Urban Crime and Its Net Implicit Price to North Carolina Households

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ABSTRACT

This study investigates the impact of urban crime rates—property and violent—on wages and rents and estimates the net implicit monetary value of crime rates for living in metropolitan areas, using the American Community Survey 2019 data for cities in North Carolina. A seemingly unrelated regression estimation finds that the crime rates are capitalized into both wages and rents, and suggests crime rates affect wages positively and rents negatively. This investigation estimates a negative value of $51.80 per month—the average net marginal implicit price—for living in cities with high city crime rates. This negative value suggests that households are being compensated for living in cities with high crime rates.

KEYWORDS

Crime Rates, Housing Rent, Wage, Net Implicit Price

INTRODUCTION

Crime rates, housing prices, and wage rates vary considerably by city across the U.S. Although cities offer higher urban amenities and higher wage rates, cities with high crime rates increase a city's disamenity that, in turn, lowers property values (Tita et al., 2006; Wilhelmsson and Ceccato, 2015). Households consider housing prices, job opportunities, wage rates, and city amenities like school quality, clean air, lower crime rates, and so on while making decisions to move to a new location and maximize their utility. Thus, households make some trade-offs while choosing one location over another, which will change housing demand as well as labor supply. Cities with higher crime rates increase costs for additional security measures; by contrast, safer cities offer similar protection at lower, sometimes zero, costs. The trade-offs involve higher property values for lower crime rates and higher wage rates for higher crime rates (Zhang and Hite, 2015). The estimated trade-off captures the net implicit monetary value that individuals will pay to reduce their exposure to or avoid crime risk.

The main objectives of this study are (1) to examine whether crime generates compensating wages and price differentials across cities in the state of North Carolina, USA; and (2) to calculate the net implicit monetary values of crime in cities with a higher crime rate. These net implicit monetary values reflect households' willingness to pay for lower crime, or willingness to accept, in cities with a higher crime rate. Thus, this study is unique as it provides important information about the implicit monetary value of households' preferences to take a job when wages may or may not have fully adjusted to crime specifically in North Carolina, something that has not yet been addressed by the scholarly literature. This analysis is done using survey data obtained from the American Community Survey (ACS)

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2019 of metropolitan cities for North Carolina[1], which is the latest data available at the time of this research (U.S. Census Bureau, 2020). The econometric modeling combines a hedonic pricing model of house rents with a hedonic wage, using a seemingly unrelated regression (SUR) approach. The SUR approach has the advantage of permitting estimation of the marginal effects of crime on both monthly rent and on households' monthly wage, while accounting for otherwise problematic correlations across the errors between the two estimated equations.

The results suggest both wages and rents account for crime rate differentials; individuals receive compensating differentials—larger increases in wages or positive effects on wage and decreases or negative effects in rents—for living in high-crime cities. These results confirm that individuals consider living in high crime cities a disamenity, and identify specific dollar values that capture the associated tradeoffs for households in metropolitan cities in North Carolina.

BRIEF REVIEW OF LITERATURE

The influence of crime rates on property values and wages remains unsettled; the results from the literature that exists lacks consensus. An earlier paper (Hoch, 1972) reports that cities offer a compensation for urban disamenities like crime, congestion, and pollution. Similarly, Roback (1988), Beeson (1991) and Black et al. (2009) find that with heterogeneous preferences, wage varies by location. In contrast, Braakmann (2009) reports that wages are almost unrelated to crime rates but demonstrate that crime rates influence property values Similarly, Lynch and Rasmussen (2001), and Foryś and Putek–Szeląg (2017) find a negative relationship between crime rates and property values. But several earlier studies suggest that skills and amenities are associated and report that skilled individuals have a higher preference for better amenities, and they are willing to give up a certain portion of their wages to live in high-amenity locations (Lee, 2010; Lee and Stewart, 2010). Further, Lee (2010) reports a relationship between amenities and skilled individuals, and states that skilled individuals are willing to accept lower wages to live in cities with high amenities. A similar result is found for high-skilled people by Gagliardi and Schlüter (2015) in British cities. Their finding suggests that even with the same level of income, the biases of high-skilled people are more inclined towards amenity consumption compared to those of lower skilled individuals. Kelly (2011) finds support for the existence of compensating wage differentials based on empirical tests for a relationship between wages and high crime-risk jobs in Miami from 1979 to 1980 in comparison to lower crime-risk cities. Notably, this study did not investigate citizens' willingness to pay for lower crime rates. Recently, Blythe et al. (2020) finds, using an experimental design and a contingent valuation method, that people are willing to pay for improved security systems and lower crime. There are inadequate studies that quantify how much households are affected by crime rates in cities in terms of monetary values: i.e., how much individuals are willing to pay for a unit reduction in crime rates, or how much individuals are willing to accept for a unit increase in crime rates. Further, whether there is a full compensating differential for living in a high crime city and how property values are affected by crime rates remain open empirical questions.

