Senior Project

Department of Economics

"Zebra Mussels: Amenity or Disamenity"

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Abstract

The paper uses a hedonic model to show that zebra mussels effect lakefront property prices in the Northern Wisconsin region. The paper not only looks at just the presence of the invasive species, but also considers the effect of the amount of time it has been present in the lake has on the overall price. The latter is the niche of this paper that extends the knowledge of the topic. The paper also takes into account many endogenous factors that are at play in order to limit the possibility of an omitted variable bias.

I. Introduction

Foreign species that invade ecosystems that are not their own are a costly, huge problem for the United States. Invasive species can be a detriment to agriculture, infrastructure, fisheries, and forestry. It is estimated that each year the cost of these invasive species to the U.S. is approximately $120 billion dollars (Pimentel, Zuniga, and Morrison 2005). These costs include repairs (caused by the species) and management of the species. Zebra mussels are one species that is causing such damages and raising these costs. For example, this species can cause damages by attaching to boat motors (reducing efficiency), attach to ladders and rocks where swimmers can cut their feet, and clog pipes. However, unlike most foreign species, the zebra mussels produce a use to the consumers living near an infested lake. The species eat plankton which results in an increase in the water clarity of their new environment. The motivation for this paper is to determine if the pros outweigh the cons. Therefore, the research question for this paper is if zebra mussels are an amenity, or disamenity.

There is a lack of hedonic studies involving not only the impact of an invasive aquatic species but also water quality in general. A hedonic regression is an analysis that is a preference method for determining demand. It dissects the dependent variable into having characteristics making it up, and attributes values to these characteristics. This paper will look to help solve this issue by analyzing the effect that zebra mussels have on housing prices. To determine what residents are willing to pay for having the species present, one must look at the increase or decrease in the price of lakefront properties in areas with zebra

mussels compared to those without the infestation. Not only will this paper look at the difference in prices in areas where the species was first found, but it will also measure how an increase in the years since the species has been present effects the property price.

The results for this study are even more convincing as the study has controlled for the possible econometric problem of endogeneity. For example, owning property by some lakes is in more demand than others, and this fact was taken into consideration. Endogeneity is a common issue amongst hedonic studies, and accounting for missing terms engulfed by the error term adds more value to the findings as it avoids a biased estimate.

II. Review of the Literature

The common question in the literature about water quality and invasive species is the estimation of their impact on residential land prices. Tuttle & Heintzelman (2015) examine approximately 3,000 lakes in a fixed effect hedonic analysis to find whether property owners value the water quality of the lake by their property. The research that was done provides valuable insight into the effects of water quality on housing prices. They found that consumers are aware of the value of the surrounding lake's water quality when purchasing a home. This is important knowledge for this paper, as zebra mussels increase water quality. The paper leads to the assumption that zebra mussels have amenity properties, the question then is if their nuisance outweighs this.

Leggett and Bockstael (1999) arrived at the same conclusion in their research of water quality on the Chesapeake Bay. Like the previously mentioned

paper they found that the higher the water quality of the area the more the consumer is willing to pay for property prices. Unlike the previous paper, they account for pollution sources being a negative impact to the price of the house on top of also polluting the lake. For example, a sewage plant would cause the price of a house to drop as well as decrease water quality. This idea of correcting for endogeneity by accounting for instances that can increase and decrease the demand of a lake was used in Johnson's paper and will be used in this paper as well.

Johnson (2013) briefly discusses how whether the impact of the species is good or bad varies across species. Her paper focusses on determining whether zebra mussels are an amenity. The study is done on the Northern counties of the Wisconsin region. Using a year and county fixed effect hedonic model to account for endogeneity, the study found that zebra mussels could be an amenity in some areas, having up to a 10% increase in housing prices due to water clarity. The paper accounts for the fact that the lakes with the infestations could be the more popular, higher demand lakes in the area, and includes variables that help account for this fact. However, a 10% increase in housing prices in some area (and close to 0% in others, depending on the specific region) is a bold statement and it is very possible that there are other variables that were not measured, due to lack of data, that account for these lakes having a higher demand leading to a higher housing price. One variable that will be used in this paper, that was not in the previous one, is the date the zebra mussel first infested the lake. This will be talked about more in the methodology section for the reasoning behind it.

Just because some invasive species causes an increase in property prices does not mean that all aquatic invasive species do. Two separate studies, on the effect Eurasian watermilfoil were conducted to determine the effect that this invasive species had on lakefront property values. This species diminishes native aquatic plants and native fish species as well (Zhang 2010). These two factors led to a decrease in land value after the species had invaded the local lake. Since it took away many popular fish, recreational boaters were less attracted to the lake. Zhang found property values diminished from <1% to 16% and Lewis and Horsch saw an average decrease of 13% for a different lake. Therefore aquatic invasive species impact on house prices has to be taken on a case by case basis (i.e. each location and each species).

