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HOUSEHOLD CARBON EMISSIONS FROM DRIVING AND CENTER CITY QUALITY OF LIFE

+ MATTHEW J. HOLIAN AND MATTHEW E. KAHN

ABSTRACT

In metropolitan areas with a vibrant center city, residents are more likely to spend time downtown for work, shopping and leisure. In the dense downtown, there are more opportunities to walk and to use public transit. We test whether households who live in metropolitan areas with more vibrant downtowns have a smaller transportation carbon footprint. We document that carbon emissions for a standardized household are lower in metropolitan areas featuring a higher concentration of college graduates living downtown. Over time, public transit use is rising more in cities featuring a higher downtown college graduate share.

CONTACT

Matthew J. Holian
San Jose State University
matthew.holian@sjsu.edu

Matthew E. Kahn
University of California, Los Angeles and NBER
mkahn@ioe.ucla.edu

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Introduction

Climate change looms as a threat to quality of life in the United States. In the absence of carbon pricing, urban economic growth has increased greenhouse gas production. Urbanization raises per-capita income through learning and specialization effects. Richer people produce more carbon emissions through consuming more products that embody carbon and by driving more and consuming more electricity (Glaeser and Kahn 2010). In growing metropolitan areas, the bulk of employment and population growth takes place in the suburbs. Such "sprawl" is associated with increased per-capita vehicle use. The transportation sector produces roughly 40% of the nation's greenhouse gas (GHG) emissions.

One potential counter veiling trend has been ongoing improvements in center city quality of life. Crime is falling in center cities and this attracts the college educated to live downtown (Berry-Cullen and Levitt 1999, Levitt 2004). Urban air pollution tends to be higher in the densest parts of a metropolitan area but in recent years, air pollution downtown has declined (Kahn 2011) and Superfund sites (that tend to be disproportionately located in center cities) are being cleaned up (Gamper-Rabindran and Timmins 2011). Urban mayors such as Michael Bloomberg of New York City have invested in local beautification projects, increased policing and other efforts to improve center city quality of life.

In this paper, we posit that a socially beneficial consequence of rising center city quality of life is to reduce a metropolitan area's transportation carbon footprint. Center cities feature a much higher population density and public transit network than the suburbs. When people spend more time downtown, they are more likely to walk and use public transit and to drive less.[1] We argue that a more robust center city increases the desire of all of the metropolitan area's residents to live a lifestyle that is oriented to visiting and spending more time in that center city.

[1] Detroit offers a salient example. In December 2012, a New York Times reporter wrote "Along with these real estate projects, Midtown Detroit is also helping to attract or develop the amenities that city dwellers want around their apartments, like bike paths, parks where residents can walk their dogs, and places to eat and shop. A Whole Foods is to open in midtown next year, and a light rail project is in the planning stages. http://www.nytimes.com/2012/12/12/realestate/commercial/new-thirst-for-urban-living-in-detroit-leaves-few-rentals.html?_r=0

Our empirical approach for identifying metropolitan areas with vibrant center cities is to proxy for this hard to measure concept using two measures of the propensity of college graduates to live downtown. One measure is the college graduates per square mile living within five miles of the city center. The second is the share of all adults who live within five miles of the city center who are college graduates. Contrast New York City and Detroit. Based on 2010 data, there were 3344 college graduates per square mile living within five miles of New York City's Central Business District (CBD) while there were only 112 college graduates per square mile living within five miles of Detroit's CBD.

In Section II, we argue that college graduates both migrate to geographic areas with high quality of life and their clustering in specific areas is likely to cause an increase in such an area's quality of life due to their political clout, and their private spending patterns. Past intra-city research has documented that home prices are higher in neighborhoods where the educated cluster (DiPasquale and Kahn 1999).

Using household level data from 2009, we estimate household-level carbon emissions from private transportation regressions. Controlling for standard socio-demographic attributes such as household income, age and size and the household's metropolitan area's urban form attributes, we document that a household's carbon footprint from transportation is smaller in metropolitan areas featuring a larger downtown college graduate density. We recognize that our empirical approach is subject to the critique that households are not randomly assigned across metropolitan areas. We discuss potential biases and contrast our approach with possible longitudinal panel research designs. A strength of our approach is to examine the carbon production from private transportation for "standardized households" who live in different metropolitan areas. Following the urban planning literature, we include typical variables such as urban population density. Controlling for such factors, we document the association between our measures of downtown vitality and a smaller carbon footprint.

