Is Cycling as an Active Transportation More than Environmentally Friendly? –
Impacts of Bicycle Networks on Property Values in Madison, WI

By

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Abstract

Whether it is a simple bike path in a park or a complex network of trails and bike lanes, bicycling infrastructure positively impacts the economy. Networks promote active transportation which results in both public and personal economic benefits. The community benefits from reduced infrastructure and health costs, reduced vehicle emissions, and increased revenues to local businesses. Individuals benefit through a healthier lifestyle as well as reduced transportation and medical expenses. There is also an economic effect on property values. Opinions vary whether a bike trail will increase or decrease the value of properties near it. While opponents feel that privacy decreases and crime increases near a bike trail, most studies have shown that bike trails will increase property values.

This study focuses on the effect bicycle trails have on property values in Madison, WI. Madison has a well-developed cycling network which acts as a corridor for transportation and recreation. While only 0.6% of workers in the U.S. commute to work by bicycle, the percentage is much higher in Madison at 5.3%. In this study, through the use of geographic information system (GIS), maps were created and statistical analyses were run to determine how assessed values of single family residential properties vary by the home’s proximity to the nearest off-street, paved bike trail. Many variables relating to the attributes of properties were also incorporated in this research. The results show a statistically significant effect of a home’s distance to the nearest bike trail on assessed value together with other property characteristics.
Introduction

Bicycle networks have a positive impact on a local economy, including personal economic savings and environmental benefits through the promotion of alternative transportation and related infrastructure, as well as increasing property values near the trail. Whether it is a simple bike path in a park or a complex network of trails and bike lanes, bicycling infrastructure is positively impacting the economy. Bicycle networks create a transportation corridor which can enhance economic development as well as offer recreational opportunities (Lindsey et al 2004).

The role of bicycles has changed over the last one hundred years. In the late 1890s, bicycles became popular as a way of transportation in Wisconsin. Once cars came to the market, bicycles became less popular for transportation and were used more of a recreational device (Wisconsin DOT 1988). In 1980, 6.7% of Americans commuted to work by bicycle or by walking. By 1990, that percentage fell to 4.4% and biking and walking were regarded as the “forgotten modes” of transportation. It was at that point that a national transportation policy was created to develop infrastructure for these “forgotten modes” (National Bicycling and Walking Study 2010). The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requires government units to include bicycle and pedestrian plans in their transportation infrastructure if they want federal funding (Wisconsin DOT 1988). As a result, communities focused more attention to bicycle and walking routes. By acting like a linkage system, bicycle networks are impacting the economy on both a local and nationwide level.

Throughout the literature review, various authors make reference to both trails and greenways. It is important to note that greenways are areas dedicated to preserving open space and can provide an opportunity for recreation, while trails are paths for recreation or
transportation. Thus, not all greenways have trails (Rails-to-Trails 2004). Another clarification to make is that at different points, authors reference bicycle infrastructure using various terms. These predominantly include terms such as bike facilities, networks, trails, paths, lanes or routes. When describing the entire system of bicycle infrastructure in a region, the term network is often applied. However, when referencing parts or individual aspects of the network, terms such as trail, path and lane are used.

Among the various articles reviewed, many authors support the claim that bicycle networks have a positive impact on a local economy. The economic benefits include promoting alternative transportation, reducing infrastructure and health costs, reducing vehicle emissions, promoting businesses near the bike trail, supporting local bike businesses, attracting tourists, encouraging healthy active lifestyles, and increasing property values near the trail.
Literature Review

Economic Impacts of Alternative Transportation and Related Infrastructure

Bicycle networks offer a location for individuals to use alternative transportation. As a result, infrastructure as it relates to transportation and alternative transportation is affected. The use of alternative transportation reduces congestion, frees us more parking spots for cars, and increases capacity of roadways. Having bicycle networks allow individuals to use alternative transportation and support the growth of bicycle related infrastructure. By supporting bicycle infrastructure, such as implementing bicycle lanes, roads see benefits as well in the way of less use (Bicycle Federation of WI 2006).

In reviewing literature on bicycle commuting, researchers from the Netherlands found that the presence of bike paths results in more people riding a bicycle as a means of transportation. People prefer dedicated, continuous bicycle infrastructure (Heinen et al 2010). If bike paths are constructed, will people use them? That is a question raised to determine if money invested in infrastructure will change people’s transportation modes.