EMPIRICAL FRAMEWORK

The use of hedonic models dates back to Court (1939) to estimate the implicit prices associated with the attributes of differentiated products. Becker's (1968) seminal work emphasized that zero crime is not optimal. Assuming costless mobility, based on the demand and supply for crime, a spatial equilibrium will result in which there will be no utility difference between locations due to crime rates.

[1] The phrase "metropolitan city" refers to either (A) the core city of a metropolitan region, as defined and used by the Office of Management and Budget, or (B) any other city within a metropolitan area with a population of 50,000 or more.

Following Rosen's (1974) influential work, this technique has been widely accepted. Thaler (1978) applied the hedonic regression method while estimating the values of crime control. Using this type of model, researchers attempt to isolate the value individuals place on specific amenities such as weather, air quality, and crime rates, as observed in the variation in wages they require and the prices they pay for housing. While estimating the net implicit price of crime, this paper first assesses whether the variation in crime rates across the U.S affects housing prices and wages significantly. To capture these effects, this study proposes a hedonic price and wage model—an analysis similar to that of Roback (1982). Implicit household competition for low crime-rate cities or cities with higher amenity benefits in two markets—housing and labor—brings both markets in equilibrium.

Since the same crime rate amenity factors affect both the hedonic wage and the hedonic price as reported by Mincer (1974), the hedonic wage equation would be:

$$W_i = \alpha_0 + \beta' Y_i + \gamma' K_i + \rho' C_i + \mu_i \quad (1)$$

in which W_i, Y_i, K_i C_i and μ_i are, respectively, the monthly wage of individual *i*, a vector of human capital characteristics, vector of demographic variables, vector of other controlled variables and crime rates at the city level, and the error term. Similarly, the hedonic rent (price) equation would be:

$$P_i = \delta_0 + \phi' Z_i + \varsigma' N_i + \varphi' C_i + \upsilon_i \quad (2)$$

in which $P_i$and Z_i, respectively, are the hedonic price (rent) of the housing unit, structural characteristics of the housing unit; N_i is the vector of neighbor characteristics, C_i is the crime rate, and υ_i is the error term. Both models include a common bundle of crime rate characteristics which facilitate estimation of the marginal effects of the crime rate on monthly house rent and wage.

ESTIMATING THE NET IMPLICIT PRICE OF CRIME RATE AS AN DISAMENITY

After using both hedonic econometric models for estimates, the estimation of the implicit price of crime as disamenity $P_C$is given as:

$$P_C = \frac{dp}{dC} - \frac{dw}{dC}\ ^{2} \quad (3)$$

Equation (3) gives the difference between the two partials—the impact of crime rates on the hedonic housing price, $\frac{dp}{dC}$, and the hedonic wage, $\frac{dw}{dC}$, —estimated by two hedonic econometric models [equation (2) and equation (1)]. The hedonic pricing model provides the marginal effect of crime amenity on monthly housing rents, $\frac{dp}{dC}$, and the hedonic wage model provides the marginal effect of the crime amenity on the monthly wage rate, $\frac{dw}{dC}$. The difference gives the average individual net monthly implicit price or marginal willingness to pay for crime as amenities if the difference is positive. If so, it is an amenity, and the value is a willingness to pay price. If not, that is to say the difference is negative, it is a disamenity, and the value is compensation for the crime disamenity, i.e., a willingness to accept price for crime as a disamenity. This estimation therefore uncovers an implicit price of crime revealed by choices of American households.

