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Crime and the Quality of Life in Wisconsin Counties

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Crime and the Quality of Life in Wisconsin Counties

Executive Summary

The impact of crime on the local quality of life of a region is examined. Using the methods suggested by Roback (1982) hedonic pricing analysis is used to examine the effects of eight categories of crime on property values and wages. The hedonic results are then used to calculate the implicit prices of the various types of crime. Prices are computed for both urban and rural areas reflecting differences in lifestyle and the corresponding impact of crime. As expected, crime has a measurable negative cost and lowers overall quality of life in a region and the level of impact varies significantly by type of crime.

The unit of analysis for this study is U.S. counties, and the variables used are county-wide percentages and averages. The study includes 2,990 counties (847 urban and 2,143 rural) for which data was available. Data from four sources were used in the model. Earnings, rental values, crime, unemployment, housing statistics, and other demographic variables come from the 1994 City and County Data Book (CCDB). Population, geography, and climate come from the U.S. Forest Service's 1997 National Outdoor Recreation Supply Information System (NORSIS) data set. Some housing statistics were collected from the 1990 Census of Housing and Population. Crime statistics are those reported by the Federal Bureau of Investigation's 1990 Uniform Crime Reporting and Program Data (FBI).

Results using the national database suggest that murder has the highest "disamenity" value with an implicit price of -$4,400 for metropolitan counties and -$3,200 for non-metropolitan counties. Rape has the second highest "disamenity" value at -$3,500 for metro counties but practically a zero value in non-metropolitan counties. This latter result for non-metro counties may be due to lower occurrence of rape being reported in rural areas or the lower likelihood of rapes receiving media attention. But, in nearly every other category of crime, the implicit price of crime is higher in non-metro counties than metro. The generally higher disamenity values of crime in rural areas may suggest that rural residents are more sensitive to crime overall than urban residents. Most other categories of crime have disamenity values ranging from few hundred dollars to actual positive values. Some types of crime, such as burglary, are attract to high quality of life areas.

For Wisconsin counties, Ozaukee, St. Croix and Pierce have the highest crime driven quality of life rankings for metro counties while La Crosse and Milwaukee counties have the lowest quality of life ranking. For non-metro Wisconsin counties Burnett, Adams and Waushara rank the highest for crime driven quality of life rankings and Dunn and Iron counties the lowest. From a national perspective Burnett county is ranked 10th in the nation out of 2,143 non-metro counties while Milwaukee is rank 754th in terms of all (847) metro counties used in the study.

Crime and the Quality of Life in Wisconsin Counties

Introduction

The impact of a region's quality of life on economic growth and development is well documented in the regional science literature (Graves 1979, 1980, 1983; Greenwood 1985; Beasley and Bowles 1991; Gottlieb 1994 Dissart and Deller 2000; and Deller, et al. 2001). It has been shown that many people and firms are willing to make sacrifices to live in high amenity areas. People are willing to accept lower wages and pay higher property prices in order to live in locations that offer a higher quality of life. Firms will accept paying higher wages and property prices in order to locate in areas where the firms' owners and employees can enjoy improved quality of life. Thus, equilibrium wages and property values can be expected to vary from region to region based on, among other things, the levels of various amenities (Roback 1982; Rosen 1979; Henderson 1982; Bloomquist, et al 1988; Deller and Tsia 1998)

It is not well known exactly what values people and firms place on various amenities when making location decisions. Most amenities, such as scenic lakes and forests, are public goods and cannot be or are not traded in any type of market; so formal prices do not exist (Hanley, et al 1997; Freeman 1993; Baumol and Oates 1988). But this does not mean that the amenities have no value. Over the past thirty-five years a wide body of literature has developed that offers various methods for measuring the value of amenities in the absence of a market price. One of the most common methods is hedonic pricing analysis. This technique, which traces its roots to the work of Griliches (1958, 1961) and Court (1939),[1] uses statistical analysis to explain the variation in the price of a good using the good's characteristics as the explanatory variables. The statistically estimated coefficients from the models are then used to compute the implicit marginal prices of the characteristics. To estimate prices for the amenities, the amenities are used as explanatory variables in predicting property prices (hedonic property models), wages (hedonic wage models), or both.[2]

The primary purpose of this study is to examine the effect of a single amenity, the crime rate, on the quality of life in Wisconsin counties. In particular, this applied analysis uses and expands upon a methodology put forth by Roback (1982) to examine the effects of different types of crime on the quality of life, using a model that captures the effects of crime in two hedonic models – one for property values and one for wages. A total of three specifications will be developed each of the wage and property models. The first includes a simple composite measure of all index crimes for which the Federal Bureau of Investigation collects and reports data including murders, rapes, robberies, aggravated assaults, burglaries, larcenies, motor

[1] Goodman (1998) provides an interesting discussion of the history of Court's early use of methods similar to today's well-known hedonic methods.
[2] See Rosen (1974), Bartik (1988), Freeman (1993, 1995), and Hanley et al (1997) for detailed discussions of hedonic theory and methods.

vehicle thefts, and arsons. The second model separates crime into two categories: violent crimes and property crimes. The final model includes all eight index crimes as separate explanatory variables. Implicit prices are calculated for the various crime categories in each model, and separate prices are calculated for urban and rural counties. Finally, for purposes of comparison, the computed prices are used to calculate a crime-quality of life index for each county in Wisconsin relative to the nationally estimated model.

The results of this study are useful in at least two ways. First, the empirical model demonstrates the complexity involved in the relationship between crime, property values, and wages. At first glance, because a low rate of crime can be viewed as an amenity, it seems logical that higher rates of crime should be negatively correlated with property values and positively correlated with wages. But this may not be the case for all types of crime. Some crimes, especially those involving theft, may be attracted to areas with higher property values and wages. In fact, a measure of wealth is often included as an explanatory variable in models that attempt to predict crime rates, especially for property crimes (Hakim 1980; Buck et al. 1990). If this attraction effect is stronger than the disamenity effect, the empirical results may not have the expected sign or may be insignificant.

Likewise, the reporting of crimes may also be correlated with wages and property values. People in wealthier neighborhoods may be more likely to have insurance policies, which require a police report when a claim is filed. This may increase the reporting of property crimes in wealthier areas. Reporting rates for violent crimes may also be higher in these areas. These effects may be strong enough to influence the empirical results. Finally, crime rates for one crime category can be expected to be correlated with those of other crime categories. This may create collinearity problems with the wage and hedonic models. More importantly, this may introduce omitted variable bias into models that exclude certain types of crimes.

A second area of importance for this study is that it investigates an area that has not received a great deal of attention in the past twenty years. The body of literature on hedonic modeling is large, but very few articles have focused on how crime affects the quality of life. Developing a greater understanding of the costs of crime, especially the difference in the costs of various crimes, may provide policy makers with better information for making decisions on how to best use limited resources. The results of this study provide an updated estimate on a national scale with a particular focus on Wisconsin. In addition, separate prices have been computed for urban and rural counties. Nearly all of the studies in the current literature have used data for urban areas while rural areas have received little attention. As shown below, the effects of crime on the quality of life in rural areas are largely similar to that in urban areas but there are some significant differences. The difference in lifestyles, hence the role of crime, is different across rural and urban America as well as Wisconsin.

Review of The Literature

Surprisingly, in the literature on property values and hedonic modeling only a handful of articles explore the relationship between crime and property value. A large number of articles in which hedonic models are estimated do not consider crime (Bailey 1966, Brigham 1965, Cropper et al 1988, Edmonds 1985, Goodman 1977, Witte et al 1979). These studies instead include other variables, like racial composition or quality of schools, which attempt to measure neighborhood quality. Knapp (1998) provides an excellent review of the literature that examines the determinants of property value. In addition, most of the studies that do explore the effects of crime were conducted thirty to forty years ago and are now dated. Several more recent studies focusing on other topics have included crime as an explanatory variable in a hedonic property model in a somewhat haphazard manner. Only Hellman and Naroff (1979), Rizzo (1979) and Thaler (1978) focus their attention on the capitalization of crime into local property values. Only two studies include the effects of violent crimes (Dubin and Sung 1990; Diamond 1980) and one looks at property crimes (Thaler 1978). Most of the available literature simply uses an aggregate measure that includes all crime. None of the studies identified explores the separate effects of different types of crime.