In a 2006 study in the Twin cities, researchers looked at the use of bicycle trails and bicycle lanes. They found that people’s use of bicycle trails is not influenced by how close they live to them. People who want to ride on a trail will travel to do so. This study brings to question whether or not having bike trails in one’s neighborhood actually improves the likelihood a person will use it. However, the study goes on to find that the distance individuals live from a bicycle lane does influence their use of it. Researchers found that people living within 400 meters of a bicycle lane are more likely to use it than someone who is 1600 meters away from a bicycle lane (Krizek and Johnson 2006). The data presented interesting points towards the conclusion that the type of bicycle infrastructure dictates people’s use of it.
The National Highway Traffic Safety Administration (NHTSA) 2012 survey showed different results. It found that 49% of respondents who lived within one-quarter mile of a bike path used it while only 14% of those living more than one-quarter mile used the bike path. For bike lanes, 49% of the respondents who lived within one-quarter mile used them as opposed to 10% of the respondents living more than one-quarter mile using the bike lanes. This survey would indicate that proximity to a bike facility influences usage (USDOT NHTSA 2013).

There are economic benefits relating to the construction of bicycle infrastructure. The costs to build bicycle infrastructure is less than infrastructure supporting motorized vehicles. One of the most profound cases of this is seen in Portland, OR. In 2008, the city of Portland calculated that it was able to build its 300 mile bicycle network for the same price as “one mile of urban freeway.” At this time, a road construction project of this size costed $60 million (Geller). The Wisconsin Bicycle Transportation Plan 2020 includes estimates for materials and labor for various bike facilities. The costs range from $20,000 per mile for paved shoulders to $90,000 per mile (both sides) for bike lanes. Off-street bike paths can cost as little as $10,000 per mile for crushed limestone or as much as $200,000 per mile for a 12 foot wide asphalt path with lighting and landscaping (Wisconsin DOT 1998). The costs of highway construction is significantly more. The Wisconsin Department of Transportation estimates that resurfacing an urban two-lane highway is $606,000 per mile and that reconstructing an urban two-lane highway is $2,649,000 per mile (Wisconsin Department of Transportation 2014).

The return on a community’s investment in bicycle networks can be observed when looking at a study of North Carolina’s northern Outer Banks cycling locations. Data shows that the money spent to build bicycling locations is nine times less than the economic rewards that result from this infrastructure (Bicycle Federation of WI 2006). Additional studies have also
pointed to the positive economic outcomes of bicycle networks. In a study designed in New Zealand to help create alternative commuting methods, researchers found that the best bicycle paths are the ones that are segregated from busy or major roads. Using systems dynamics modeling, they estimated that the benefits would be 10 - 25 times more than the cost to build the infrastructure (Macmillan et al. 2014).

**Economic Impacts on Health Costs**

With bicycle networks influencing a healthy and active lifestyle, a number of economic benefits can occur as a result of having a healthier community. Job sites can achieve economic benefits since a healthier workforce can reduce sick days used and health insurance costs for the employer (Flusche 2012). In an attempt to quantify the economic value of the benefits of cycling, researchers at the University of Wisconsin-Madison concluded that in the cities of Madison and Milwaukee there would be $319,572,108 in annual savings if people met the minimum physical activity requirements of 150 minutes a week (Grabow et al. 2010).

**Economic Impacts of Reduced Emissions**

Many of the economic benefits as a result of alternative transportation are seen in the reduction of energy related costs. Most of the trips taken in the U.S. are over short distances and 72% are done via motorized transportation. The Department of Energy reports that in 2007, 30% of energy consumed in the U.S. was through transportation. In addition, the transportation sector generates one-third of the carbon dioxide emissions and 80% of the carbon monoxide emissions (National Bicycling and Walking Study 2010).

The placement of networks and infrastructure for bicycling provides the opportunity to use modes of transportation other than cars. By using bicycles, the surrounding environment is positively affected. Cycling is an activity that creates zero pollution and uses zero fossil fuel
(Bicycle Federation of WI 2006). The same cannot be said about motorized transportation.

Twenty pounds of carbon dioxide is emitted per gallon of gas used and the EPA estimates that 12,100 pounds of carbon dioxide are generated per vehicle each year (Wisconsin DOT Calculator 2015). Besides just the act of cycling being beneficial to the environment, the construction of trails also has rewards. Trails and greenways often conserve habitats and preserve surrounding plants; therefore, the amount of air pollution is lowered since the plants act as natural air purifiers. Additionally, trails along rivers act as a buffer for runoff and provide a natural flood plain (Heinen et al 2010). The benefit that trails and greenways have on air and waterways is a very redeeming quality. In an attempt to quantify the economic value of the benefits of cycling, researchers from the University of Wisconsin-Madison made the following conclusion regarding potential environmental cost savings if 20% of commuters in Madison and Milwaukee used bicycles: $89,214,200 would be saved in better air quality and $1,157,859 saved in lower greenhouse gases (Grabow et al. 2010).