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[2] Both dependent variables of econometric estimation models, equations (1) and (2), are transformed into natural logarithm so that their partial values are estimated as follows:

$\frac{dp}{dC} = exp(\hat{X\beta'}) * \hat{\phi}$ and $\frac{dW}{dC} = exp(\hat{X\beta'}) * \hat{\rho}$

DATA

This investigation uses data obtained from the American Community Survey (ACS) 2019 of metropolitan cities for North Carolina, which is the latest data available at the time of this research (U.S. Census Bureau, 2020). The ACS data is a public use microdata area (PUMA) based on the 2010 Census. The data provides a record of 29,047 observations on housing units and rich micro level information on households with demographic information. The crime rate data is obtained from bestplace.net/crime/north_carolina (2019) and data are obtained for each city as defined by PUMA. Each city is ranked by crime on a scale of 1 (low) to 100 (high). Heating degree-days (HDD) and cooling degree-days (CDD) (proxy for climate) are obtained from National Climatic Data Center/NOAA (2019) for each city.

VARIABLE DEFINITIONS

DEPENDENT VARIABLES

The monthly wage variable used in this study is proxied by dividing annual household income by twelve. The sample used in the wage equation was restricted to wage-earning homeowners and apartment renters. To reduce noise, the variable for monthly wages is then transformed into its natural logarithm (LnWAGE).

For the second variable of housing rent, this study draws from the American Community Survey (ACS) data which provides two types of information: monthly house rent and current property value of dwelling unit of the owner-occupant. For owner-occupied units where monthly rents are not given, the monthly rent was imputed by multiplying the value of the unit by an annual discount rate of 7.5 percent. This is a standard approximation adopted by several studies (see, for example, Hand et al. (2008) and Koirala and Bohara (2014)). As before, to reduce noise, a natural logarithmic transformation is then applied to the imputed monthly rents to obtain the dependent variable used in the hedonic housing equation (LnMRENT).

INDEPENDENT VARIABLES

The key variables of interest are property crime rate and violent crime rate, measured on a 0 to 100-point scale (with lower values representing lower crime rates). A natural logarithm transformation is applied to both the property crime rate (LnPROPCRIM) and the violent crime rate (LnVIOCRIME). Both crime rate variables are included in both models. Included control variables follow the hedonic pricing theory, the nature of the analysis, and limits of data availability. The wage hedonic model includes as controls the unemployment rate in percentage (UNEMPLRATE), individuals with associate degrees or college degrees (EDUAD), individuals with high school degrees (EDUS), and job experience of the household head, transformed into a natural logarithm (LnEXP). Other household-related control variables are household size (HHSIZE), whether the household head is single (SINGLE), and whether the household is not a U.S. citizen (NUSCIT). Further, this study also controls for households' country of origins: whether the household head is an American (AMERICAN), Asian origin (ASIAN), Hispanic (HISPANIC), or from Europe (EUROPEAN). This study has also examined commuting-related variables that could affect wage or housing price such as mode of commuting to work. Specifically, the controls include commuting by car to work (TRAVCAR) or commuting by public transportation to work (TRAVPUB), the travel time in minutes to work, transformed into natural logarithms (LnTRVLTIME). Commute-time is important to control in both hedonic models because there is a cost of travel. As reported by Athira et al. (2016) if a trip length increases, the value of time also increases which implies

that households would like to receive higher wages if they must travel longer distances for work, and they would choose to live farther if the rent is cheaper.

Variables used in the rent hedonic model are mostly building related. The building unit structure variables used in this estimation are whether the building has fire/hazard insurance (BLDINSU) and number of rooms (NBEDROOM). Similarly, related to the unit types are whether the house is a single unit (SNGLBULD), and whether the housing unit is an apartment (APT). Further, this study also controlled for kitchen types—if a building has complete kitchen facilities (KIT), and the year building was constructed (YBL). The rationale for including the KIT and YBL variables is that kitchens with a complete facility will, all else equal, generate higher rent, while an older unit will lower the housing rent or value.