The literature on the effects of wages on crime is even sparser than the literature on property values. Most hedonic wage studies include only characteristics of people and jobs as explanatory variables and do not attempt to control for neighborhood or regional characteristics. Only a handful of studies include crime as an explanatory variable in a hedonic wage model. Roback (1982) reports a positive relationship between wages and crime, suggesting that people need to be compensated for working in a high crime area with higher wages. Deller et al. (2001) finds a negative, though not highly significant, relationship between income growth and crime. Many studies use hedonic wage models to estimate the value placed on the risk of injury in various jobs (e.g., Herzog and Schlottman 1990), and several studies have examined the relationship between environmental amenities and wages (Roback 1982; Rosen 1979; Henderson 1982; Smith and Gilbert 1985; Bloomquist, et al 1988). These studies have shown that, with other factors held constant, wages tend to be lower in areas that are rich in environmental amenities. Since a low crime rate can be considered to be an amenity (or conversely, high crime rates serve as a “disamenity”), it is reasonable to expect that, on average, low crime areas will have lower wage rates, other factors held constant.

Theoretical and Empirical Model

The implicit prices of crime presented below are calculated using methods developed by Roback (1982). Roback expands the work of Rosen (1979) by developing a valuation technique using the hedonic modeling approach to examine the value of amenities through their effects on land and labor markets. In short, the Roback expanded model integrates property and wage hedonic models to fully capture the capitalization (i.e., price) effects of amenities, including disamenities such as crime. The result is a simple general equilibrium model to compute the implicit price of an amenity.

The basic premise of the Roback model can be described in wage-land value space as depicted in Figure 1. The figure shows a set of indifference curves for consumers and isocost curves for firms. The consumer's curve is the set of all the combinations of wages and land values that will keep the consumer at a constant level of utility, for a given level of crime (CR). In this case CR can be any category of crime. Likewise, the firm's isocost curve is the set of all combinations of wages and land values at which a firm can produce at a constant cost, given CR. There will be an equilibrium at the point where the consumer's indifference curve intersects the firm's isocost curve. In Figure 1, the system starts at an equilibrium point A where the crime rate is CR. If crime then *decreases* to CR' the equilibrium point moves to B. Here both wages and land values increase, but this may not always be the case. The position of B relative to A depends on the shapes of the curves. Since crime harms both consumers and firms, the value of land should always increase with a decrease in crime. This occurs because both consumers and firms are willing to pay higher land prices to avoid crime. The change in wage depends on the shape of the curves. Consumers will accept lower wages to avoid crime, but firms will pay higher wages to avoid crime. The net change in wages depends on which effect is stronger, and the effect may vary across different types of crimes.

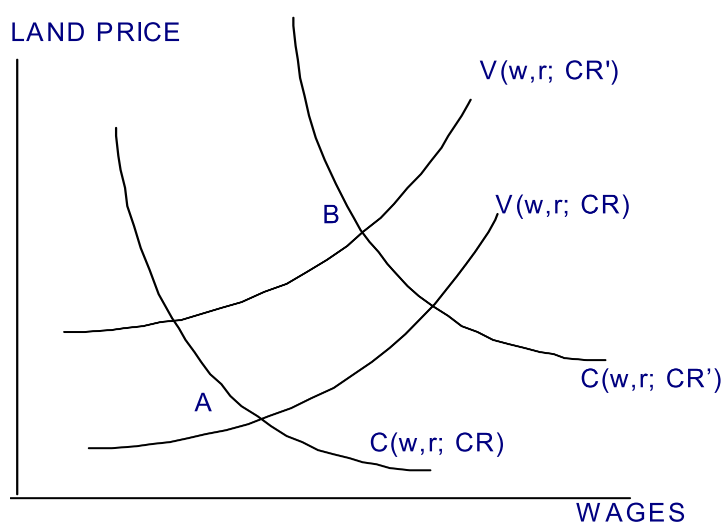

Figure 1: Effects of crime on prices.

More formally, Roback develops a simple general equilibrium model to compute the implicit price of an amenity, *s* (which can be measured continuously). The model is a static, or short-run model. All quantities are assumed to be constant, and cannot be altered by the actions of consumers or firms. For simplicity, capital and labor are assumed to be completely mobile between cities (i.e. there are no relocation costs for firms or workers). Commuting to work within a region (e.g., city) is assumed to be costless, but commuting to work in another region is assumed to be prohibitively expensive. The quantity of land is, of course, fixed within regions. However, land is assumed to be perfectly mobile between uses within a city. Given these assumptions and an equilibrium distribution of labor and capital across cities, it is possible to characterize wages and rents as a function of *s*. The key to the analysis is to empirically isolate the affects of the amenity, in this case crime, on property values and wages, then recombine those effects into a single scalar price. Given observed levels of each explanatory variable, in particular the amenity variables, and the estimated prices, a relative ranking of quality of life can be computed for each observation (i.e., county). A formal derivation of this approach is provided in a technical appendix.

Data

The unit of analysis for this study is U.S. counties, and the variables used are county-wide percentages and averages. The study includes 2,990 counties (847 urban and 2,143 rural) for which data was available. Data from four sources were used in the model. Earnings, rental values, crime, unemployment, housing statistics, and other demographic variables come from the 1994 City and County Data Book (CCDB). Population, geography, and climate come from the U.S. Forest Service's 1997 National Outdoor Recreation Supply Information System (NORSIS)[3] data set. Some housing statistics were collected from the 1990 Census of Housing and Population. And crime statistics are those reported by the Federal Bureau of Investigation's 1990 Uniform Crime Reporting and Program Data (FBI). Table 1 provides a list of these variables, their sources, mean values, and standard deviations. Finally, since data on the budget share of land for the average household are not readily available, the estimate (3.5%) used by Roback will be used in computing implicit prices below. The value used for k_l is 19.17%, which is the average budget share of a mortgage in the U.S. in 1993.[4]

Model Specification

Three separate specifications of the wage and property value equations are estimated using different aggregation measures of crime across each type. Hence a total of six equations are estimated and discussed. The variables used in specifying each equation are outlined in Table 1. For both the wage and property value equation, a set of variables to capture disequilibrium effects including the unemployment rate, income growth rates between 1980 and 1990 and income growth rates squared as well as wealth accumulation measures including

[3] Developed by the USFS Wilderness Assessment Unit, Southern Research Station in Athens Georgia.

[4]. Average 1993 annual household mortgage payment in US is $5,988 (1993 American Housing Survey) with median household income of $31,241. The ratio of 19.17 percent is straightforward.

number of banks and other financial institutions per 1,000 persons. In addition, two sets of dummy variables are used in each set of equations. Specifically an urban and rural dummy (rural = 1) identifier is used to separate the effects of city and rural lifestyles and a set of regional dummies to capture geographical differences across the country (New England as reference base). A range of interaction terms between the rural dummy and our crime measures are used to separate the effects of urban and rural lifestyles.

For the property value equation several controls are included ranging from the median age of homes, the percentage of homes that are large, the percentage of homes that are mobile homes, the percentage of multifamily homes and the average number of persons per room. These measures have become widely accepted in the hedonic literature. For the wage equation control variables include the poverty rate, percent of the population over 25 years of age with a minimum of a bachelor's degree, the percent of the population over 65 years of age, and the percent of the jobs within the county in agriculture, manufacturing, wholesale and retail trade, health services and government. These variables are intended to capture both supply (poverty, education, age) and demand (economic base) considerations in the labor market. Again, the specification of the wage equation is consistent with the available literature.

Results

Three sets of models, as described above, are estimated for this analysis. Each set includes a hedonic property model, with the log of median home value as the dependent variable, and a hedonic wage model, with the log of weekly per capita earnings as the dependent variable. The first set of models includes a single measure of crime, the total of all eight FBI index crimes. The second set of models splits crime into two categories: violent crimes and property crimes. The final set of models separates crime into eight separate categories, one for each type of crime: murders, rapes, robberies, aggravated assaults, burglaries, larcenies, motor vehicle thefts, and arsons. The results for the property and wage models are presented below in Tables 2 and 3, respectively.