Cross-city trends in public transit usage provide a second test of our core hypothesis. We posit that public transit use is rising in large cities where more college graduates live downtown.

Over the years 1991 to 2009, there has been a large drop in center city crime in many major cities. Using a second public transit panel data covering major U.S metro agencies over the years 1991 to 2009, we find that public transit ridership has increased more in those metropolitan areas where a larger share of downtown adult residents are college graduates.

Our paper melds insights from both the determinants of driving literature (see Brownstone and Golob 2009, Glaeser and Kahn 2010) and the cross-city quality of life literature. Past work on quality of life differentials have mainly focused on creating metrics ranking different metropolitan areas quality of life (i.e San Francisco vs. Houston) and studying the consequences of such spatial differences in local public goods on local home prices and wages (see Roback (1982), Blomquist, Berger and Hoehn (1988), Gyourko and Tracy (1991), Albouy (2008).

The intra-city quality of life literature has not related the spatial distribution of local quality of life to the global challenge of mitigating carbon emissions. In the absence of Pigouvian gas pricing, there are social benefits when households choose to use public transit rather than a private car (Parry and Small 1998). Our findings suggest the possibility that enhancing downtown quality of life may offer local "green city" benefits and some global sustainability benefits.

Quality of Life Differentials between Center Cities and Suburbs

While urban scholars have created rankings of cross-city quality of life (see Albouy 2008, Gyourko and Tracy 1991), we know of no research ranking center cities versus suburbs within the same metropolitan area. In the absence of such direct objective measures of quality of life, we posit that within metropolitan area quality of life is higher in those areas where the college educated cluster (see Bruckner, Thisse and Zenou 1999, Clark, Lloyd, Wong and Jain 2002). This outcome is likely to be due to both selection and treatment effects.

In a Tiebout model of migration, the educated have the financial resources to locate in those areas within a metropolitan area that offer high quality of life. Taking the intra metropolitan area real estate pricing gradient as given, the educated will choose the most desirable areas (Sander 2005). When the high skilled cluster in a specific geographic area, this is likely to cause an improvement in local quality of life as these individuals are more active in civic life and to be environmentalists (Moretti 2004, Kahn 2002, Krizek and Johnson 2006). Spatial clusters of educated, high income individuals will attract better restaurants, shops and culture to locate nearby (Clark, Curid and Williams 2010, Florida 2002, Storper and Scott 2009, Waldfogel 2008). Educated, richer people are more likely to invest in improving the residential real estate capital stock and this contributes to center city gentrification (Brueckner and Rosenthal 2009).

In Table 1, we report human capital facts for 29 major U.S metropolitan areas whose 2010 population exceeds two million people. Based on 2010 data, we report each metropolitan area's share of adults who are college graduates and the college graduates per square mile who live within five miles of the CBD (we will refer to this as the downtown college graduate density). As shown in Table 1, Detroit has a low overall college percentage and a low downtown college graduate density. In contrast, in cities such as San Francisco, New York City and Portland and Seattle we observe the reverse. Across our full sample of 366 metropolitan areas, the correlation between the two variables is 0.38.

In Table 2, we report how the count of downtown restaurants, hotels, museums and bars, and the central city murder rate correlates with the metropolitan area's downtown count of population and the downtown count of college graduates (where downtown is defined as the area within a five mile radius of the CBD).[2] We find consistent evidence that college graduate

[2] Many measures of urban form have been used in the empirical literature. Our five-mile counts reflect elements of both "largeness" and "compactness". The establishment counts were calculated from the 2008 Zip Code Business Patterns data series (and cover industry codes 722110, 721110, 712110 and 722410.) We calculated the number of establishments in these industries in zip codes whose centroids were within five miles (8.05 kilometers) of the CBD. The murder variable is the average murder rate (murders per 100,000 residents) for the years 2005-2009 for each metropolitan area's principle city. This was obtained by averaging the annual murder rates obtained through the State of the Cities Data Systems (SOCDS). Finally, the population count and college graduate county variables were calculated with geocoded block-group level data from the 2011 American Community Survey (these are five-

density is more highly correlated with these objective measures of downtown quality of life than is overall population density.

