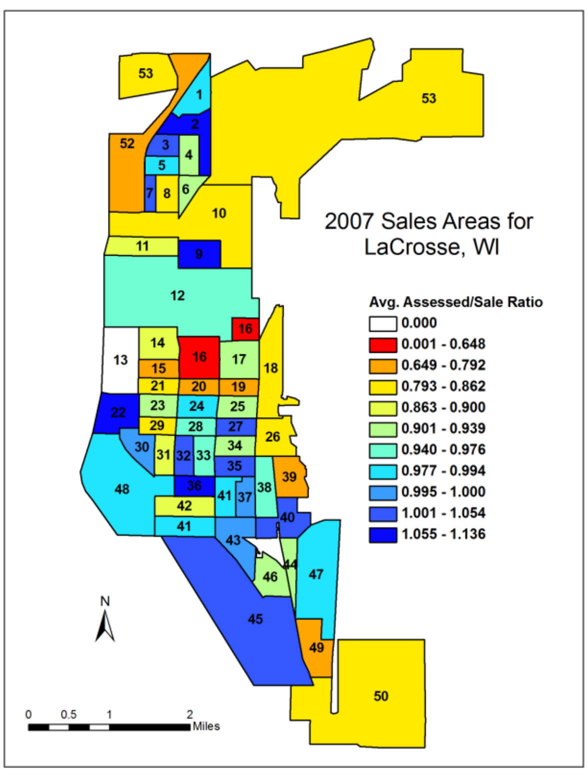
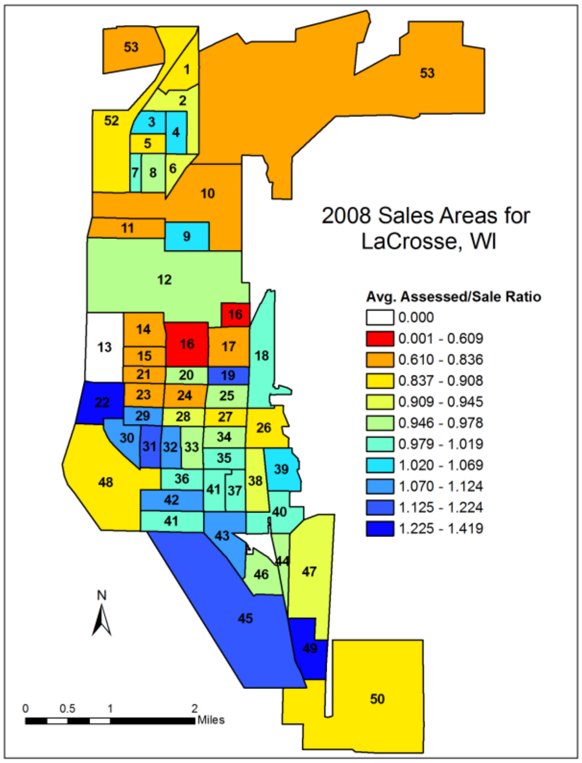
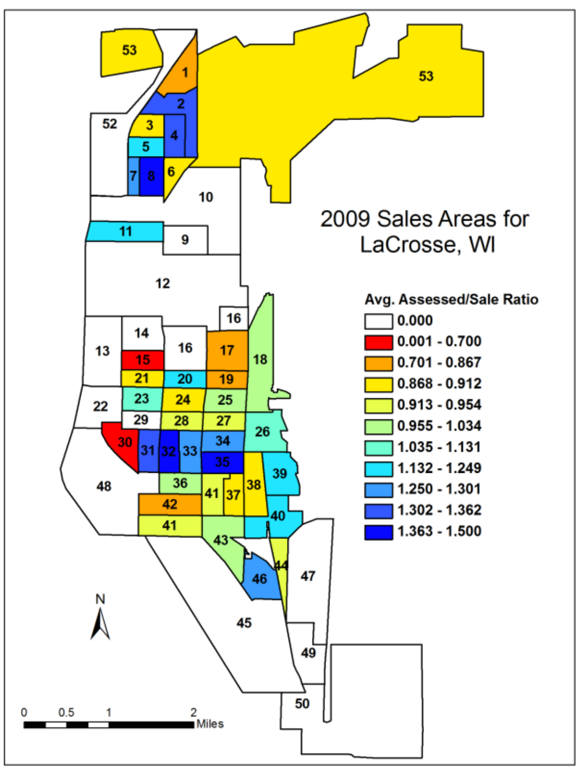
Appendix A. City of La Crosse Sales Areas Maps for each year of the analysis.









*All symbology was classified using the Natural Breaks Jenks method
** 2009 sales areas map only has sales from January 2009 – April 2009 resulting in much of the area classified with no data