The Impact of Water Clarity on Home Prices in Manitowoc, Calumet, Kewaunee and Sheboygan Counties, Wisconsin

Dr. David Wolf, Dr. Thomas Kemp, and Ms. Megan Roehl[1]

Executive Summary

We were tasked with answering the question of: How does water clarity affect housing values within Manitowoc County? To do this within this study, we examined over 8000 housing sale transactions within a four-county region including and adjacent to Manitowoc County. In order to evaluate water clarity, satellite data from the Wisconsin DNR was utilized. Using hedonic modeling, we find that a one-foot increase in water clarity will result in a 3.2% increase in home values for properties located within 250 meters of a lake. This proposes a clear economic rationale for improving water quality in lakes within this region.

[1] Drs. Wolf and Kemp are Assistant Professor and Professor of economics in the Department of Economics at the University of Wisconsin, Eau Claire. Ms. Megan Roehl is an undergraduate student in the UW-Eau Claire department of economics.

Introduction

The idea that perceptions of water quality and water clarity have a significant impact on residential property values is well established. Holding all else constant, we expect home values to be higher if they are located near clearer waterbodies, as homeowners are likely to experience greater benefits from living near a clear river or lake. Higher property values may also provide additional benefits to the community by increasing the local and state tax revenue. However, improvements to water clarity cannot be done without cost. This situation becomes a balancing act: If the economics benefits exceed the costs of water clarity improvement, there is clear evidence pointing towards policy intervention.

Manitowoc County, located in East-Central Wisconsin, has 58 lakes which range in surface area from 1 acre to 136 acres.[2] 14 of the 58 lakes have public access points which are monitored by the Manitowoc County Parks Department. This study also looks at near lake home transactions that occurred in the adjacent counties of Sheboygan, Calumet and Kewaunee. These counties are similar to Manitowoc County in that they also have many small lakes with public access points and share a border with a very large freshwater lake (i.e. Lake Michigan for Sheboygan, Manitowoc and Kewaunee County and Lake Winnebago for Calumet County). For continuity purposes, we exclude Lake Michigan and Lake Winnebago from the study as homeowners likely view living near these large waterbodies much differently than living near a smaller inland lake. In this region, the lakes are considered an important amenity for outdoor recreationalists, as many residents and visitors use them to go fishing, swimming, and boating in the summer and ice-fishing in the winter. Many of the recreationalists in this four-county area live either adjacent or near a lake. If the water clarity or perceived quality were to drop, the benefit from these recreational activities would be reduced, especially for those who reside near the lake.

Figure 1. East Alaska Lake (source: Jackie Pezdera)

Through this study, we seek to understand the value that is associated with an improvement in water clarity for residents living near or in Calumet County. From this analysis we can estimate a significant part of the

[2] https://www.lake-link.com/wisconsin-lakes/manitowoc-county/762/ .

economic benefits (losses) that both the private and public sector would experience from an improvement (degradation) in water clarity.

The Study Area:

Initially, we were tasked with examining the impact of water clarity on housing prices for Manitowoc County. However, due to the small number of near lake housing transactions, we decided to expand the study area to include the counties adjacent to Manitowoc County. These counties were chosen based on the idea that they are fairly close substitutes. If someone was looking for a house in Manitowoc County, they might expand their search to also include homes in Sheboygan, Calumet and/or Kewaunee County. Although Brown County is adjacent, it was not included because of it is a metropolitan hub containing Appleton and would likely be considered a different housing market. Within these counties, we examined water bodies that are monitored by the WI DNR and have remote sensing water quality data available over the course of the study's timeframe (2013 – 2016).

Literature

The primary question in a study of this type is: "What aspects of water convey value upon a residential property?" One might be inclined to think that various pollutants or the water's drinkability might have a significant bearing upon the value of adjacent property. While this almost certainly would be the case for water diverted for agricultural purposes, other studies have shown that this is not always the case with residential property. For example: Steinnes (1992) found that it is the perception of water quality (clarity) rather than actual water quality that has the most significant bearing upon property values suggesting that subjectivity was an important factor. Subsequent literature has consistently reinforced this finding that the perception of water quality has the most significant bearing upon residential property prices.

The specific method of establishing clarity method has also been widely discussed in the literature. A paper by Poor et.al. (2001) found that there existed significant differences between the economics values produced using subjective measures of water clarity when compared to using objective measures. In that study the authors found that subjective measures tended to under report water clarity when compared to

objective measure (such as Secchi disk readings). Subsequent studies have reinforced these findings. In summary the use of hedonic models combined with objective measures of water clarity (rather than quality) have become the 'industry standard' when attempting to uncover the implicit value of water clarity on property prices.