Main Hypotheses and Data

This paper's empirical work focuses on testing the following two hypotheses related to carbon dioxide production from transportation by metropolitan area households.

Hypothesis 1: All else equal, at a point in time, a household's transport carbon emissions are lower in metropolitan areas featuring a higher downtown college graduate density measure.

Hypothesis 2: Over time, public transit use has increased the most in metropolitan areas where the educated concentrate downtown.

To test these hypotheses we rely on two data sources. Our first data source is the Department of Transportation's 2009 National Household Travel Survey (NHTS). The NHTS micro data reports gasoline consumption for a large representative sample of households. We have been able to access a special version of the data that has census tract identifiers. For each household, we observe which metropolitan area it lives in, its distance to the city center, and the population density of the census tract in which it resides. We also have data on MSA density, and a variety of other variables that we discuss later. We restricted our sample to households living within 35 miles of each MSA's central business district (CBD).[3]

The dependent variable is gallons of gasoline consumed by the household annually, which we convert into GHG emissions. We calculated GHG emissions from driving for each household in two steps. First, we obtained the estimate of annual household gasoline consumption contained in the NHTS, and then we converted gallons of gasoline into carbon dioxide (CO2) emissions by multiplying by 20.98. A standard conversion factor used by the

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year averages which cover the years 2007-2011). We summed total population and population with a college degree or higher for all block groups whose centroid is within five miles from downtown.

[3] MSA definitions change every few years. We use the 2006 MSA definitions and the principle cities identified by the U.S. Census Bureau. The location of each MSA's central business district (CBD) was obtained by recording the geocode returned when entering the central city name in Google Earth. These CBD geocodes are available upon request.

Department of Energy is 19.64;[4] however, this conversion factor includes only the direct emissions from burning a gallon of gasoline, not the indirect emissions associated with refining and transporting gasoline to the pump.[5] Therefore, we increase the factor by seven percent, and assume that each gallon of gas is associated with 20.98 lb of $CO2$ emissions. The dependent variable has a mean of 24,289 and a standard deviation of 16,864.

Our primary empirical approach to modeling GHG emissions from transportation involves estimating OLS regressions using observations on 68,685 households based on the equation below, which is presented in equation (1).[6]

□□□□□□= □□□□□□+□□□□□□ +□□□□□□+□□+ □□+ □□ (1)

In this regression, the dependent variable is the level of annual household GHG emissions □□□ refers to the value of individual characteristic □ for household □. We include standard household attributes such as the household's income, the head's age, and the household's size □□□ refers to the value of characteristic □ in tract □. For example, we include the census tract's population density and the tract's centroid's distance to the Central Business District. The final □□□, refers to attribute □ of MSA □. These are MSA-level attributes that vary across metropolitan areas but not within metropolitan areas and includes: the 2008 percentage of voters who voted for President Obama, the metropolitan area's log of population density, the metropolitan area's percentage of adults who are college graduates and the metropolitan area's college graduate count per square mile within five miles of the city center (called "college graduate density") in the tables. The last three terms are the individual-level, MSA-level, and tract-level error terms, respectively. The standard errors are clustered by MSA.

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[4] U.S. Energy Information Administration, "Voluntary Reporting of Greenhouse Gases Program, Table 2: Carbon Dioxide Emission Factors for Transportation Fuels." www.eia.gov/oiaf/1605/coefficients.html

[5] "Petroleum refining and distribution efficiency = 0.83," U.S. Government Printing Office (2000, p. 36,987). http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2000_register&docid=00-14446-filed.pdf. Therefore, 20.98 is conservative in that it reflects efficiency of about 0.93, and thus likely understates the actual emissions associated with a gallon of gasoline.

[6] To ensure that anomalous households or computer errors do not skew our results, we followed several data rules. First, we top coded the top one percent of the sample for the dependent variable. We also restricted the sample to households whose head is between the ages of 18 and 65, and for whom we have complete demographic and geographic data.