In Hedonic studies of environmental characteristics these estimating their economic value, and can address endogeneity issues. The problem is that higher demand lakes are more likely to become infested but at the same time are also more likely to have higher housing prices. Johnson tackles the problem of endogeneity that can be found in hedonic price models in three ways. First, the paper included eurasion milfoil infestation status as a control for zebra mussel infestation. Second, an improved ramp variable is added to capture the fact that more boats are present in the lake which indicates that the lake is more likely to become infested. Third, assessing land value that accounts for neighborhood characteristics. This paper will replicate these methods, as well as include the date the lake was first infected by milfoil, to help reduce endogeneity.

There are some issues, however, with the hedonic pricing model in this

particular case. The major issue is that there is no theoretical basis for the functional form of the model. Another issue is that hedonic pricing models have an issue with omitted variable bias and endogeneity. The second issue has been addressed and can be seen above. The first issue will be addressed by giving the theory behind hedonic pricing in general.

III. Theoretical Model

The price of the overall house is determined by the combination of characteristics it displays. Therefore properties possessing a stronger amount of good qualities will result in higher prices and properties with a large amount of poor qualities will result in lower prices. The very basic equation for this can be seen as such:

$$P=P(z)$$

So the price, P, is a function of the values that make it up (z); which define its characteristics. The function is a hedonic price function. This applies to housing because, P, is the price of the property and (z) is the characteristics of the house that cause the house to either increase or decrease in price.

The problem here is that the (z) characteristics are hard to measure exogenously as they often affect each other. For example, if two houses had a pool but one was located in the South and the other in the cold North the effect the pool has on the price in the South will be stronger than the North. The geographical characteristic here effects not only the price but also the pool's impact on the price.

Another issue with hedonic pricing models is that when estimating the pricing

of the house the marginal pricing is not always constant. If all properties have the same characteristic except one it is not always found to be true that the additional amount paid for the property is not all for the characteristic. Also as the amount paid for the property with the extra characteristic will decline as the number of total characteristic increases.

IV. Empirical Examination

The goal of this study is to show the effects that the growth of zebra mussels will have on lakefront property prices. From reading the previous literature the hypothesis was concluded to be zebra mussels will have a positive impact on housing prices. Proving this will answer the research question of if zebra mussels are an amenity or disamenity to the public. The main independent variable is the duration of the zebra mussel in the lake and the dependent variable is the latter. This new independent variable will show how time has impacted the price of the houses, and capture the growth of the species in the infested lake. The more the species grows, the more of a nuisance they can become. However, the more the species grows the cleaner the lake could become.

Other variables will be included as well, and as it has been determined by to previous literature eurasion milfoil infestation will be one of the variables. This is to illustrate which lakes have a higher usage (higher demand) in the area. If Milfoil has infested the lake as well as zebra mussels this shows that the lake might be highly sought after, as many boaters head here. Including this accounts for why the housing price might be higher in this area. Milfoil transmit the same way as well as cause numerous problems similar to that of the zebra mussels.

These problems include, but are not limited to, negative effects on boating, fishing, and recreational activities. It has been shown that this species decreases property values by up to 40% (Halstad et. al 2003). This analysis will use methods for zebra mussels that previous papers have used for eurasion milfoil.

The main variable estimated will be a dummy variable where the existence of zebra mussels in the lake will be set equal to one and non-existence set equal to zero. Following Johnson's previous study, there will also be a measure of the percentage of infestation by lakes in the county for these two species. For example, if 2 out of 5 lakes in the country are infested then this will be .4 or 40%. This will help to remove some endogeneity by accounting for the region (county) having higher demanded lakes than other counties.

Other variables that will be looked at will mostly be characteristics of properties such as acreage of the property (*acreage)*, assessed land value (*land),* assessed improvements (*improved)*, lake frontage (*frontage), and* lake area (*lakeacreage).* Whether or not the lake has been endorsed for fishing (*endorsed*) is included as lakes that do not endorse fishing would attract people who are less inclined to fish for species that could be affected by zebra mussels. Water clarity will also be measured, and it should relate to the growth of zebra mussels as the species cleans the waters. Legget et al (year) as well as Tuttle (year) show that an increase in water clarity causes the price of housing of lakefront properties to go up as well. The variable *Secchi* will be included as it is an indicator of water clarity, and should show cleaner lakes being an amenity. Whether or not the lake has an improved boat launch is also included (*improved*) for reasons mentioned

earlier. The percent of lakes infested in the same county (if 2 out of 5 lakes infested in the same county then it is .4 or 40%) is measured as well (*%zebra* and *%milfoil*). The variable *County* includes county level variables which contains land regulations, tax rates, and zoning. The last variable is a dummy variable that indicates the year the property was sold.