Property Value

The model specifications for the property models perform well. In each case the adjusted R-squared value is greater than 0.80, which is quite high for a cross sectional analysis. The individual regression coefficients for the non-crime variables have the expected signs and are highly significant (at the 95% level or above) in nearly every case. Perhaps the only unexpected sign is the significant and positive coefficient for unemployment. This may be attributable to the demand for housing of people who move into an area to seek work. It could also be capturing the effect of some omitted variable. Variance in the quality and types of housing is controlled for using the median age of homes (negative), the percentage of homes that are large (positive), the percentage of homes that are mobile homes (negative), the percentage of multifamily homes (positive), and the average number of persons per room (positive).

The interaction terms capture the differences in the effects of crime between urban and rural counties. For many of these variables the coefficients are not highly significant. But their inclusion significantly improves the explanatory power of the model.[5] Aggregate crimes (from Model 1), property crimes (from Model 2), murders, rapes, robberies, burglaries, and larcenies all have positive coefficients for the interaction terms. This indicates that property values in rural areas are affected less negatively by these types of crimes than property values in urban areas. The other categories all have negative coefficients and thus have a greater negative effect on rural property values. Note that in some cases the magnitude of the interaction coefficient is large enough to change the sign of the marginal effect of the particular type of crime for rural areas.

The coefficients for the crime variables display some interesting results. They highlight the need to use caution when choosing explanatory variables to use in model specification and the potential problems that can result from simply including whichever measure of crime happens to be readily available. In the first model, the composite crime variable has a coefficient that is negative and significant, indicating an inverse relationship between property values and crime. This follows conventional wisdom and matches the results of most previous research efforts. The results for Model 2 and Model 3, however, are somewhat surprising. In Model 2 the coefficient for property crime is negative and significant, as expected. Its magnitude is nearly twice that of the crime variable in the first model. The coefficient for violent crime is significant and positive, which defies the conventional logic. It is possible that this represents a collinearity effect between the two crime variables. When the model is run using only the violent crime variable, its coefficient is insignificant. When only the property crime variable is used, its coefficient remains negative and significant. The positive sign on violent crime may also be a result of how the variable is defined. In Model 3, violent crime and property crime are split into their four component crime categories.[6] The coefficients in this model offer some surprises. The coefficients for rapes, burglaries, and larcenies are negative, while the coefficients for aggravated assault and motor vehicle theft are positive and statistically significant. The measures for murders, robberies, and arsons all have insignificant coefficients.

Several factors could be affecting the results in the second and third models. First, there is undoubtedly correlation among the eight crime categories. Second, there may be a dual relationship between some types of crime and property values. High levels of crime make an

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[5] A restricted least squares model was estimated setting all interaction term coefficients equal to 0. The coefficient for i66 is significant at the 95% level, as shown by its t-value. The resulting F-values were 63.41 for Model 2 and 21.07 for Model 3. All three are significant at the 95% level.

[6] To test the overall significance of the 8 crime variables a restricted least squares version of Model 3 was estimated setting the eight crime coefficients to 0. The resulting F-value is 21.51, which is significant at the 95% level.

area less desirable to live in, but wealthier areas will provide better targets for certain types of crimes. The stronger effect will determine the coefficient's sign. Third, there may be issues in how crimes are reported and how they are perceived. Crimes in wealthier neighborhoods may be more likely to be reported, especially for property crimes, which require a police report in order for the victim to file an insurance claim. In addition, the perception of risk may differ by the type of crime. Crimes that do not often occur in or near the home, like robberies, may not have a great affect on property values because they are somewhat independent of the neighborhood or area that the home is located in. For other crimes, like murders, the victims often know the perpetrators, so the crimes are more or less independent of location. Thus, they may not significantly affect property values. For example, when the murder rate is included as the only crime variable in the model its coefficient remains insignificant at the 95% level. A similar result is found for robberies and arsons. Finally, this model looks at crime at the county level using aggregate and average measures. While this provides insights on crime in the nation as a whole, variation within counties, which can be significant, is not accounted for in the model.

Wages

The three wage models also perform well. In each case the adjusted R-square value is at least 0.42, not as large as those for the property models but still quite high for a cross-sectional analysis. The education (positive coefficient) and age (negative) variables control for the characteristics of the work force. The industry employment variables (negative) control for differences in industry concentrations within the county. The coefficient for the rural dummy is positive but not significant at the 95% level.

The interaction terms capture the differences in the effects of crime between urban and rural counties. As in the property models, many of the coefficients are not highly significant, but they have been included because they significantly improve the explanatory power of the model.[7] Aggregate crimes (from Model 1), property crimes (from Model 2), rapes, aggravated assaults, larcenies, and arsons all have negative coefficients on the interaction terms. This indicates that wages in rural areas are affected more negatively by these types of crimes than wages in urban areas. The other categories all have positive coefficients and thus have a lesser negative effect on rural property values. Note that in some cases the magnitude of the interaction coefficient is large enough to change the sign of the marginal effect of the particular type of crime for rural areas.

[7] In Model 1, the coefficient for i66 is significant at the 95% level, as shown by it's t-value. For the other models a restricted least squares model was estimated, setting all interaction term coefficients equal to 0. The resulting F-values were 13.38 for Model2, 4.46 for Model 3. Both are significant at the 95% level.

The coefficients on the crime variables provide fewer surprises than those in the property models.[8] In the first model the coefficient on aggregate crime is positive and significant, suggesting that wages must be higher to compensate people for living in high crime areas. Similarly, the coefficients for the violent crime and property crime variables in the second model are positive and their values are roughly equal to the coefficient on crime in the first model. In the third model, many of the crime coefficients (murders, aggravated assaults, robberies, and arsons) are positive but insignificant. The coefficients for rapes, larcenies, and motor vehicle thefts are positive and statistically significant, as expected. Burglaries, on the other hand, have a significantly negative coefficient. This is most likely because wealthier areas provide more attractive targets for burglars.

Estimated Prices

Implicit prices of the various categories of crime for the average U.S. county, rural and urban, are reported in Table 4. Prices are calculated using the methods detailed above and the results of the hedonic (property and wage) models. With a few notable exceptions, the prices make intuitive sense. Nearly all the prices are found to be negative, which indicates that most crimes can be considered to be disamenities. Overall, the price of aggregate crime is -$162.92 for urban areas, but only -$67.25 for rural, likely a reflection of the higher rates of crime in urban areas. Both prices are significant at the 95% level. The negative price is indicative of crime being a disamenity. Clearly, murder has the highest impact at -$4,420.62 for urban areas and -$3,151.09 for rural. Yet, its price is not significant in either urban or rural counties. Perhaps this result is because most murderers know the victim and, thus, the likelihood of being a murdered is not highly correlated with living or work location.

The rape variable shows a distinct and interesting difference between urban areas, where it's price (-$3,510.96) is negative and significant at the 95% level, and rural areas where the price is highly insignificant. This likely has to do with the patterns of the crime in urban areas (where the perpetrator is more likely to be a stranger) compared to rural areas. On the other hand, the pattern is reversed for robberies which have a negative and significant price in rural areas but an insignificant in urban areas, and motor vehicle. Burglaries in both urban and rural counties have positive and significant implicit prices. This most likely occurs because wealthier areas provide more attractive targets for theft. Arsons also have a positive price in both rural and urban areas, but neither is significant. The prices for larcenies and motor vehicle thefts are negative in both urban and rural areas. Their prices are significant at the 95% level, except for urban vehicle thefts, which is positive at the 85% level.

[8] A restricted least squares version of Model 3 was run setting the eight crime coefficients to 0. The resulting F-value is 30.02, which is significant at the 95% level.

The magnitudes of the prices are also interesting. For some categories of crime the implicit price is higher in urban counties than in rural counties. There is not a clear pattern for this relationship. But, in both urban and rural counties, a clear pattern in the prices of different types of crimes is evident. The prices of violent crimes tend to be more negative than the prices of property crimes. And more serious crimes within a category (murders, rapes, and motor vehicle thefts) have prices that are more negative than less serious crimes (aggravated assaults and larcenies).

Wisconsin County Rankings

Given the estimated wage and property value equations and the corresponded estimated prices for different types of crime, it is possible to compute quality of life indices for each individual observations (county) contained in the database. The results of these computations for the subset of Wisconsin counties contained in the database are reported in Tables 5 and 6. It is important to note that the model has been constructed to reflect differences in rural and urban attitudes toward crime and the crime dependent quality of life measures and corresponding rankings are specific to metro and nonmetro counties.