Several lake water clarity studies have been done using Secchi disk data and classic hedonic models. These include but are not limited to Michael, Boyle, and Bouchard (1996), Boyle et.al (1998); Krysel, Boyer, Parson, and Welle (2003); and Kemp and Ng (2017). In addition to the customary locational and structural variables, the authors used Secchi disk readings as an objective measure of water clarity. The results achieved by these studies produced similar results with a rough doubling of the value attributable to water clarity being associated with an improvement of an additional 1 meter of clarity (for those lakes with low initial water clarity).

This study builds upon these findings but incorporates so called 'fixed effects' analysis (described in depth below) and utilizes satellite data to determine clarity levels. The former allows us to better control for changes that occur to the housing stock, variation in neighborhood-level amenities, and seasonality. Satellite data was used due to shortage of actual Secchi readings within the study area.

Data Sources

Remote sensing water clarity data and lake amenity information was obtained from the Wisconsin DNR and the USGS Wisconsin Water Science Center respectively.[3] We attached an average annual measure of water clarity to each housing transaction using the transaction's sale date and water clarity data from the closest lake. For those houses sold during the winter months clarity readings from the previous summer and fall were used. Although they were not used to complete this study the Wisconsin DNR provide annual water quality reports for many of the lakes statewide. These are available free to the public and, in many cases, date back several years. Reports are published several times a year at irregular intervals for most lakes and include data on water clarity as well as a host of other information. Water clarity data is based upon DNR Satellite Imagery.

Housing sale prices and structural attributes were taken from the Wisconsin Department of Revenue. Houses with extreme physical characteristics (i.e. houses with 10 bathrooms) were labeled as outliers and were excluded from the dataset. Overall, we used a total of 8,372 housing transactions in this analysis, which occurred between 2013 and 2016.

[3] Reports available at http://dnr.wi.gov/lakes/waterquality/

In sum, data was gathered on the following structural attributes,

- Age of the house
- Square footage in hundreds of feet
- Number of bathrooms
- Fireplace[4]
- Garage
- Basement

The following spatial data was also collected from parcel and lake shapefiles and attached to each transaction using GIS (Geographic Information System):

- Distance from lake[5]
- Parcel Acreage

Finally, census tract identification numbers were attached to each house using GIS and the US Census' Tiger Line shapefiles. A dummy variable was created for each census tract in the four-county study area and included as a spatial fixed effect in the hedonic model. These spatial dummies account for observable and unobservable, time-invariant amenities that influence a home's value, including things like school quality, proximity to urban centers, access to open space, and municipal crime and tax rates. It should be mentioned that it would be possible to develop a longer list of attributes for the given set of properties; however, it would not assist us in finding the specific value of water clarity – the focus of this study.

Method - Hedonic Modeling

Hedonic Modeling is a commonly used technique used to estimate the value of a specific attribute within a larger set of attributes which characterize a differentiated product.[6] The most common usages include estimating the value of structural improvements, the impact of public space, and the value of nearby environmental attributes on property values. Using these models, a researcher can isolate and analyze the

[4] These include wood-burning and fabricated fireplaces
[5] Indicator variables designating if it the property is within 250 meters of a lake, between 250 and 500 meters of a lake or between 500 and 750 meters of a lake.
[6] See Monsoon (2009) or Malpezzi (2012) for a recent, more complete overview of the uses of hedonic modeling.

marginal value associated with each attribute of a given property. If desired, the additional step can be taken to create a hypothetical situation in order to determine the economic benefit of making a change to that attribute. This can then be weighed against the costs associated with making the change to test the economic feasibility of the project. Regression analysis is the specific statistical technique that serves as the foundation for hedonic modeling. For studies that seek to determine the value of a specific environmental attribute, such as water quality, the basic form of the regression generally looks like;

$P = f(S,L,E)$

Where,

P = Sale Price of the Property

S = A Vector of Structural Attributes[7]

L = A Vector of Locational Attributes[8]

E = A Vector of Environmental Attributes[9]

From the estimated coefficients on each of the attributes within of the vectors we can develop an idea about the marginal value of each of those attributes. The regression output (see below) is commonly referred to as the fundamental hedonic equation. Attributes with negative coefficient estimates have a negative impact on property prices while attributes with positive coefficient estimates have a positive effect on property prices. For example, in the case of this study we would expect the estimated coefficient for water quality to have a positive coefficient. That is, the greater the water clarity, the higher the sale price. Conversely, we would expect the estimated coefficient on the distance from the lake to be negative.