For this study I will be taking the natural log of the dependent variable. The coefficient on *Zebra* will show the magnitude of the amenity/disamenity.

The equation for the model used in the first draft is shown below. All the variables that directly involved with the property is enveloped in the variable "Land", involving lake characteristics "Lake", and involving invasive species "Invasive".

$$ln(Price_i) = \beta_0 + \beta_1 Land_i + \beta_2 Lake_i + \beta_3 Invasive_i + \beta_4 Year_i + u_i$$

V. Data

The data for the study was received by Marianne Johnson and collected from the Wisconsin Integrated Property Assessment System, county-level assessment, the University of Wisconsin lake survey project, the Wisconsin Department of Natural Resources lake database, and Geographic Information System data. There paper will consider the Wisconsin DoT's definition of the counties in North Central Wisconsin (Department of Transportation), 17 counties. The descriptive statistics for these variable can be seen in table 2.

VI. Analysis

This paper will use the same methods to solve for endogeneity that Johnson used. The county fixed effects control for any idiosyncratic difference in sales

price between counties and time dummies capture any differences in sales prices across time due to general macroeconomic conditions. The following is the result of a regression run that included variables for the model listed above and used the data listed above. The results can be seen in table 2.

The results show zebra mussels contribute to higher property value, however the more infested a county is with zebra mussels the less impact this has, and in fact has a negative impact on price. Other factors in the regression show to be true with past findings and research. This is all in accordance with the previous literature, and the main variable of focus in the results is duration of infestation, and duration of infestation squared. Duration of infestation shows that each additional year that the species is infested in the lake there is a 1.8% increase in the property price. These variables show that there is actually a point where the housing price stops increasing, at 11.25 years, and the impact on housing price becomes negative at 25 years.

VII. Conclusion

Zebra mussels were shown to have a positive impact on housing prices. In short, Zebra mussels can be considered an amenity. The turning point however is when the lake has been infested for 11.25 years, and after about 25 years of the infestation the zebra mussel becomes a disamenity. This is the "niche" of the paper, that there is a point at which the infestation becomes a disamenity. The conclusion of the paper is that as zebra mussels grow geometrically in lakes, the more of a nuisance they become, and the more that they hinder the activities and other amenities of owning a lake. At first, they do clean the lake, leading to a

higher property price, but after the stated times they become a disamenity as their negative qualities outweigh the positive one.

VIII. Limitations

One of the limitations of this data is it is only limited to the Upper Wisconsin area. Availability of more diverse data would yield more accurate results to whether the infestation is an amenity or disamenity. Another limitation is that there needs to be more data across a longer time period to yield results. The data for property sales is only across 2009 and 2010, and would be better suited if it was from current years as this would allow for more years in between the sale and the infestation data, leading to more results for the higher years in the variable “duration of infestation”.

While the variable “duration of infestation” accounts for some of the growth of the zebra mussels in these lakes, data showing the actual growth of the species for each lake would provide a more accurate feel for how infested the lakes are becoming over time. Having this exact data would probably show that zebra mussels become a disamenity after a while, but would show a more accurate point at which this happens.

IX.Appendix

Table 1: Descriptive Statistics		
Variable	**Mean or Frequency**	**Standard Deviation**
Sales Price	303,489	219,587
Acreage	1.87	7.24
Lake Frontage in Feet	160.71	157.28
Assessed Land	166,282	151,273
Assessed Improved	141,406	116,216
Secchi Depth	9.56	5.09
Endorsed	57.14%	--
Acreage	1127.43	2143.99
Improved Access	57.8%	--
Zebra Mussel Infestation	9.4%	--
% of Lakes in County infested with Zebra Mussels	4.6%	--
Milfiol Infestation	40.5%	--
% of Lakes in County infested with Milfoil	32.0%	--
Number of Observations	1167	--
Number of Counties	17	--
Number of Lakes	413	--

Table 2: Regression Analysis	
Variable	**Beta Coefficient (Standard Error)**
lnAssessed	0.38 (0.03)***
lnImproved	0.41 (0.02)***
Acreage	0.001 (0.00007)**
Frontage	-0.0001 (0.0001)
lnSecchi	0.06 (0.022)***
Endorsed	0.08 (0.024)***
Acreage	0.007 (0.006)
Improved	0.02 (0.024)
Zebra	0.091 (0.048)**
%Zebra	-0.01 (0.009)
Milfoil	-0.05 (0.028)*
%Milfoil	-0.007 (0.01)

Duration of Infestation	0.018 (0.0134)*
Duration of Infestation^2	-0.00073 (0.00982)*
Year 2009	0.093 (0.038)**
Year 2010	0.077 (0.021)***
Constant	3.45 (0.31)***
N and R-Squared	1072, 0.7222

X. Bibliography

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