For Wisconsin metro counties Ozaukee reported lowest overall crime rates with only a $78 premium being paid for violent crimes but $3,153 for property crimes (Table 5). The total price for the disamenity of crime in Ozaukee county is $3,230 which ranks Ozaukee as the best metro county for crime driven quality of life in Wisconsin and 113th in the nation, out of 847 metro counties in the national database. Other high ranking metropolitan counties in Wisconsin include St. Croix, Pierce, Waukesha and Calumet. It is relevant to note that many of these high ranking, at least within Wisconsin, counties could be considered “suburban” counties adjacent to more traditional urban centers.

Metropolitan counties that ranked lower, include Milwaukee, La Crosse, Douglas, Rock and Dane. For Milwaukee County, the premium paid for violent crimes is $3,694 and $11,776 for property crime for a total price of crime of -$15,470 per household. Of the 847 metro counties in the national database, Milwaukee County ranked near the bottom in the 754th position. The metro areas with the highest crime disamenity affect include Atlanta, St. Louis, New Orleans, Atlantic City, Miami, Dallas and Washington DC. The type of crime that appears to have the biggest impact on “poor” performing Wisconsin metro counties is larceny.

For rural Wisconsin rural counties, Burnett in particular report very low prices of crime and ranks 10th in the nation out of 2,143 nonmetro counties (Table 6). Although Burnett has a higher than average incident of burglary, likely due to the high number of seasonal recreational homes, the lower than average rates of other crimes drives the overall crime driven quality of life ranking high. Care must be taken, however, because of the positive price associated with burglaries (recall the results suggest that high quality of life areas tend to attract certain types of crime, in particular burglary) the result for Burnett and a handful of other rural Wisconsin counties may suggest that crime is a non-issue for these areas. This is clearly not that case. Other counties with relatively high crime related quality of life rankings include Adams, Wuashara, Marquette and Rusk.

Rural Wisconsin counties that have lower crime related quality of life rankings include Sauk, Manitowoc, Shawano, Fond du Lac, Dunn and Iron. For Iron County, the lowest ranked Wisconsin rural county, the price of violent crime is only -$416 and -$3,672 for property crimes. The total price of crime is slightly more than -$4,000 per household. This is only slightly higher than the best ranked urban county (Ozaukee at -$3,230) and much lower than most other urban counties in Wisconsin. For Iron County, larceny, motor vehicle theft and assault appear to be driving the lower crime related quality of life rankings.

Conclusions

The results of this analysis have shown that crime rates have a significant impact on property values and wages, and that by examining these relationships it is possible to make inferences about the relative impacts of crime on the quality of life. The results also demonstrate that there are similarities and differences between the effects of crime in rural areas and crime in urban areas. In addition, the results from the hedonic analyses show that the effects of crime on property values and wages may not be as straightforward as they might seem. There are complicated relationships at work; as a result, modeling efforts should carefully consider the types of crime categories included in the analysis.

As one would expect violent crimes, such as murder and rape, have a much higher price attached to them. But non-violent crimes, such as motor vehicle theft and larceny, can have a much broader impact because of the higher rate of frequency for these types of crime. Result for Wisconsin, and the nation as a whole, suggest that the cost of crime, as measured through the implicit prices estimated and reported here, is significantly lower in rural than urban counties. This is due not only to differences in the rates of crime, but also in the values attached to crime by rural and urban residents.

The results provide here should help local policy decision makers craft more informed decisions on how to allocate scarce resources in improving overall quality of life. For some areas, such as Milwaukee County small reduction in crime can have a significant impact on quality of life. In other areas, such as Burnett County, a similar change in crime rates may have much smaller affects on quality of life. Clearly crime is but one factor that affects overall quality of life, but for many places, it is one factor that can be influenced by local policies.

TABLE 1 Variables Used in Hedonic Property and Wage Models						
Variable	**Definition (units)**	**Source**	**Rural**		**Urban**	
			Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
DEPENDENT VARIABLES						
MORTPYMT	1990 annual mortgage payment for median-valued home, assuming 10% down payment and 10.04% interest rate (1990 dollars per year)	CCDB	4,202.22	1,938.02	7,524.30	4,272.66
LOG_MORT	log (MORTPYMT)	CCDB	8.28	0.35	8.82	0.42
EARN	1990 annual per capita earnings (1990 dollars)	CCDB	23,872.47	11,864.35	30,238.44	14,478.16
LOG_EARN	log (EARN)	CCDB	10.01	0.37	10.22	0.43
VARIABLES TO CAPTURE DISEQUILIBRIUM & WEALTH EFFECTS						
UNEMPLOY	1991 Civilian unemployment rate (%)	CCDB	7.38	3.52	6.60	2.21
INC_GROW	Change in Median Household Income 1980-90 (%)	CCDB	64.46	18.29	75.22	20.70
INC_GSQR	INC_GROW squared (% squared)	CCDB	4,490.01	2,510.14	6,086.53	3,204.29
BANK	1990 Number of banks and savings institutions (number per 1,000 population)	CCDB	0.51	0.28	0.33	0.11
HOUSING MARKET CHARACTERISTICS						
HM_AGE	1990 Median age of homes (years)	1990 Census	27.04	9.73	23.32	8.73
LRG_HM	1990 Homes with 3+ bedrooms (%)	1990 Census	57.09	7.12	58.39	8.79
MOBLHM	1990 Homes classified as mobile home or trailer (%)	CCDB	15.76	8.05	9.93	7.95
MULTIFAM	1990 Homes in buildings with 5+ units (%)	CCDB	4.00	3.79	11.62	8.98
PPRM	1990 Average persons per room in household (number of persons)	NORSIS/ 1990 Census	0.41	0.07	0.45	0.05
LABOR MARKET CHARACTERISTICS						
EDUBACH	1990 population over 25 with bachelor's degree or higher (%)	CCDB	11.74	4.84	18.01	7.94
OLD	1990 population age 65+ (%)	CCDB	15.98	4.12	12.08	3.53
E_AG	1990 Civilian labor force employed in agriculture, forestry, and fisheries (%)	CCDB	10.84	9.38	2.94	2.51
E_MAN	1990 Civilian labor force employed in manufacturing (%)	CCDB	18.42	11.34	18.96	8.03
E_TRADE	1990 Civilian labor force employed in wholesale and retail trade (%)	CCDB	18.94	3.56	21.40	2.55
E_HEALTH	1990 Civilian labor force employed in health services (%)	CCDB	7.44	2.66	8.22	2.13
E_GOV	1990 Civilian labor force employed in public administration (%)	CCDB	4.75	2.86	4.95	3.16
CRIME VARIABLES						
CRIME	FBI Index Crimes reported (number per 1,000 population)	FBI	27.06	18.41	47.59	24.63
VCRIME	FBI Index Crimes reported - violent (number per 1,000 population)	FBI	2.47	2.55	4.94	4.55
PCRIME	FBI Index Crimes reported - property (number per 1,000 population)	FBI	24.59	16.92	42.65	21.10
C_MURDER	Murders reported (number per 1,000 population)	FBI	0.05	0.09	0.06	0.08
C_RAPE	Rapes reported (number per 1,000 population)	FBI	0.19	0.25	0.34	0.25
C_ROB	Robberies reported (number per 1,000 population)	FBI	0.22	0.37	1.22	1.93
C_ASSLT	Aggravated assaults reported (number per 1,000 population)	FBI	2.01	2.23	3.32	2.88
C_BURG	Burglaries reported (number per 1,000 population)	FBI	7.00	5.02	10.60	5.76
C_LARCEN	Larcenies reported (number per 1,000 population)	FBI	16.12	12.69	28.16	13.77
C_MVT	Motor vehicle thefts reported (number per 1,000 population)	FBI	1.27	1.02	3.59	3.87
C_ARSON	Arsons reported (number per 1,000 population)	FBI	0.19	0.28	0.30	0.28

TABLE 1 (CONT.)