**Economic Impacts on Local Businesses and Bike Shops**

Another of the many economic benefits of bicycle networks includes promoting businesses such as convenience stores and food establishments near bike trails. Bicycle and walking paths can reinvigorate shopping districts (National Bicycling and Walking Study 2010). In the case of an area in Memphis, TN, businesses have seen economic benefits from the local bicycle lanes. In one situation, a business has seen a 30% increase in revenues yearly (Flusche 2012). On the other hand, critics of bicycle lanes have stated that by building bicycle lanes in place of parking spots there could be a negative impact on businesses (Flusche 2012). While bicycle lanes may reduce the number of parking spots near businesses, the rewards of having a bicycle friendly street can be quite beneficial to local businesses.
Throughout the United States, local economies are benefiting from Americans spending more money as a result of bicycling. One specific type of business that receives the benefits of bicycle networks is bicycle shops and related industries. When networks are created, the bicycle industry sees economic gains. The higher the number of cyclists using bicycle networks, the more people that will need the support of a bicycle shop (Flusche 2012). Whether it is a cyclist spending more money on meals at restaurants or needing to get their bike serviced at the local bike shop, bicycle networks provide the corridors for this economic growth to occur.

**Economic Impacts on Tourism**

Bicycle networks have the ability to attract tourists to the neighborhoods or cities that these systems reside in. In a 2006 study conducted by the Bicycle Federation of Wisconsin for the Governor’s Bicycle Coordinating Council, it stated that over the previous five years, 27 million people participated in cycling vacations (Bicycle Federation of WI 2006). In Wisconsin alone there were 57 single day bike tours in 2004 (Bicycle Federation of WI 2006). Among these, two of the bike tours in Wisconsin, GRABAAWR and SAGBRAW, produced $3.7-$6.2 million during the 2004 events (Bicycle Federation of WI 2006). Rides such as these have the potential of drawing in riders from outside the state, leading to increases in tourism. Additionally, participants in events on these rides can boost business and help the economy in each of the towns and neighborhoods that the ride passes through.

In an attempt to quantify the economic value of the benefits of cycling, researchers from the University of Wisconsin-Madison estimated that $924,211,000 was brought in as a result of tourism and recreation as it pertains to bicycling (Grabow et al. 2010). With such a high number of vacationers using cycling as their motivation to travel, local economies can certainly benefit
from tourists on bicycle related vacations. By having a strong cycling network, cities can attract more of these tourists, thus fueling the local economies.

**Economic Impacts on Personal Transportation Expenses**

The 2009 NHTS reports that approximately 43% of automobile trips are three miles or less (USDOT NHTS). If short errands were done by biking or walking, the U.S. could reduce fuel consumption significantly. For those who use a bicycle for transportation, the economic benefits are fairly substantial. The U.S. Department of Transportation funded *National Bicycling and Walking Study: 15-Year Status Report* released in 2010 estimated that owning and operating an automobile costs approximately $9,000 a year. On the other hand, owning and operating a bicycle is estimated at $120 per year (National Bicycling and Walking Study 2010). The Wisconsin Department of Transportation has a cost calculator to determine commuting costs. This calculator assumes that it costs 58 cents per mile to use a car based on 2015 data from the American Automobile Association (Wisconsin DOT Calculator). According to the study conducted by the Bicycle Federation of Wisconsin, it costs 5 -10 cents per mile to use a bike (Bicycle Federation of WI 2006). Although individuals can save money based on these figures, critics report that cycling is said to be more dangerous than driving a car for transportation. In a study in the Netherlands, data showed that there are 5.5 times more traffic deaths per km traveled on bicycles than in cars (de Hartog et al. 2010). However, despite previous claims, the same study concluded that the risks associated with not being active are far greater than the ones associated with cycling (de Hartog et al. 2010).

**Economic Impacts of Healthier Lifestyles**

Bicycle networks have the power to encourage healthy/active lifestyles. In doing so, there can be reductions in medical costs. It is known that physical activity is key to staying
healthy. The World Health Organization recommends that people have 150 minutes of exercise per week (Lankford et al 2011). Inactive people are more likely to have health issues such as “heart disease, obesity, diabetes, osteoporosis, and depression.” (Bicycle Federation of WI 2006) Active people have a better quality of life and less health care expenses. With such positive impacts on one’s health, bicycle commuters are rewarded with health benefits as a result of biking to their destination (Lankford et al. 2011). Trails are also an inexpensive location to exercise and people who commute by bicycling do not need to set aside time to exercise. In Indiana, a survey of the users of six different trails found that 70% of the users are exercising more because of the trails (Rails-to-Trails 2004). In this case, it is seen that bicycling infrastructure can help foster healthy and active lifestyles.