The results from estimating equation (1) are reported in Table 3. This table does not report the coefficients for the household income categories; these estimated coefficients on these variables are monotonically increasing with income. In Table 3, the key explanatory variable is the college graduate density measure based on the count of college graduates who live within five miles of the CBD. We calculated this measure using geocoded, block group-level data from the 2007-2011 American Community Survey. It is important to note that we are controlling for the metropolitan area's total percentage of college graduates. The correlation between this variable and the downtown college density is .37.

As shown in Table 3's column (1), the land-use variables all have the predicted signs and are statistically significant. Population density, whether at the tract or MSA level, reduces GHG production. More distance to the MSA's center is associated with higher average gasoline consumption.

In each regression, we include the share of the metropolitan area's voters who voted for President Obama in 2008. This variable proxies for the fact that metropolitan areas differ with respect to their average political ideology. Some metropolitan areas such as San Francisco are much more liberal than other areas such as Houston. In the liberal/environmentalist metro areas, residents are more likely to embrace a "green ideology" and desire to use low carbon public transit (Kahn 2007, Kahn and Morris 2010). Such individuals are also more likely to vote for public policies intended to improve the quality and quantity of public transit. Both of these factors should lead to a negative coefficient on the Obama vote share in the regressions. As shown in Table 3, the Obama coefficient is negative and statistically significant in each regression. A ten percentage point increase in the vote share for President Obama in 2008, reduces the household's annual GHG emissions from transportation by roughly 800 pounds. This effect grows in size when we focus on the subset of metro areas whose population is at least 500,000 people in the year 2010 (see column 3).

Table 3 reports three OLS estimates of equation (1). In column (1), we include the intra-metropolitan area urban form variables while in column (2) we use the same sample but exclude the log of the household's distance from the city center and the log of the household's census tract's population density. We present these two specifications because we recognize that households who choose to live closer to the center city and to live at higher density may have different travel demand preferences.[7]

Controlling for standard household demographics such as household income categories, the head's age, the number of people and the number of drivers in the household, we find that there is a negative and statistically significant coefficient on the downtown college density measure. Based on column (2), all else equal, a household who lives in a metro area with New York City's downtown college density would create 2288 fewer pounds of carbon dioxide emissions relative to if the same household lived in Detroit.[8] We also find that Northeast households have a smaller carbon footprint than other regions, while households in the South have a much larger transport footprint.

In column (3), we restrict the sample to metropolitan areas with more than 500,000 people. The downtown college density variable remains statistically significant but the MSA % College graduate variable is no longer statistically significant. In interpreting these results, it is important to keep in mind that we always control for the metropolitan area's population density. This variable has a negative and highly statistically significant coefficient (in column 1).

We recognize that an alternative measure for the educated living downtown is to include the share of adult residents who are college graduates. In Table 4, we replace the downtown college graduate density measure with the share of adults who live within five miles of the CBD who are college graduates. We also include the MSA's share of adults who live more than five miles from the CBD who are college graduates. We continue to include the log of MSA population density, but we add the MSA's share of employment located within five miles from the CBD. In column (1), we include the household's census tract's distance to the CBD and the census tract's population density. In column (2), we drop these intra-metropolitan area control

[7]Studies exploring this include Bagley and Mokhtarian (2002), Boarnet and Sarmiento (1998), Boarnet and Greenwald (2000), Brownstone and Golob (2009), Frank et al. (2007), Krizek (2003) and Vance and Hedel (2007).
[8] This calculation is based on -.708*(3344-112).

variables. The key point to emerge from these regressions is that the downtown college share has a negative coefficient and is statistically significant while the suburban college share is small in magnitude and statistically insignificant. Based on the results reported in Table 4's column (2), a ten percentage point increase in the share of downtown adults who are college graduates is associated with a 900 pound per year production of carbon dioxide emissions from private household transportation.