Variables Used in Hedonic Property and Wage Models

Variable	Definition (units)	Source	Rural		Urban	
			Mean	Std. Dev.	Mean	Std. Dev.
Crime Interaction Variables						
I66	RURAL*CRIME	Calculated	27.06	18.41		
I67	RURAL*VCRIME	Calculated	2.47	2.55		
I68	RURAL*PCRIME	Calculated	24.59	16.92		
I69	RURAL*C_MURDER	Calculated	0.05	0.09		
I70	RURAL*C_RAPE	Calculated	0.19	0.25		
I71	RURAL*C_ROB	Calculated	0.22	0.37		
I72	RURAL*C_ASSLT	Calculated	2.01	2.23		
I73	RURAL*C_BURG	Calculated	7.00	5.02		
I74	RURAL*C_LARCEN	Calculated	16.12	12.69		
I75	RURAL*C_MVT	Calculated	1.27	1.02		
I76	RURAL*C_ARSON	Calculated	0.19	0.28		

Dummy Variables

Variable	Definition (units)	Source	Percent = 1	
			Rural	Urban
RURAL	County designated as nonmetro using ERS codes (codes 4-7)*	NORSIS	100.00	0.00
R_ENC	County in Census Bureau East North Central Region**	1990 Census	87.30	81.63
R_ESC	County in Census Bureau East South Central Region**	1990 Census	12.70	18.37
R_MA	County in Census Middle Atlantic Region**	1990 Census	87.26	90.63
R_MTN	County in Census Bureau Mountain Region**	1990 Census	12.74	9.37
R_PAC	County in Census Bureau Pacific Region**	1990 Census	97.43	88.66
R_SA	County in Census Bureau South Atlantic Region**	1990 Census	2.57	11.34
R_WNC	County in Census Bureau West North Central Region**	1990 Census	89.12	95.81
R_WSC	County in Census Bureau West South Central Region**	1990 Census	10.88	4.19

* Defined using U.S. Department of Agriculture, Economic Research Service (ERS) 1993 Rural/Urban Continuum Code

** Base region is New England

TABLE 2
Results of Hedonic Property Models

	MODEL1		MODEL2		MODEL3	
Degrees of Freedom	2,870		2,870		2,870	
Adjusted R-squared	0.8124		0.8150		0.8220	
Variable	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**
INTERCEP	9.4323	132.9780	9.5012	132.1310	9.5902	133.5380
POP_INC	0.0035	11.0310	0.0037	11.4790	0.0038	12.0500
UNEMPLOY	-0.0091	-6.6490	-0.0096	-7.0760	-0.0091	-6.7090
INC_GROW	-0.0060	-6.6300	-0.0058	-6.4260	-0.0050	-5.6740
INC_GSQR	0.0001	10.5310	0.0001	10.1180	0.0001	9.2050
BANK	-0.0717	-3.6420	-0.0724	-3.7000	-0.0711	-3.6960
HM_AGE	-0.0145	-21.1810	-0.0151	-21.9350	-0.0152	-22.4000
LRG_HM	0.0058	9.0810	0.0060	9.4850	0.0055	8.6750
MOBLHM	-0.0083	-11.9490	-0.0087	-12.4790	-0.0085	-12.3000
MULTIFAM	0.0203	22.2380	0.0201	22.0410	0.0163	16.5350
PPRM	-0.3243	-4.8900	-0.3486	-5.2250	-0.4426	-6.5320
R_ENC	-0.4545	-16.1260	-0.4670	-16.6270	-0.4645	-16.6350
R_ESC	-0.6170	-20.8390	-0.6377	-21.4280	-0.6166	-20.8080
R_MA	-0.1723	-5.8620	-0.1872	-6.3830	-0.1913	-6.5190
R_MTN	-0.3849	-12.9610	-0.3966	-13.4010	-0.3982	-13.5740
R_PAC	-0.0968	-3.1040	-0.1057	-3.4070	-0.1005	-3.2790
R_SA	-0.4987	-17.9290	-0.5152	-18.4260	-0.4881	-17.3650
R_WNC	-0.6350	-22.2860	-0.6466	-22.7840	-0.6392	-22.7610
R_WSC	-0.6511	-22.1140	-0.6662	-22.6100	-0.6415	-21.8130
RURAL	-0.2336	-12.5710	-0.2641	-13.8490	-0.3027	-14.9590
I66	0.0036	9.3310	---	---	---	---
CRIME	-0.0019	-5.7490	---	---	---	---
I67	---	---	-0.0108	-3.6190	---	---
I68	---	---	0.0060	10.6350	---	---
VCRIME	---	---	0.0125	5.4580	---	---
PCRIME	---	---	-0.0044	-8.5980	---	---
I69	---	---	---	---	0.1904	1.4420
I70	---	---	---	---	0.1087	2.6900
I71	---	---	---	---	-0.0204	-1.1760
I72	---	---	---	---	-0.0057	-1.3610
I73	---	---	---	---	0.0108	4.2440
I74	---	---	---	---	0.0046	5.1800
I75	---	---	---	---	-0.0044	-0.6390
I76	---	---	---	---	-0.0246	-0.7710
C_MURDER	---	---	---	---	-0.2482	-1.9860
C_RAPE	---	---	---	---	-0.1249	-3.4440
C_ROB	---	---	---	---	0.0256	2.9500
C_ASSLT	---	---	---	---	0.0095	2.7510
C_BURG	---	---	---	---	-0.0157	-6.8480
C_LARCEN	---	---	---	---	-0.0010	-1.1570
C_MVT	---	---	---	---	0.0141	3.7700
C_ARSON	---	---	---	---	0.0138	0.4890

TABLE 3
Results of Hedonic Wage Models

	MODEL1		MODEL2		MODEL3	
Degrees of Freedom	2,870		2,870		2,870	
Adjusted R-squared	0.4285		0.4287		0.4464	
Variable	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**
INTERCEP	10.1538	96.5660	10.1574	96.5540	10.2081	97.5920
POP_INC	-0.0048	-10.2890	-0.0047	-10.1160	-0.0042	-8.8950
UNEMPLOY	-0.0219	-9.8000	-0.0221	-9.8810	-0.0206	-9.2850
INC_GROW	-0.0066	-4.3010	-0.0067	-4.3180	-0.0062	-4.0680
INC_GSQR	0.0000	4.5540	0.0000	4.5250	0.0000	4.2810
BANK	0.2183	7.0000	0.2207	7.0700	0.2188	7.0970
EDUBACH	0.0187	14.1310	0.0190	14.1720	0.0170	12.5080
OLD	-0.0290	-15.4460	-0.0290	-15.4520	-0.0255	-13.5010
E_AG	0.0100	7.7590	0.0100	7.7410	0.0096	7.4970
E_MAN	0.0043	4.2500	0.0043	4.2800	0.0035	3.4720
E_TRADE	0.0024	1.0770	0.0027	1.2050	0.0005	0.2060
E_HEALTH	0.0048	1.7560	0.0048	1.7280	0.0029	1.0600
E_GOV	-0.0035	-1.4740	-0.0036	-1.5450	-0.0039	-1.6690
R_ENC	-0.0300	-0.6740	-0.0330	-0.7400	-0.0362	-0.8150
R_ESC	-0.1438	-3.1680	-0.1531	-3.3460	-0.1549	-3.3950
R_MA	0.0545	1.1830	0.0496	1.0740	0.0540	1.1670
R_MTN	-0.0928	-1.9430	-0.0972	-2.0310	-0.1090	-2.2920
R_PAC	0.0462	0.9330	0.0423	0.8530	0.0270	0.5500
R_SA	-0.0866	-2.0200	-0.0961	-2.2230	-0.0930	-2.1430
R_WNC	-0.0949	-2.0870	-0.0978	-2.1500	-0.1042	-2.3070
R_WSC	-0.0913	-1.9840	-0.0987	-2.1350	-0.0810	-1.7590
RURAL	0.1160	3.9330	0.1137	3.7300	0.0932	2.8590
I66	-0.0033	-5.6930	--	--	--	--
CRIME	0.0065	14.3640	--	--	--	--
I2	--	--	0.0004	0.0940	--	--
I3	--	--	-0.0036	-4.0370	--	--
VCRIME	--	--	0.0081	2.2770	--	--
PCRIME	--	--	0.0061	7.8720	--	--
I4	--	--	--	--	-0.0167	-0.0800
I5	--	--	--	--	-0.1263	-1.9670
I6	--	--	--	--	0.0676	2.4970
I7	--	--	--	--	0.0048	0.7240
I8	--	--	--	--	-0.0041	-1.0070
I9	--	--	--	--	-0.0041	-2.8950
I10	--	--	--	--	0.0253	2.3120
I11	--	--	--	--	-0.0441	-0.8710
C_MURDER	--	--	--	--	0.1376	0.6960
C_RAPE	--	--	--	--	0.1231	2.1380
C_ROB	--	--	--	--	0.0140	1.0590
C_ASSLT	--	--	--	--	0.0019	0.3560
C_BURG	--	--	--	--	-0.0089	-2.4630
C_LARCEN	--	--	--	--	0.0095	7.3100
C_MVT	--	--	--	--	0.0123	2.0790
C_ARSON	--	--	--	--	0.0021	0.0480