Arguments can be made that cycling, especially in bike lanes on roads, can negatively affect your health. Critics propose that while cycling, a rider will breathe in more pollutants due to faster breathing rates and is more likely to be injured in an accident (de Hartog et al. 2010). However, the study showed that the health benefits gained as a result of cycling are nine times greater than the risks associated with cycling (de Hartog et al. 2010).

**Economic Impacts of Proximity to Bike Trails on Property Values**

Uniquely enough, bicycle networks can have an economic impact on property values. The proximate principle, a concept that property values increase when near a park, dates back to the early 1800s in England. In studying the economic impact of New York’s Central Park in the 1850s, Frederick Olmsted determined that the city had to pay approximately $800,000 a year for purchasing and developing the park. However, property values near the park increased and generated $5.24 million in tax revenues annually. Research findings show that passive parks increase property values more than active parks (Compton 2005).
Trails and real estate seem to have a strong relationship. Studies have been conducted to determine the impact bike networks have on property values. Many of these studies used surveys of homeowners and realtors. The use of GIS allows the studies to be more quantitative.

In 2006, a University of Delaware study examined property values in New Castle County. They used the hedonic pricing model (property value model) which is commonly used in researching property values. It is a statistical model which incorporates a number of variables from property characteristics and sales. In this particular study, they used actual sales transactions in its calculations. They used a 50 meter buffer around the bike paths in the county. The dependent variable was the last sales price of a property and the independent variables included acreage, land value, last sales price and age of structure. The study found that a bike path had a positive effect on the property values and that houses within a 50 meter buffer were at least $8,800 more than houses outside the buffer area (Racca and Dhanju 2006).

Another study was conducted in 2006 in the Twin Cities. In this study the Hedonic method was also used but the study looked to see if the type of bike facility and location of the bike facility had different impacts on property values. The study found that in the city, on-street facilities negatively impacted property values but off-street bicycle facilities positively impacted home values. In the suburbs, the author found that both on and off street bicycle facilities negatively impacted home values. The researcher pointed out that there can be a legacy effect on property values for “rails to trails” paths. Many rail lines were not located in desirable neighborhoods when they were operating and the lower property values carried over (Krizek 2006).

A subsequent study was conducted in 2007 in the Twin Cities using a different method. They conducted a matched pairs, longitudinal study and looked at property sales two years
before (1998-1999) and two years after (2004-2005) the construction of the trail and used a control area which had similar characteristics to the study area. The study used seven bike paths which were built between 2000 and 2004. Three kilometer buffers were created around each path and 120 census tracts were in the study. The control census tracts had to have three similarities: location, median household income (most significant), and population density. The control had to be in the same “urban ring” as the study census tract. The study concluded that bicycle paths did not have a short term effect on property values (Poindexter et al 2007).

A study of Indianapolis trails used the Hedonic price method and Multiple Listing Service (MLS) data. The independent variables included square footage, number of bathrooms, presence of air conditioning, the age of the house and the number of garage bays. They used three different models which showed that not all greenways have the same impact. While the results showed that home values increased when near a trail, homes along a conservation corridor had higher values than homes along a multi-use recreational trail. When they studied the popular Monon Trail by itself, they found that it had a significant impact and homes near that trail were valued $13,000 more than homes not near the trail (Lindsey et al 2003).

A University of Delaware report states that critics of trails near or along properties believe that property values decrease near trails in that people lose their privacy. Additionally, opponents claim that crime rates could also rise on and near the trails (Racca and Dhanju 2006). However, in this study conducted at the University of Delaware, statistics showed that major crimes are not prevalent on trails. The rate of crime on a trail is often closely associated with crime levels in neighboring areas and the bike path design (Racca and Dhanju 2006). This being the case, bike trails themselves do not inherently attract crime. However, the placement and route of the trail can influence if or where crimes occur along it. Careful planning and a strong
understanding of a trail’s surroundings can help avoid the impacts of crime on a trail. Thus, doing so allows trails to have a greater economic value in the eyes of property owners.