In addition to the wage and building related variables, the estimated models also include both heating degree days (HDD) and cooling degree days (CDD) as proxies for climate, which can influence both wage and rent (Koirala and Bohara, 2014). The variable definitions and descriptive statistics are given in Table 1.

Table 1. Variable Definition and Descriptive Statistics

Variables	Variable Definitions	Mean	Std. Dev.
Dependent Variables			
LnWAGE	*Monthly wage in $ transformed into a natural logarithm*	*8.470*	*1.179*
LnRENTM	*Monthly rent in $ transformed into a natural logarithm*	*6.897*	*0.942*
Independent Variables			
LnPROCRIME	*Property crime rate measured in 100 points transformed into natural logarithm*	*3.959*	*0.373*
LnVIOCRIME	*Violent crime rate measured in 100 points transformed into natural logarithm*	*3.261*	*0.450*
UNEMPLRATE	*Unemployment rate in percentage*	*4.044*	*0.870*
EDUAD	*Individual with associate degree or college degree*	*0.312*	*0.463*
EDUS	*Individual with high school degree*	*0.486*	*0.500*
SINGLE	*If respondent is living as a single, binary*	*0.364*	*0.481*
HICOVRD	*If income has health insurance coverage, binary*	*0.893*	*0.310*
NUSCIT	*If respondent is a U.S. citizen, binary*	*0.019*	*0.136*
AMERICAN	*If respondent is American, binary*	*0.915*	*0.279*
ASIAN	*If respondent is Asian Origin, binary*	*0.017*	*0.128*
HISPANIC	*If respondent is Hispanic Origin, binary*	*0.043*	*0.202*
EUROPEAN	*If respondent is EUROPEAN, binary*	*0.021*	*0.144*
TRAVCAR	*If respondent commute on car for work, binary*	*0.364*	*0.481*
TRAVPUB	*If respondent commute on public transportation for work, binary*	*0.000*	*0.012*
LnTRVLTIME	*Travel time in minutes to work transformed into a natural logarithm*	*1.452*	*1.884*
BLDINSU	*Fire/hazard insurance*	*942.320*	*848.719*
NBEDROOM	*Number of bedrooms*	*3.166*	*0.820*
SNGLBULD	*If a building is a single unit, binary*	*0.839*	*0.368*
A.P.T.	*If a unit is an apartment, binary*	*0.055*	*0.227*
Y.B.L.	*Year of building constructed*	*6.697*	*3.753*
K.I.T.	*If a building has complete kitchen facilities*	*1.003*	*0.053*
HDD	*Heating Degree Day*	*1308.617*	*211.925*
CDD	*Cooling Degree Day*	*1687.434*	*233.050*

Note: N=29047

EMPIRICAL RESULTS

The empirical design consists of two regression models with two dependent variables, monthly house rent and monthly wage, and a cross-equation contemporaneous correlation cannot be ruled out since wage can affect rent, and *vice versa*. Presence of such correlation between a dependent variable from one equation and the error term in another equation challenges the accuracy of standard Ordinary Least Square (OLS) estimates due to a simultaneity problem. To circumvent this problem, this study applies a seemingly unrelated regression (SUR) estimation technique. As suggested by Zellner (1962), the SUR estimation technique accounts for the potential inter-correlation of the error terms across estimating equations. A chi-squared test of independence as recommended by Breusch and Pagan

(1980), also referred to as a test of independence of the errors, for the null hypothesis of no contemporaneous correlation has been performed. The null hypothesis of no contemporaneous correlation was rejected at the 99 percent confidence level for all the models by a Breusch-Pagan test (χ^2 = 876.396 with one degree of freedom) indicating the presence of a simultaneity problem. Hence the empirical strategy applies an iterative SUR estimation technique, which iterates over the estimated disturbance covariance matrix to provide an efficient estimate. Estimated results of both hedonic wage (Equation 1) and rent (Equation 2) models are reported in Table 2. Results of each hedonic model are discussed below.