Table 4

Implicit Prices of Crime by Category

Crime Category	Units	Implicit Price			
		Rural		Urban	
		Mean	T-stat*	Mean	T-stat*
Model1					
CRIME	Crimes/1,000 persons	-$67.25	-3.80	-$162.92	-15.00
Model2					
VCRIME	Violent Crimes/1,000 persons	-$196.09	-1.38	-$135.90	-1.59
PCRIME	Property Crimes/1,000 persons	-$54.07	-1.89	-$166.87	-8.88
Model3					
C_MURDER	Murders/1,000 persons	-$3,151.09	-0.46	-$4,420.62	-0.93
C_RAPE	Rapes/1,000 persons	$0.54	0.0003	-$3,510.96	-2.54
C_ROB	Robberies/1,000 persons	-$1,924.84	-2.65	-$218.18	-0.68
C_ASSLT	Aggravated Assaults/1,000 persons	-$142.18	-0.69	-$2.75	-0.02
C_BURG	Burglaries/1,000 persons	$288.56	2.20	$141.60	1.62
C_LARCEN	Larcenies/1,000 persons	-$113.19	-2.43	-$232.13	-7.40
C_MVT	Motor Vehicle Thefts/1,000 persons	-$852.07	-2.84	-$228.18	-1.61
C_ARSON	Arsons/1,000 persons	$951.66	0.58	$11.98	0.01

Prices calculated using the regression coefficients reported in Tables 3 and 4 and the following values:
Average Annual Earnings per Worker - rural: $23,872
Average Annual Earnings per Worker - urban: $30,238
Average Budget Share of Mortgage: 19.17%

*Discrete t-statistic calculated using a Monte Carlo simulation with 10,000 iterations.

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Table 5: Crime Indices, Prices and National Ranking for METRO WISCONSIN Counties	C_MURDER	C_RAPE	C_ROB	C_ASSLT	C_BURG	C_LARCEN	C_MVT	C_ARSON	Violent Crimes	Property Crimes	All Crimes	NATIONAL COUNTY RANK
Implicit Price	**-$4,420.62**	**-$3,510.96**	**-$218.18**	**-$2.75**	**$141.60**	**-$232.13**	**-$228.18**	**$11.98**	**---**	**---**	**---**	**All Crimes**
Average Crime Rate (Metro Counties)	**0.02**	**0.15**	**0.53**	**1.05**	**6.77**	**29.63**	**2.28**	**0.23**	**---**	**---**	**---**	
Ozaukee, WI	0.01	0.00	0.07	0.71	2.61	14.73	0.45	0.11	-$78	-$3,153	-$3,230	113
St Croix, WI	0.02	0.18	0.12	0.86	4.34	15.56	1.73	0.10	-$745	-$3,392	-$4,137	175
Pierce, WI	0.00	0.09	0.03	0.40	3.14	18.28	1.59	0.09	-$329	-$4,160	-$4,489	199
Waukesha, WI	0.00	0.09	0.19	0.85	4.67	19.30	1.47	0.16	-$344	-$4,153	-$4,497	200
Calumet, WI	0.06	0.12	0.06	0.47	4.75	18.75	0.82	0.06	-$681	-$3,865	-$4,547	207
Chippewa, WI	0.04	0.06	0.04	0.73	4.43	21.58	1.18	0.10	-$380	-$4,651	-$5,032	239
Washington, WI	0.01	0.08	0.07	0.67	4.38	24.67	0.98	0.19	-$359	-$5,327	-$5,686	291
Marathon, WI	0.00	0.12	0.09	0.96	5.25	25.54	1.34	0.16	-$447	-$5,489	-$5,936	304
Outagamie, WI	0.00	0.05	0.09	0.68	5.67	27.59	0.65	0.07	-$197	-$5,751	-$5,948	305
Eau Claire, WI	0.01	0.08	0.09	0.76	8.50	32.46	1.55	0.38	-$363	-$6,680	-$7,043	392
Sheboygan, WI	0.00	0.08	0.13	1.37	6.12	32.11	1.00	0.40	-$304	-$6,809	-$7,113	396
Winnebago, WI	0.01	0.03	0.10	0.78	7.09	34.49	1.25	0.14	-$156	-$7,287	-$7,443	420
Brown, WI	0.02	0.11	0.14	1.69	4.91	31.67	1.54	0.26	-$524	-$7,004	-$7,528	429
Kenosha, WI	0.04	0.35	0.86	0.84	10.22	33.65	2.69	0.44	-$1,595	-$6,972	-$8,567	504
Racine, WI	0.06	0.19	1.90	2.85	12.42	35.83	3.13	0.34	-$1,381	-$7,267	-$8,648	511
Dane, WI	0.01	0.22	0.82	1.94	8.98	38.27	2.72	0.32	-$1,010	-$8,230	-$9,240	547
Rock, WI	0.01	0.21	0.65	1.07	8.95	40.10	1.90	0.43	-$907	-$8,468	-$9,375	553
Douglas, WI	0.02	0.12	0.34	0.46	13.17	43.61	3.16	0.17	-$601	-$8,977	-$9,578	566
La Crosse, WI	0.00	0.21	0.12	1.00	3.86	41.05	1.47	0.10	-$783	-$9,317	-$10,099	600
Milwaukee, WI	0.16	0.56	4.59	1.98	12.01	43.35	14.98	0.51	-$3,694	-$11,776	-$15,470	754

Table 6: Crime Indices, Prices and National Ranking for NON-METRO WISCONSIN Counties	C_MURDER	C_RAPE	C_ROB	C_ASSLT	C_BURG	C_LARCEN	C_MVT	C_ARSON	Violent Crimes	Property Crimes	All Crimes	NATIONAL COUNTY RANK
Implicit Price	**-$3,151.09**	**$0.54**	**-$1,924.84**	**-$142.18**	**$288.56**	**-$113.19**	**-$852.07**	**$951.66**	---	---	---	
Average Crime Rate (Metro Counties)	**0.02**	**0.10**	**0.04**	**0.83**	**6.32**	**17.71**	**1.19**	**0.12**	---	---	---	
Burnett, WI	0.08	0.08	0.00	0.38	17.35	8.25	1.07	0.00	-$295	$3,160	$2,865	10
Adams, WI	0.00	0.26	0.19	0.57	17.92	18.88	1.91	0.00	-$450	$1,404	$954	95
Waushara, WI	0.00	0.05	0.00	0.36	11.45	17.44	0.77	0.15	-$51	$819	$768	113
Marquette, WI	0.09	0.18	0.09	2.82	10.74	13.01	0.64	0.27	-$863	$1,342	$480	171
Rusk, WI	0.00	0.27	0.00	2.25	8.42	12.60	0.66	0.13	-$320	$565	$245	234
Washburn, WI	0.00	0.00	0.00	1.52	9.73	13.43	1.38	0.00	-$217	$112	-$105	383
Trempealeau, WI	0.00	0.04	0.00	0.13	3.25	7.38	0.34	0.04	-$18	-$146	-$164	412
Polk, WI	0.03	0.14	0.00	0.12	6.93	8.22	1.73	0.32	-$107	-$100	-$207	433
Oconto, WI	0.03	0.03	0.07	0.13	3.71	9.33	0.23	0.00	-$250	-$184	-$435	570
Vernon, WI	0.00	0.27	0.08	0.23	1.99	8.04	0.16	0.16	-$183	-$320	-$504	613
Bayfield, WI	0.07	0.00	0.00	0.36	8.71	12.64	1.78	0.21	-$276	-$234	-$510	617
Buffalo, WI	0.00	0.00	0.00	0.15	2.43	8.83	0.52	0.15	-$21	-$598	-$619	682
Kewaunee, WI	0.05	0.16	0.00	0.05	3.39	8.16	0.85	0.16	-$174	-$516	-$690	719
Clark, WI	0.00	0.16	0.00	0.09	3.57	10.90	0.73	0.13	-$13	-$703	-$716	733
Marinette, WI	0.02	0.07	0.00	0.42	10.16	22.05	1.28	0.07	-$137	-$586	-$723	735
Green, WI	0.00	0.00	0.00	0.66	6.92	18.52	0.99	0.30	-$94	-$660	-$753	753
Sawyer, WI	0.00	0.14	0.07	1.13	10.79	17.77	1.90	0.00	-$296	-$520	-$816	787
Iowa, WI	0.00	0.15	0.00	0.00	2.73	10.72	0.55	0.05	$0	-$844	-$844	809
Forest, WI	0.00	0.11	0.00	1.71	12.76	20.17	2.51	0.00	-$243	-$736	-$979	894
Juneau, WI	0.14	0.00	0.09	0.69	9.33	19.26	1.11	0.14	-$713	-$300	-$1,013	918
Taylor, WI	0.00	0.26	0.05	0.63	5.71	14.76	1.01	0.05	-$192	-$828	-$1,020	923
Lafayette, WI	0.00	0.06	0.12	0.25	1.93	7.59	0.56	0.00	-$275	-$780	-$1,054	945
Vilas, WI	0.11	0.28	0.11	1.30	12.48	21.52	2.37	0.51	-$758	-$371	-$1,129	986