In examining the literature of the effects that bike trails have on property values, the majority of the studies found that bike paths either increase or have no effect on the sale price of homes (Racca and Dhanju 2006). For a homeowner or someone that owns property near or along trails, the economic gains of having a trail are beneficial to property values. For a local government, the increase in property values results in additional property tax revenue.
Hypothesis

H_0: Bicycle networks do not have a positive impact on local economies.

H_A: Bicycle networks have a positive impact on local economies.

H#1_0: Bicycle networks do not provide personal economic and environmental benefits through the promotion of alternative transportation.

H#1_A: Bicycle networks provide personal economic and environmental benefits through the promotion of alternative transportation.

H#2_0: There is no positive relationship between a home’s assessed value and its proximity to a bicycle trail.

H#2_A: There is a positive relationship between a home’s assessed value and its proximity to a bicycle trail.
Methodology

Study Area

Madison, Wisconsin is home to a number of bicycle trails and routes. It’s well developed cycling network makes it a popular place for cycling. Trails are found all throughout the city, which act as a corridor for transportation and recreation (Figure 1). Based on the 2015 City of Madison bike map, the bike network is composed of 52 miles of bike trails, 127 miles of bicycle lanes and 116 miles of bicycle routes. While only 0.6% of workers in the U.S. commute to work by bicycle, the percentage is much higher in Madison at 5.3% (U.S. Census Bureau 2013).

Figure 1. Bicycle Trails in Madison, WI
Madison currently has a population of 236,901 people. The median value of a home is $219,600 and the median household income is $54,093 in Madison (“Economic development,” n.d.). Madison is the state’s capital and is home to the University of Wisconsin - Madison.

**Study Site**

This study included a focus on the cycling network in Madison, specifically investigating the paved, off street trails found throughout the city. Figure 2 shows an example of a bicycle counter located along one of the city’s major paths. By looking at the trails, one is able to interpret what impact their proximity has on property values. To accomplish this, various map layers were acquired or created using GIS software (ArcGIS Desktop). Layers included Madison’s urban area, block group level data of population density and median household income, the bicycle trail locations, and the individual parcel data.

![Image of bicycle counter and Southwest Commuter Path]

Figure 2. Picture of bicycle counter and Southwest Commuter Path
**Data Acquisition and Analyses**

While the literature review highlights a number of the benefits that bicycles and bicycle networks can have on an individuals as well as a community, this research focused on investigating two of these benefits.

*Calculate personal economic and environmental benefits of alternative transportation*

At a city wide level, the economic impact of using bicycles as a form of transportation was examined. To do so, information regarding those who commute by bicycle was gathered. The American Community Survey (ACS) provides figures pertaining to the number of people who commute by bicycle at the state, county, census tract and block group levels (Figures 3 and 4). Data for this study was gathered at the block group level.

![Figure 3. Percent of workers commuting by bicycle: 1990](image1)

![Figure 4. Percent of workers commuting by bicycle: 2013](image2)

To understand the trend in bicycle commuting, the above maps show the change in bicycle commuter levels between 1990 and 2013. To quantify the amount of bicycle commuting in Madison, the number of commuters using bicycles was multiplied by the average distance traveled by a bicycle commuter each day. This daily information was then converted to annual figures. This annual mileage was then multiplied by the difference of the cost of driving a car
per mile and the cost of using a bicycle per mile. This figure represents the personal economic savings of using a bicycle as an alternative form of transportation.

In addition, the environmental benefit was calculated. Based on the distance ridden by bicycle opposed to using a car for transportation the amount of CO$_2$ released into the environment changes. To determine the change, the number of gallons saved through biking was multiplied by the amount of CO$_2$ released per gallon of gas burned.

*Spatial and statistical analyses of the relationship between a home's assessed value and its proximity to a bicycle trail.*

To undertake the analysis of the effect that bicycle trails have on property values, a number of datasets were acquired. The initial step required contacting the GIS specialist from the City of Madison to gather the data pertaining to the city’s bicycle network. After getting this information, data regarding the city’s parcels was needed. To acquire this information the Dane County Land Information Office (GIS Services) was contacted. After placing an order for the county’s parcel information, this data was added as a layer in ArcGIS. To complete the data gathering process, a few more pieces of information was needed before beginning the analysis.

To outline the urban area of the City of Madison, the shapefile was extracted from the urban layer in ESRI Data and Maps. This layer provided the boundary for the analysis. To complete the initial data gathering process, the census block group level information was needed pertaining to the City of Madison. This data was extracted from the Business Analyst Updated Demographics database. Population density and median household income were the key attributes to be used from the block group layer.