We recognize that if the error term in equation (1) has a subcomponent that is serially correlated that this could induce an endogeneity bias such that the factors that attracted college graduates to live downtown could be correlated with unobserved determinants of carbon dioxide emissions. In Table 5, we report additional estimates of equation (1). In columns (1) and (2), we contrast OLS and instrumental variables estimates for the same subsample. To address this concern, in column (2) we instrument for the downtown college graduate share in the year 2000 using micro data from the 1930 Census of Population. These data indicate whether a household lives in the center city. For each metropolitan area's center city, we calculate the adult male's average Duncan Socioeconomic Index (a measure of economic status based on a worker's industry and occupation). We use this 1930 variable to instrument for the year downtown college density.[9] This 1930 variable is not available for every metropolitan area. In Table 5's column (1), we re-estimate equation (1) for the subset of households for which we can construct our 1930 instrument and in column (2) we report the IV estimates. Both the OLS and IV estimates of the downtown college graduate density are negative and statistically significant. The IV estimate is roughly double the size of the OLS estimate.

Contrasting Our Research Design with a Longitudinal Research Design Approach

We recognize that the 2009 NHTS data limits us to making cross-sectional comparisons. At this point in time, we are comparing the carbon emissions from private transportation for

[9] This would not be a valid instrument if there are time invariant features of downtowns that attract college graduates and are correlated with transportation patterns. A univariate regression of the downtown college graduate share in 2000 regressed on the center city's average 1930 Duncan Index yields a $R2 = .031$.

observationally identical households who live in different metropolitan areas. On average, those households who live in metropolitan areas where the college graduates cluster downtown are creating fewer greenhouse gas emissions. If we could access time diaries for these households, we would seek to test whether in the metropolitan areas with large college downtown densities, are households spending more time downtown on week nights and weekends (for evidence on time diaries see Levinson and Kumar 1995). As shown in Table Three's column (1), this result is robust to controlling for where the household lives in the metropolitan area (as measured by miles from the Central Business District). We recognize that some vibrant center cities such as Boston, New York City and San Francisco have stringent zoning rules making it difficult to build new housing in the center. While it is beyond the scope of this study, we posit that a city that has a vibrant downtown and that permits vertical construction (think of Hong Kong) will have an even smaller carbon footprint from transportation. Again, the new idea here is to focus not solely on employment downtown but the "Consumer City" opportunities offered by the downtown. As the population ages and people work shorter hours, this dimension of travel activity takes on more policy relevance.

Any cross-sectional regression approach is subject to the omitted variables critique. We recognize that an alternative experimental design would be to build a metropolitan level panel data set and to examine how aggregate gasoline consumption changes as the downtown's quality of life evolves.[10] Such research could examine whether gasoline consumption declines more in metropolitan areas where downtown crime declines the most. Assuming the researcher could overcome the challenge of assembling annual gasoline consumption by county by year, this research would still face the challenge of scaling the data (how many vehicles are registered in the county in a given year) and measuring the evolving demographics and income of the population by county/year.

[10] Krizek (2003) represents a rare panel example of studying changes in travel behavior tracking the same households within one city.

Time Trends in Public Transit Use and Downtown Vitality

Public transit is known to be a lower carbon transport option than private vehicles. In this section, we test whether public transit ridership has increased between 1991 and 2009 in those metropolitan areas where a larger fraction of downtown adult residents were college graduates in 1980. Our claim is that the metro areas with a larger baseline share of college graduates are more likely to be robust center cities and such cities will be more likely to experience public transit growth as this mode of travel is focused on serving the city center.

We use data from the National Transit Database's Service Data and Operating Expenses Times Series file.[11] This data source provides us with data on the passenger miles travelled (PMT) by mode by urban area by year. We aggregate this into total PMT per year for each urban area and we run OLS regressions of the form:

LOG□(□□□□□)=□□+□1□+□2□ □□+□3□ □□+□□□ (2).

□□ is the urban area fixed effect, □ is the time trend (1991 is set equal to 1) and □1 is the
□□ is an indicator variable equal to one if the population of the urban area is greater than one
□2 is a coefficient to be estimated, □□ is a variable measuring the share of downtown residents
□3 is a coefficient to be estimated, and □□□ is the error term. In this equation, we focus on the two interaction terms. The first is the interaction between the time trend and a dummy variable that equals one if the UZA's population is greater than one million, and the second is the interaction between the time trend and the 1980 share of downtown college graduates. As documented by Levitt (2004), the early 1990s was when urban crime started to decline sharply.