	C_MURDER	C_RAPE	C_ROB	C_ASSLT	C_BURG	C_LARCEN	C_MVT	C_ARSON	Violent Crimes	Property Crimes	All Crimes	NATIONAL COUNTY RANK
Table 6 (cont): Crime Indices, Prices and National Ranking for NON-METRO WISCONSIN Counties												
Implicit Price	**-$3,151.09**	**$0.54**	**-$1,924.84**	**-$142.18**	**$288.56**	**-$113.19**	**-$852.07**	**$951.66**	---	---	---	
Average Crime Rate (Metro Counties)	**0.02**	**0.10**	**0.04**	**0.83**	**6.32**	**17.71**	**1.19**	**0.12**	---	---	---	
Barron, WI	0.00	0.15	0.17	2.06	6.31	13.91	1.35	0.22	-$624	-$695	-$1,319	1,093
Green Lake, WI	0.00	0.05	0.00	0.70	3.38	14.37	0.75	0.00	-$99	-$1,291	-$1,390	1,121
Price, WI	0.06	0.13	0.00	0.71	4.55	19.74	0.77	0.45	-$302	-$1,150	-$1,452	1,147
Lincoln, WI	0.00	0.00	0.04	0.07	5.22	19.19	1.04	0.11	-$82	-$1,443	-$1,525	1,178
Pepin, WI	0.00	0.14	0.00	0.70	2.11	10.98	0.98	0.00	-$100	-$1,472	-$1,572	1,202
Richland, WI	0.00	0.17	0.00	2.45	3.08	15.87	0.51	0.11	-$349	-$1,236	-$1,584	1,209
Grant, WI	0.02	0.02	0.04	0.65	3.43	15.43	0.89	0.12	-$234	-$1,401	-$1,636	1,235
Florence, WI	0.00	0.00	0.22	0.44	5.66	15.25	1.31	0.00	-$481	-$1,205	-$1,687	1,262
Waupaca, WI	0.02	0.09	0.04	1.32	5.66	20.43	0.98	0.02	-$340	-$1,490	-$1,830	1,317
Jackson, WI	0.06	0.06	0.00	0.66	7.84	23.51	1.63	0.24	-$284	-$1,557	-$1,841	1,321
Door, WI	0.08	0.12	0.00	0.08	4.94	19.58	1.09	0.12	-$256	-$1,607	-$1,864	1,331
Oneida, WI	0.03	0.03	0.03	1.26	10.20	24.72	2.08	0.09	-$340	-$1,541	-$1,880	1,337
Crawford, WI	0.00	0.19	0.00	0.19	4.33	23.15	0.82	0.19	-$27	-$1,887	-$1,914	1,351
Langlade, WI	0.00	0.10	0.05	1.18	6.51	24.71	1.08	0.05	-$266	-$1,787	-$2,053	1,400
Monroe, WI	0.11	0.30	0.03	0.82	3.36	16.92	1.04	0.25	-$513	-$1,597	-$2,110	1,426
Dodge, WI	0.03	0.04	0.04	0.37	4.00	18.91	1.16	0.05	-$210	-$1,928	-$2,138	1,437
Columbia, WI	0.00	0.02	0.04	0.86	5.72	21.29	1.66	0.11	-$208	-$2,071	-$2,279	1,482
Portage, WI	0.02	0.23	0.02	1.35	6.60	28.69	0.98	0.18	-$275	-$2,007	-$2,282	1,484
Walworth, WI	0.00	0.05	0.12	0.77	5.09	24.39	1.28	0.44	-$341	-$1,963	-$2,303	1,494
Wood, WI	0.00	0.07	0.07	1.89	5.33	23.14	1.32	0.14	-$399	-$2,076	-$2,475	1,550
Jefferson, WI	0.00	0.06	0.10	0.47	4.09	24.19	1.12	0.24	-$266	-$2,290	-$2,556	1,585

Table 6 (cont): Crime Indices, Prices and National Ranking for NON-METRO WISCONSIN Counties	C_MURDER	C_RAPE	C_ROB	C_ASSLT	C_BURG	C_LARCEN	C_MVT	C_ARSON	Violent Crimes	Property Crimes	All Crimes	NATIONAL COUNTY RANK
Implicit Price	**-$3,151.09**	**$0.54**	**-$1,924.84**	**-$142.18**	**$288.56**	**-$113.19**	**-$852.07**	**$951.66**	**---**	**---**	**---**	
Average Crime Rate (Metro Counties)	**0.02**	**0.10**	**0.04**	**0.83**	**6.32**	**17.71**	**1.19**	**0.12**	**---**	**---**	**---**	
Ashland, WI	0.06	0.00	0.00	0.31	5.27	22.93	1.59	0.00	-$237	-$2,433	-$2,670	1,626
Sauk, WI	0.00	0.04	0.09	0.45	3.17	25.20	0.72	0.02	-$227	-$2,534	-$2,762	1,655
Manitowoc, WI	0.01	0.09	0.07	0.57	4.07	25.33	1.16	0.14	-$264	-$2,549	-$2,813	1,670
Shawano, WI	0.03	0.16	0.00	0.46	5.19	25.06	1.64	0.00	-$150	-$2,736	-$2,886	1,684
Fond du Lac, WI	0.03	0.07	0.09	1.83	4.57	29.20	1.15	0.10	-$536	-$2,873	-$3,410	1,799
Dunn, WI	0.00	0.06	0.03	0.84	3.54	26.32	1.92	0.14	-$172	-$3,463	-$3,635	1,845
Iron, WI	0.00	0.00	0.00	2.93	6.66	21.29	3.74	0.00	-$416	-$3,672	-$4,088	1,915

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Technical Appendix

Following Roback define:

$s =$ quantity of amenity s
$x =$ amount of other goods consumed
$w =$ wage rate
$L =$ rental price of land
$I =$ nonlabor income
$u =$ utility at equilibrium
$l^c =$ land used by consumers
$l^p =$ land used in production
$N =$ total number of workers
$k_l =$ share of land in consumer's budget
$p_s^* =$ implicit price of amenity *s*

Individuals:

The consumer's problem is the standard one, maximize utility, subject to an income constraint.

$$V = \max U(x, l^c; s) \quad \text{subject to} \quad w + I = x + Ll^c \qquad (1)$$

For simplicity, all workers are assumed to be homogenous and leisure is ignored (all workers supply exactly one unit of labor). The solution to (1) is the indirect utility function. Following the standard properties of utility, $V_w > 0$ and $V_r < 0$. For an amenity, $V_s > 0$, and for a disamenity, $V_s < 0$. The equilibrium condition for workers is:

$$V(w, L; s) = u \qquad (2)$$

Thus, to reach equilibrium, wages and rents adjust so that utility is equalized across all cities. If not, an incentive to relocate would exist.