To analyze the data and determine the relationship between the assessed value of property and its distance to the nearest bicycle trail, it was important that all the data be prepared properly before final analysis. First, the parcel layer needed to have all necessary data added to
the attribute table. While the attribute table of the parcel layer did contain a lot of information, it was necessary to add in data from an external source. From the City of Madison’s website, additional information regarding property assessment can be found in a table format. Data in this table included a number of important property characteristics, which were crucial to the analysis. In addition to the data from the City of Madison, information pertaining to the quality of schools in Madison was also needed in the parcels’ attribute table. The source for this information was from the Wisconsin Department for Public Instruction. Posted on their website is a table of “2013-2014 School Report Card Data.” After downloading the data as an Excel workbook, a separate table was created to store the school’s name and the overall accountability score, which is a comprehensive score indicating the relative quality of a school. The table with the schools’ names and scores was then joined to the parcels’ attribute table. At last, additional fields including total home square footage, home value per square foot, and the age of the home, were calculated using the field calculator in ArcGIS based on known attributes of total living area, finished basement square footage, total assessed home value, and year built.

With such a large dataset, it was important that some data cleaning be performed before running any tests and analyses. First, the selection was limited to only the properties in Madison which were listed as single family residences. After doing this, all parcels which had a zero assessed value per square foot were deleted. Next, a review was performed to see if the remaining homes and their value per square foot had a logical relationship. For example, there appeared to be a number of newly built homes (one year old or less) that had a very low value per square foot. Since this relationship appeared to be unusual, all properties which were one-year old or less and had a value per square foot less than $40 were placed into a different
“outliers” layer. This step was done so that the properties with unusual age and value per square foot relationships could be excluded from the main test group.

Since the main aspect of the research is studying the effect that bicycle trails have on assessed property values, it was important that the dataset for the parcels layer contain how far each parcel is from the nearest bicycle trail. To determine this, a tool in ArcGIS was used to calculate this exact distance. The near tool allows users to specify an input feature, in this case parcels, and a near feature, the bicycle trails. After running the tool, a new field was added to the parcels layer which showed the distance each parcel is from the nearest trail in feet.

To determine the significance of the distance a property is from the closest trail, a few different statistical tests were carried out. Before doing these tests, the dependent and independent variables were identified. The dependent variable in this study is value per square foot which was calculated by taking assessed value and dividing it by total living area plus finished basement. The independent variables in this study included a number of property and neighborhood characteristics. Property characteristics included the number of stories, the home’s age, home’s total square footage, the number of half and full bathrooms, and the number of bedrooms. Neighborhood characteristics included population density, median household income, and school quality assessments. The last independent variable was the property’s distance from the nearest bicycle trail. With this information identified, the statistical tests could now be run.

First, the Exploratory Regression was run to evaluate all possible combinations of the input candidate explanatory/independent variables at the property and neighborhood level for statistical significance and redundancy. Then OLS (Ordinary Least Squares) Regressions were run with significant and non-redundant independent variables in order to explain the variation in
the dependent variable of assessed property value per square foot. First, an OLS model was built with only one variable of property distance to the closest bike trail to investigate its separate effect. Secondly, an OLS model was built with seven significant variables to better explain the dependent variable and investigate the relative effect of proximity to bike trails compared with other property and neighborhood characteristics.
Results

**Personal Economic and Environmental Benefits of Alternative Transportation**

While many recognize that bicycles are great forms of transportation, it’s important to remember that they are only effective if proper infrastructure is in place. Having a well-developed bicycle network can be the catalyst to motivate and encourage individuals to use their bicycle for transportation. As a result of using a bicycle, individuals and the environment can reap rewards. In Table 1, the annual savings of using a bicycle instead of an automobile is shown. Within Madison, one can save an estimated $680 annually by choosing to bicycle in place of driving. Furthermore, when looking at the total cost savings of all bicycle commuters in Madison, one sees that as a whole, bicyclists save approximately $4.8 million annually. While completing this calculation, it was important to determine the number of realistic days that a bicyclist could commute to work. Starting with 52 weeks, 12 weeks were subtracted due to vacation time, holidays and inclement weather (cold/snow). The forty remaining weeks were then multiplied by 5 to arrive at 200 total bicycle commuting days (Table 2).
The reduction in CO$_2$ which results from using a bicycle is also calculated. Table 3 shows the total amount of CO$_2$ (lbs.) that is not emitted by using a bicycle. This number was calculated based on the total reduction from all bicycle commuters in Madison. With a reduction of approximately 8.3 million pounds of CO$_2$, bicycle commuting in Madison has a positive impact on the environment.
Spatial and Statistical Analyses of the Relationship Between a Home’s Assessed Value and its Proximity to a Bicycle Trail.