Table 2. Results of Hedonic Wage and Rent Model

Variables	Wage Model b/se	Rent Model b/se
INTERCEPT	*9.514***	*8.201***
	(0.29)	*(0.18)*
LnPROPCRIM	*+0.257***	*-0.032***
	(0.03)	*(0.01)*
LnVIOCRIM	*+0.072***	*-0.224***
	(0.02)	*(0.02)*
UNEMPLRATE	*-0.504***	
	(0.05)	
EDUAD	*-0.012*	
	(0.02)	
EDUS	*-0.007*	
	(0.02)	
LnEXP	*-0.013*	
	(0.04)	
lnEEXPSQ	*0.000*	
	(0.01)	
SINGLE	*-0.015*	
	(0.02)	
NUSCIT	*0.057*	
	(0.05)	
ASIAN	*0.204***	
	(0.05)	
HISPANIC	*-0.017*	
	(0.03)	
EUROPEAN	*0.254***	
	(0.05)	
TRAVCAR	*0.003*	
	(0.06)	
TRAVPUB	*-0.446*	
	(0.58)	
LnTRVLTIME	*-0.003*	*0.005***
	(0.02)	*(0.00)*
HDD	*0.0007***	*-0.001***
	(0.00)	*(0.00)*
CDD	*0.0009***	*-0.001***
	(0.00)	*(0.00)*

Table 2. Continued

BLDINSU		*0.000****
		(0.00)
NBEDROOM		*0.226****
		(0.01)
SNGLBULD		*1.130****
		(0.01)
APT		*1.214****
		(0.02)
YBL		*0.035****
		(0.00)
KIT		*-0.131*
		(0.17)
R^2	*0.191*	*0.50*
N	*29047*	*29047*

Note: * p<0.05, ** p<0.01, *** p<0.001

EFFECTS OF CRIME RATES ON HOUSEHOLD WAGE

This estimation finds that both property and violent crime rates positively and significantly impact households' monthly wages, *ceteris paribus*. This finding suggests that firms should offer higher wages in high crime areas to attract more workers. Results show that for 1 percent increase in the property crime rate and violent crime rate, households' monthly wage will increase by 0.257 percent and 0.072 percent, respectively. While these findings are consistent with previously reported empirical analyses (see Kelly (2011) for details), none of the analyses was aimed at finding a casual effect of crime rate on wage. Houston and Bernstein (2000) report that falling unemployment and crimes rates move together whereas rising wages and crime rates move differently. On the contrary, Braakmann (2009) suggests that wages are unrelated to changes in crime rates.

EFFECTS OF OTHER VARIABLES ON HOUSEHOLD WAGE

Estimated impacts of included control variables in the hedonic wage model are consistent with theoretical predictions and prior literature, thereby lending credence to the present study's empirical strategy. The effect of unemployment on wages is negative and significant as expected—the higher the unemployment rate the lower the wage rate; the wage rate goes down by about 5.08 percent for a 1 percent increase in the unemployment rate. This finding suggests households have lower bargaining power if the unemployment rate is high.

This study has empirically tested the effect of a few demographic variables related to country of origin on their wages and finds that the effects on wages of being Asian or European are positive and significant; being Hispanic has no statistically significant impact. The analysis further tested the effect of travel-related variables to work, mode of travel, and travel time. Neither mode of travel nor travel time appeared to have any statistically significant impact on the monthly wage in this study.

Households consider climate during location choice, and climate affects wage and firms' productivity. The results indicate both higher cooling degree days (CCD) as well as higher heating degree days (HDD) have positive and significant impacts in explaining household wages. These signs reveal that households consider both higher CDD and higher HDD as disamenities and require higher wages to compensate for a worse climate.