Firms:

Assume that firms produce a single good, X, using a constant-returns-to-scale production function, $X = f(l^p, N; s)$. At equilibrium, unit cost must equal the product price (which is normalized to unity in this case):

$$C(w, L; s) = 1 \qquad (3)$$

So, in equilibrium, unit costs are equal. Otherwise, firms would seek to relocate to cities where costs are lower. The cost function is assumed to have the standard properties, $C_w > 0$ and $C_r > 0$. In addition, with constant returns to scale, $C_w = N/X$ and $C_L = l^p/X$. Also note that for a productive amenity, $C_s > 0$ and for an unproductive amenity, $C_s < 0$.

Equilibrium:

We can use the Implicit Function Theorem and equations (2) and (3) to find $w = w(L, s; u)$ and $L = L(w, s; u)$. Differentiating (2) and (3) with respect to s and solving for dw/ds and dL/ds yields:

$$dw/ds = \frac{1}{\Delta}(-V_s C_r + C_s V_r) < 0 \qquad (4a)$$

$$dL/ds = \frac{1}{\Delta}(-V_w C_s + V_s C_w) \gtrless 0 \qquad (4b)$$

where $\Delta = V_w C_L - V_L C_w = L_i V_w / X > 0$, and L_i is the total land available. Assuming that s is a productive amenity (i.e. $V_s > 0; C_s > 0$), and using the properties of the cost function and the indirect utility function, we see that $dw/ds < 0$ and that the sign of dL/ds depends on the relative size of $V_w C_s$ and $V_s C_w$.

Implicit Prices:

Using the results above, the implicit price of an amenity can be found using Roy's Idendity, as follows:

$$p_s^* = \frac{V_s}{V_w} = l^c \frac{\partial L}{\partial s} - \frac{\partial w}{\partial s}, \qquad (5a)$$

or

$$\frac{p_s^*}{w} = k_l \frac{\partial \log L}{\partial s} - \frac{\partial \log w}{\partial s} \qquad (5b)$$

A simple rearrangement of equation (5b) yields the final formula for implicit price:

$$p_s^* = \left[k_l \frac{\partial \log L}{\partial s} - \frac{\partial \log w}{\partial s} \right] w \qquad (6)$$

where p_s^* is the implicit price of crime (*CR*), k_l is the share of land in consumer's budget, w is the wage rate, and L is the price of land. In equation (6), all of the terms are observable, either directly or using regression techniques.

The values of $\frac{\partial \log L}{\partial CR}$ and $\frac{\partial \log w}{\partial CR}$ can be estimated using a hedonic property model and a hedonic wage model, respectively. The price formula calls for a semi-log functional form in each case. The hedonic property model takes the following form:

$$\log(L_i) = \alpha + \beta_1 X_i + \beta_2 R_i + \beta_3 CR_i + \beta_4 CR_i * R_i + e \qquad (7)$$

where L_i is the median value of owner occupied homes in region i, X_i is a vector of characteristics of homes within region i and of region i itself, R_i is a dummy variable equal to one if region i is rural and C_i is a vector of crime rates for various categories of crime. Note that for this specification:

$$\frac{\partial \log L_i}{\partial CR_i} = \beta_3 + \beta_4 R_i \qquad (8)$$

Similarly, the hedonic wage model takes the following form:

$$\log(w_i) = \alpha + \beta_1 X_i + \beta_2 R_i + \beta_3 C_i + \beta_4 CR_i * R_i + e \qquad (9)$$

where w_i is the average weekly per capita earnings in region i and $L_{i,}$ $X_{i,}$ $R_{i,}$ and C_i are defined as in the property model. Again note that:

$$\frac{\partial \log w_i}{\partial CR_i} = \beta_3 + \beta_4 R_i \qquad (10)$$

Substituting equations (8) and (10) into the price equation (6), gives the final formula for calculating the implicit price of crime.

$$\hat{p}^*_{CR} = \left\{ \overline{k}_l \cdot \left(\hat{\beta}_3 + \hat{\beta}_4 \cdot R_i \right) - \left(\hat{\beta}_7 + \hat{\beta}_8 \cdot R_i \right) \right\} \cdot \overline{w} \qquad (11)$$

where a ^ over each term indicates an expected value, $\overline{k}_l$ is the U.S. average % of household income dedicated to paying a mortgage, and $\overline{w}$ is average household wage earnings in the U.S. (by rural/urban county type). Note that this expression depends on the value of N_i, or on whether a county is rural or urban. Thus, all models estimated will yield separate estimates for prices in rural counties and urban counties. This will allow for comparisons between prices in rural and urban areas.

In equation (11), the expression of $\hat{p}^*_s$ is a linear combination of normal random variables.[9] Thus, $\hat{p}^*_s$ is also a normal random variable. The expected value of $\hat{p}^*_s$ can be found easily by substituting the expected values of the β coefficients from the regression output into equation (4 and 5). What about the variance of $\hat{p}^*_s$? It would be quite useful to have some idea of about the reliability of the estimate of $\hat{p}^*_s$. A t-statistic for $\hat{p}^*_s$ can be computed if the standard deviation of $\hat{p}^*_s$ is known. In many hedonic models obtaining this estimate is simple because the implicit price is simply equal to the regression coefficient obtained from a model and the standard t-statistic reported with the regression output provides an indication of the significance of price. In this case, however, since the price equation is a linear combination of several regression coefficients, the variance of the estimated price is correctly expressed as follows

[9] The regression coefficients in an OLS regression model are normal random variables. The expected value and standard deviation for each coefficient are reported in the model output.

$$V\left(\hat{p}_s^*\right) = V\left(\overline{w}k_l\beta_3\right) + V\left(R\overline{w}k_l\beta_4\right) + V\left(\overline{w}\beta_7\right) + V\left(R\overline{w}\beta_8\right) + 2 \cdot \sum_{i<j}\sum Cov\left(X_i, X_j\right) \quad (12)$$

where the (X_i, X_j) pairs are all the possible combinations of the first four terms in the equation. Since the β coefficients used in equation (11) come from two separate regression models these covariance terms are not known for many of the (X_i, X_j) pairs.[10] In addition, since amenities affect both wages and property values it is likely incorrect to assume that that estimates of the β coefficients are independent (which would mean the covariance terms equal zero). Thus, it is not possible to directly compute the standard deviation of $\hat{p}_s^*$ needed to compute a t-statistic to test the significance of $\hat{p}_s^*$. In the current literature using the Rosen-Roback method to estimate, either no mention of the significance of the price estimates is given or authors make an implicit assumption of the independence of the β estimates in their calculation of the t-statistics (e.g., Gyourko and Tracy 1991; Blomquist et al 1988).

One solution to this problem is to use a simulation program to compute a discrete mean and standard deviation for $\hat{p}_s^*$, which can then be used to calculate a t-statistic to test the significance of the estimated price. For each of the models in this analysis, the expected value and the standard deviation of the implicit prices are computed in @RISK using a Monte Carlo simulation. For each amenity in the model, the values of β_3, β_4, β_7, and β_8 are entered into @RISK as normal random variables, where the mean and standard deviation for each normal random variable are obtained from the OLS models. Then $\hat{p}_s^*$ is computed 10,000 times, each time using different values for β_3, β_4, β_7, and β_8 that are randomly determined according from their normal distributions. The mean and standard deviation of these 10,000 observations of $\hat{p}_s^*$ are the discrete mean (expected value) and discrete standard deviation of $\hat{p}_s^*$, respectively. Dividing the discrete mean by the discrete standard deviation, gives a discrete t-statistic $\hat{p}_s^*$.[11] While these discrete values are not the true values for the mean, standard deviation, and t-statistic for the significance of $\hat{p}_s^*$, the very large number of iterations used in the simulation ensures that they are accurate enough to provide a useful test of the reliability of the estimate of $\hat{p}_s^*$.

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[10] Implicit in this statement is the assumption that the errors across the wage and property equations are independent.

[11] This t-statistic is the familiar test of the null hypothesis that $p_s^*=0$, and is equal to the expected value divided by the standard deviation. If the absolute value of the t-statistic is greater than or equal to 1.645, the null hypothesis is rejected and p_s^* is statistically different from zero at the 90% level of significance.