The analysis and recognition of spatial patterns is one of the central themes within the field of geographic research. In many cases, it can be highly beneficial to study spatial trends
using a map since it is a good way of presenting this kind of information. Figures 5 and 6 display the spatial patterns of population density by block group and median household income by block group.

Figure 5. Population density by block group
In some cases, however, visualizations can only communicate so much information to the reader or researcher. Figures 7 and 8 show property value per square foot and nearby bicycle trails in two sample neighborhoods.
In the former one, properties closer to a bike trail seem to have higher values while the latter one does not show any apparent relationship. To investigate the quantitative impact that bicycle trails have on properties values, two statistical tests were run.

The first was the exploratory regression test which provided a summary of independent variable significance (Table 4).
In this table, all of the candidate independent variables which were considered for this research are summarized. The table shows the level of statistical significance that these variables have on the dependent variable which is the value per square foot of a home. The results of this test communicate a number of important findings. First, it is apparent that the key factor that this research is testing, property distance to nearest bicycle trail, does not rank as one of the most significant variables. Above this variable are eight others which ranked as being more significant. However, with the distance to nearest bike trail variable reporting 95.2% significance, the influence of this variable cannot be ruled out. This table also shows that this same variable has a negative percentage of 98.9, which means there is a consistently negative relationship between a property’s distance to the nearest trail and its value per square foot. Therefore, as the distance a property is from the nearest trail increases, the value per square foot of that property decreases.

The results from the ordinary least squares (OLS) regression also provided a number of meaningful findings. When running the OLS in ArcGIS, two different tests were completed using different sets of explanatory variables. For the first test, the independent variable was the

<table>
<thead>
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<th>Variables</th>
<th>% Significant</th>
<th>% Negative</th>
<th>% Positive</th>
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</thead>
<tbody>
<tr>
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<td>100</td>
<td>0</td>
<td>100</td>
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<tr>
<td>Age of Home</td>
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<tr>
<td>Neighborhood Population Density</td>
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<td>100</td>
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<tr>
<td>Neighborhood Median Household Income</td>
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</tr>
<tr>
<td>Neighborhood Elementary School</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Neighborhood Middle School</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Home Square Footage</td>
<td>98.22</td>
<td>98.58</td>
<td>1.42</td>
</tr>
<tr>
<td>Neighborhood High School</td>
<td>96.44</td>
<td>8.36</td>
<td>91.64</td>
</tr>
<tr>
<td>Property Distance to Nearest Bicycle Trail (ft.)</td>
<td>95.2</td>
<td>98.93</td>
<td>1.07</td>
</tr>
<tr>
<td>Number of Half Bathrooms</td>
<td>90.21</td>
<td>23.49</td>
<td>76.51</td>
</tr>
<tr>
<td>Number of Full Bathrooms</td>
<td>88.26</td>
<td>20.64</td>
<td>79.36</td>
</tr>
<tr>
<td>Number of Bedrooms</td>
<td>87.9</td>
<td>82.38</td>
<td>17.62</td>
</tr>
</tbody>
</table>
distance to nearest bike trail variable and the dependent variable was property value per square foot. Key aspects of the results are summarized in Table 5.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>105.977358</td>
</tr>
<tr>
<td>Property Distance to Nearest Bicycle Trail (ft.)</td>
<td>-0.004872</td>
</tr>
<tr>
<td>Adjusted R-Squared</td>
<td>0.015746</td>
</tr>
</tbody>
</table>

The result from this test shows that both the coefficient and adjusted R-squared values are very low. Upon examining the adjusted R-squared value for this test, one can see that this variable, by itself, only explains 1.5% of the variation of assessed value per square foot of a property in the study area. Furthermore, the low absolute value of the coefficient in this results table suggests that for every foot that a property is away from the nearest bicycle trail, the assessed value per square foot of that property decreases by approximately 0.5 cent.