Table 6 reports the results. We find statistically significant evidence that the positive time trend in public transit use is higher for cities with larger shares of downtown human capital. In Table 6, we report two estimates of equation (2). In both regressions, we include urban area

[11] http://www.ntdprogram.gov/ntdprogram/data.htm

fixed effects. The regressions include data for 214 urban areas from 1991 to 2009. As shown in column (1), passenger miles travelled have increased by 1.8% per year on average. In column (2), we re-estimate equation (2) and include the two interactions. Urban areas with a population greater than 1 million have experienced a time trend of 2% per year. Those urban areas with a larger share of college graduates living downtown in 1980 have experienced greater growth. The coefficient of 0.094 indicates that a 10 percentage point higher downtown share increases the trend growth rate by 0.9% per year, so a city with more than 1 million people and with a 10 percentage point higher share of college graduates downtown would have PMT grow by 2.9% per year more than a city with fewer than a million people and less human capital downtown.

Conclusion

Given that climate change is a global public bad and that there is no national carbon tax, no metropolitan area has strong financial incentives to unilaterally seek to be a "low carbon" city. In contrast, in this footloose age where cities are transitioning from being producer cities to consumer cities, center cities have strong incentives to offer a high quality of life (Glaeser, Kolko and Saiz 2001). Such cities that offer significant local public goods and consumption opportunities are more likely to retain the skilled to live in their jurisdiction. This paper has used several data sets to document that there is an association between attracting the highly educated downtown and the overall metropolitan area having a smaller carbon footprint from transportation.

We conclude that an unintended consequence of the rise of downtown consumer cities is a lower carbon metropolitan area. Past research has not explored the relationship between the geography of local quality of life and global externality production. Future research could examine other cities around the world such as Singapore, London, and European cities to explore the relationship between the center city's quality of life and the population's aggregate annual carbon transportation production.

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Table 1

Cross-Metropolitan Area Facts about Human Capital in the year 2000

Metropolitan Area	College Five Mile Density	College Share
Atlanta-Sandy Springs-Marietta, GA	1,045	0.33
Baltimore-Towson, MD	1,047	0.34
Boston-Cambridge-Quincy, MA-NH	3,372	0.43
Chicago-Joliet-Naperville, IL-IN-WI	3,095	0.33
Cincinnati-Middletown, OH-KY-IN	698	0.28
Cleveland-Elyria-Mentor, OH	304	0.27
Dallas-Fort Worth-Arlington, TX	1,170	0.31
Denver-Aurora-Broomfield, CO	1,509	0.38
Detroit-Warren-Livonia, MI	201	0.27
Houston-Sugar Land-Baytown, TX	1,392	0.28
Kansas City, MO-KS	331	0.33
Los Angeles-Long Beach-Santa Ana, CA	1,762	0.30
Miami-Fort Lauderdale-Pompano Beach, FL	1,038	0.29
Minneapolis-St. Paul-Bloomington, MN-WI	1,551	0.38
New York-Northern New Jersey-Long Island, NY-NJ-PA	9,631	0.35
Orlando-Kissimmee-Sanford, FL	638	0.27
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	1,582	0.33
Phoenix-Mesa-Glendale, AZ	384	0.28
Pittsburgh, PA	1,116	0.28
Portland-Vancouver-Hillsboro, OR-WA	1,818	0.32
Riverside-San Bernardino-Ontario, CA	383	0.19
Sacramento--Arden-Arcade--Roseville, CA	756	0.29
St. Louis, MO-IL	638	0.29
San Antonio-New Braunfels, TX	341	0.25
San Diego-Carlsbad-San Marcos, CA	1,158	0.35
San Francisco-Oakland-Fremont, CA	3,912	0.43
Seattle-Tacoma-Bellevue, WA	1,961	0.36
Tampa-St. Petersburg-Clearwater, FL	577	0.26
Washington-Arlington-Alexandria, DC-VA-MD-WV	3,411	0.47

Table 2: Correlation between Quality of Life Indicators, Population and College Graduates

	Total Population Within 5 Miles	College Graduates Within 5 Miles
Restaurants	0.90	0.97
Musical Groups	0.68	0.77
Museums	0.88	0.94
Hotels	0.78	0.82
Murder rate	0.24	0.14
College Graduates Within 5 Miles	0.91	1.00

Pearson correlation coefficient between quality of life (QOL) indicator, population and college graduates downtown. The first four QOL measures are counts of establishments within 5 miles of the Central Business District (CBD). The fifth QOL measure is number of murders in the principle city of the metro area, divided by principle city's population (in ,000s).