EFFECTS OF CRIME RATES ON HOUSE RENT

The estimates indicate that both property crime and violent crime rates have significant negative impacts on housing rents. Due to the logarithmic transformations, estimated effects of both crime rate variables are interpreted as elasticities. The estimated property crime rate elasticity of rent of -0.032 indicates that if property crime rates increase by 1 percent, the average house rent will decrease by 0.032 percent. Similarly, the estimated violent crime rate elasticity of rent is -0.224, suggesting that if violent crime rates increase by 1percent, the average house rent will decrease by 0.224 percent. Notably, the estimated coefficient of violent crime rate is a larger negative number than the estimated coefficient of property crime rate on property rent. The estimated crime rate elasticity values in both cases are smaller than 1 ($|\varepsilon| < 1$), suggesting that the housing rent has an inelastic response to crime rates, regardless of whether the type is property crime, violent crime, or both. Although housing rent is one of the determinants of crime rate in the United States, research estimating the counter-causal effect of crime rate on house rents remains scarce. However, the estimates obtained in this study are consistent with the few existing studies which report a negative association between crime rates and property values (Tita et al., 2006; Ceccato and Wilhelmsson, 2011; Wilhelmsson and Ceccato, 2015).

EFFECTS OF OTHER VARIABLES ON HOUSE RENT

Other included variables also explain the variation in housing rent in this estimation. Starting with the variables related with building structure, building insurance for natural hazardous and fire insurance (BLDINSU), year of construction (YBL), number of bedrooms (NBEDROOM), and apartment status (APT) are all found to be highly significant with positive signs, suggesting that these variables increase house rent. However, a building with a complete kitchen facility (KIT) appeared to be insignificant. Two climate related variables—higher cooling degree days (CCD) as well as higher heating degree days (HDD)—appear highly significant with negative signs. The negative signs suggest that renters dislike extreme weather and are willing to pay more to avoid such extremities. Energy consumption is sensitive to both higher values of heating degree days and cooling degrees days (Moustris et al., 2015). This is an important finding given the rising concerns with climate change, and homeowners' concerns about trading off comfort and monthly energy costs. Finally, the estimates find that rents fall weakly with commuting time, suggesting that individuals travel longer in pursuit of cheap rents.

ESTIMATING THE IMPLICIT PRICE OF CRIME RATE

After estimating both hedonic econometric models—equation (1) and equation (2)—the marginal effects of crime on house rent and wage are obtained to calculate the implicit price of crime rates using equation (3): $P_C = \frac{dp}{dC} - \frac{dw}{dC}$. The calculated net implicit prices of both property crime rate and violent crime rate are reported in Table 3. The estimated monetary values of the property crime rate and violent crime rate are $-33.33 per month (2020 price level) and $-18.47 per month (2020 price level), respectively. The total net implicit price per month is estimated to be $51.80. This study finds the net implicit price of both types of crime rates to be negative, revealing that crime of any kind is a disamenity on net: individuals receive higher monthly wages compared to house rent to motivate them or to compensate them for the disamenity of working in higher crime areas.

Table 3. Net Implicit Price of Property and Violent Crime per Month in US$ (2020 price levels)

Variable	Mean
Property Crime	*- 33.33*
Violent Crime	*-18.47*
Total Compensation	*-51.80*

CONCLUSION AND RECOMMENDATION

This study estimates the net marginal willingness to accept price for crime rates, property crime rate and violent crime rate, in urban North Carolina. Using a novel SUR approach that mitigates potential simultaneity concerns, it quantifies the crime rate capitalization into wages and house rents across North Carolina cities using data from the U. S. Census Bureau's American Community Survey of 2019. Results indicate that individuals are indeed compensated for living in high-crime areas in the U.S., suggesting that a high crime area is a net disamenity. The net marginal implicit price for living in higher property and violent crime areas in the U.S. is about $51.80 in 2020 prices.

Miller et al. (2021) reports that the estimated monetary cost of high crime rates in the U.S. is about $620 billion based on 2017 data. The results from the present study indicate a key area of open inquiry: extending the analysis by investigating maximum willingness to pay to reduce both property and violent crimes to acceptable levels to live safely in urban areas of the U.S. One possible direction for future research is to focus on differences in marginal willingness to accept prices across regions or states in the U.S. Further, while our analysis focuses on how crime affects wages and rents, it is also possible that variability in wages and rents may influence local economic conditions, and thereby affect crime itself. However, the mechanism underlying these reverse effects are likely to operate over a much longer time horizon. Further research on the gentrification as natural experiments can shed more light on the question of endogeneity.

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