In the second OLS test, seven of the twelve total explanatory variables were included. These were selected based on their level of significance as outlined in Table 4. Middle and high school accountability scores were excluded due to high levels of correlation with elementary school scores. The results from this test are found in Table 6.
Table 6. Summary of OLS Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-18.368738</td>
</tr>
<tr>
<td>Number of Stories in house</td>
<td>16.224804</td>
</tr>
<tr>
<td>Home Square Footage</td>
<td>-0.006996</td>
</tr>
<tr>
<td>Age of Home</td>
<td>0.227105</td>
</tr>
<tr>
<td>Property Distance to Nearest Bicycle Trail (ft.)</td>
<td>-0.000257</td>
</tr>
<tr>
<td>Neighborhood Population Density</td>
<td>0.001539</td>
</tr>
<tr>
<td>Neighborhood Median Household Income</td>
<td>0.000443</td>
</tr>
<tr>
<td>Neighborhood Elementary School</td>
<td>0.850871</td>
</tr>
<tr>
<td>Adjusted R-Squared</td>
<td>0.363923</td>
</tr>
</tbody>
</table>

Upon examining the adjusted R-squared value for this test, one can see that this set of variables explain approximately 36% of the variation in assessed value per square foot of a property in the study area. Furthermore, the coefficient of the property distance to the nearest bicycle trail indicates that for every foot that a property is away from the nearest bicycle trail, the assessed value per square foot of that property decreases by approximately 0.02 cent. When this variable is considered alongside the other six variables, its coefficient goes down, meaning its relative effect is minor, while this entire set of variables combined are better able to account for the observed differences in per square foot property values.
Discussions and Conclusion

When considering the results from this research, it is important to put them in perspective. When looking at the individual cost savings of bicycle commuting, it’s visible that bicycle commuting does provide economic benefits. By determining this, it allows for the rejection of null hypothesis #1. When looking at the results from the Exploratory Regression, it did indicate that a property’s distance to the nearest bike trail is a statistically significant independent variable in explaining per square foot property value and it has a consistently negative effect on the dependent variable. To that extent, the null hypothesis #2 can be rejected with confidence. It is worth noting that when comparing the coefficients and adjusted $R^2$ values of the two OLS models, the relative effect that a property is from the nearest bicycle trail may seem minor. However, it is important to point out that the goal of this thesis was not to argue that a property’s distance to the nearest bicycle trail is the top indicator of a property’s assessed value. Instead, this research did intend to verify this variable as being a role player in affecting the assessed value of a home. Considering that the property distance variable had a statistical significance of more than 95%, it is apparent that this variable is relevant, although not as critical.

Often times when one thinks about the factors that go into influencing the price of a home, variables such as age, number of stories or home square footage come to mind. However, considering the effect that a nearby bicycle trail has on a property value may be less obvious. In an effort to bring this variable to the front of people’s minds, this research brings a lesser known property variable into the spotlight. Understanding that spatial relationships exist between property values and a nearby bicycle trail is the primary goal of researching this topic. Utilizing
spatial and statistical analysis tools provided by GIS software has been proven useful in understanding this relationship.

While research on this topic may draw to a close for the moment, a number of tracks could be taken to expound upon this research. For example, in addition to looking at the entire bicycle trail network in Madison, a specific investigation could be done on just a few trails. Focusing on only a select number of trails could allow the researcher to take a closer look at any regional differences in the effect that bicycle trails have on property values. A comparison could be performed among the different changes in property values through specific locations in the City of Madison. Another consideration that could be taken into account for this research would be calculate additional “distance” variables such as distance a property is from the closest shopping district, lake or train stations. Including these data would allow for more explanatory variables to be considered in a more complete regression model. Also, it would be interesting to see how these other distance variables compare to the significance that the distance to closest bike trail variable carries.

Another aspect of future research could include a study of whether trails influence the construction of homes. During this research, an examination of the effect that the nearest bicycle trail had on property values was studied during the most current year; 2015. However, understanding if the homes in this study were recent builds, as a result of trail installation, or were already present, was not specifically researched. While a comprehensive study was not carried out, one of the trails in Madison provides insight into this topic. The Southwest Commuter trail was built in 2001, and has a number of properties located along it. Examining when the homes were built is important in determining whether or not the trail truly affects their value. In the case of the Southwest commuter trail, a majority of the homes surrounding it were
built prior to 2001. It appears that properties were not specifically built as a result of the trail. This supports the idea that when a trail is installed in a neighborhood, the trail can contribute to raising the value of existing properties.

To further understand the impact of the bicycle trails effect on property values, a study could be done over the course of multiple years. The initial property values in an area would be recorded pre-trail installment. Then, these same properties would be examined post-trail installation. By studying the property values before and after the trail was installed, one can gain a better understanding of the effect of bicycle trails on property values. All in all, continuing future work on this topic would allow for a greater understanding of the relationship between bicycle trails and their impact on property values in a more holistic context.
Bibliography


de Hartog, Jeroen Johan, Hanna Boogaard, Hans Nijland, and Gerard Hoek. 2010. "Do the Health Benefits of Cycling Outweigh the Risks?" Environmental Health Perspectives 118, no. 8: 1109-1116.