The Model

This study uses actual property sale price as the dependent (determined) variable and housing attributes (structural, locational, and environmental) as the independent or determining variables. Linear regression was then used to test the degree to which specific attributes can be said to determine property sale price. A semi-log functional form was used due to the expected relationship between marginal values of attributes and their expected impact on home prices. This relationship was confirmed with a Box-Cox test. To explain:

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[7] Structural attributes include: Fireplace, Garage, Basement, Age of House, and Square Footage of House.
[8] Locational attributes consist of census tract-level fixed effects and measures of lake proximity.
[9] Consisting of annual lake clarity values derived from satellite imagery, measured in feet.

it is expected that people would be willing to pay more to increase their square footage of living area from 100 to 200 than they would to increase square footage from 3000 to 3100. In a similar manner we would expect that people would be willing to pay more for the first meter of clarity than the sixth or seventh meter of water clarity. Additionally, there was not significant correlation between any housing attributes such as lot size, bedrooms or bathrooms and water clarity.

In order to ensure that the final dataset did not exhibit any significant issues related to multicollinearity, we examined the correlation between the structural and locational attributes of a home with water clarity. This was done to ensure that we had good sampling within the dataset. For example: it might have been the case that nicer homes were also located on lakes with clearer water. Some of the value attributed to water clarity changes would then be attributed to differences in structural characteristics. We found that, within the dataset, this is not the case. **Within the dataset, we found very little to no correlation between housing attributes and water clarity.** Moreover, we did find correlations between variables where they might be expected to exist. For example, properties with more bedrooms also have more bathrooms, are more likely to have a garage, and have a larger square footage of living area. Similarly, properties with larger living areas were correlated with properties having more bedrooms and bathrooms.

Summary Results

VARIABLES	Dependent Variable Log Price
Secchi_250	0.0322***
	(0.0087)
Secchi_500	-0.0008
	(0.0062)
Secchi_750	0.0029
	(0.0082)
Lake_250 (0/1)	0.2447**
	(0.1148)
Lake_500 (0/1)	0.0880*
	(0.0490)
Lake_750 (0/1)	0.0039
	(0.0428)
Acres	0.2535***
	(0.0320)
Age	-0.0059***
	(0.0010)
Sqft (100s)	0.0443***
	(0.0054)
Totalbaths	0.0706***
	(0.0091)
Fireplace (0/1)	0.1301***
	(0.0138)
Garage (0/1)	0.0520***
	(0.0175)
Basement (0/1)	0.1556***
	(0.0351)
Acres Squared	-0.0361***
	(0.0068)
Age Squared	0.0001
	(0.0001)
Sqft Squared (10000s)	-0.0004***
	(0.0001)
Constant	10.9405***
	(0.0853)
Census Tract Fixed Effects	Yes (60)
Year Dummies	Yes (3)
Month Dummies	Yes(11)
Observations	8,372
R-squared	0.7281

Notes: *, **, and *** represent significance at the 10%, 5%, and 1% level respectively. Robust standard errors have been clustered at the census tract level.

From the results table located to the left, we find houses that are located within 250 meters of a lake a lake will experience a 24% price premium when compared to homes more than 500 meters distance. Similarly, homes located within 500 meters but greater than 250 meters will experience an 8.8% premium when compared to houses more distant from a lake.

For the average home within 250 meters of a lake, a 1-foot increase in water clarity will increase its value by 3.2%. Within the study area, the average home price within 250 meters of a lake is $215,000. Using our results, we would expect that if water clarity improved from 3 to 4 feet this home would experience an average increase in sale price by $6,880 and have a total value of $221,880. However, when we increase this distance to 500 or 750 meters away from the lake, we find no correlation between water clarity and home sale price.

In a similar manner, we would expect the average home in the study area to lose roughly 3% of its value with a one-foot loss in water clarity. Thus, using the numbers above, an average $215,000 home would lose roughly $6,880 of its value. In metric terms, we would expect that a one-meter loss of clarity on the same $215,000 property would result in a $23,327 loss in value (10.85%).

These results are consistent with previous similar studies conducted by the authors and within the wider literature. Lending credence to the specific results discussed above, we also find that home structure attributes influence home sale prices in a manner and increment that we would expect. For instance, houses that have a basement, a larger garage or a fireplace, are predicted to have a higher sale price than smaller homes with fewer amenities. The addition of a full basement would increase the home value by 15%, this addition would equate to a $22,500 increase on the average home in the study area ($149,000). These findings demonstrate the strength of both the model and the dataset.

Given that there are conservatively 1,374 houses located within 250 meters of a lake in Manitowoc County we would expect that the total valuation losses from even a modest 1-foot loss of clarity would be roughly 9.45 million dollars. A 2 - foot loss of clarity in lake water within the county would be expected to produce a 18.9 Million dollar loss in valuation within Manitowoc County alone.

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