Table 3

Determinants of Household Carbon Dioxide Emissions from Private Transportation

	(1)	(2)	(3)
Explanatory Variables	The Dependent Variable = Pounds of CO2 Emissions		
College Density Within 5 Miles	-0.534***	-0.708***	-0.744***
	(0.081)	(0.079)	(0.097)
MSA % College Graduates	-8,298.382***	-7,499.969***	-4,723.690
	(2,260.459)	(2,518.740)	(3,511.064)
% of MSA Vote for Obama	-4,497.839**	-5,690.475***	-8,588.800***
	(1,851.000)	(1,967.678)	(2,966.896)
Head of Household Age	-3.345	9.072	28.538**
	(11.798)	(12.393)	(13.502)
Household Size	870.064***	909.672***	1,049.769***
	(112.170)	(115.274)	(126.293)
Driver Count in Household	7,159.385***	7,476.719***	7,292.169***
	(288.341)	(266.032)	(309.190)
Midwest	1,032.019*	1,048.998*	829.029
	(576.946)	(588.212)	(687.649)
South	1,343.491***	1,722.527***	1,606.012***
	(487.774)	(504.834)	(594.617)
West	728.662	155.532	140.574
	(461.651)	(484.875)	(555.336)
Log(MSA Population Density)	-159.180	-625.273***	-318.127
	(226.558)	(205.002)	(317.787)
Log(Distance to CBD)	1,133.882***		
	(252.789)		
Log(Tract Population Density)	-1,284.001***		
	(131.113)		
Constant	17,720.769***	13,552.646***	11,375.741***
	(1,676.149)	(1,665.639)	(2,472.627)
Observations	68685	69502	45482
R-squared	0.409	0.388	0.395

This table reports three OLS estimates of equation (1) in the text.
The omitted category is a household who lives in the Northeast in a metropolitan area.
The regression includes control variables for household income categories. Robust standard errors are reported in parentheses. The standard errors are adjusted for metro area clustering. A note the differences between columns two and three.

Table 4

Determinants of Household Carbon Dioxide Emissions from Private Transportation Using an Alternative Center City Vitality Measure

Explanatory Variables	(1) The Dependent Variable = Pounds of CO2 Emissions	(2)
Downtown % College Graduates	-9,384.565***	-9,003.637***
	(1,878.918)	(2,326.244)
Suburbs % College Graduates	375.459	-660.760
	(2,911.608)	(3,509.749)
Downtown % of MSA Employment	857.522	-360.597
	(1,001.836)	(1,143.711)
% of MSA Vote for Obama	-3,760.864*	-4,639.526**
	(2,046.557)	(2,242.305)
Head of Household Age	-4.699	8.214
	(11.749)	(12.407)
Household Size	862.777***	898.887***
	(113.599)	(116.986)
Driver Count in Household	7,189.758***	7,534.145***
	(289.322)	(266.516)
Midwest	1,884.187***	2,152.283***
	(516.007)	(649.567)
South	2,412.307***	3,026.557***
	(498.209)	(649.741)
West	1,589.697***	1,282.240*
	(519.711)	(652.872)
Log(MSA Population Density)	-716.948***	-1,525.440***
	(214.656)	(287.746)
Log(Distance to CBD)	1,147.882***	
	(253.765)	
Log(Tract Population Density)	-1,352.807***	
	(139.005)	
Constant	19,980.005***	17,630.301***
	(1,806.928)	(1,901.072)
Observations	68685	68685
R-squared	0.406	0.384

*** p<0.01, ** p<0.05, * p<0.1

This table reports two OLS estimates of equation (1) in the text. The omitted category is a household who lives in the Northeast in a metropolitan area. The regression includes control variables for household income categories. Robust standard errors are reported in parentheses. The standard errors are adjusted for metro area clustering.

Table 5

Contrasting OLS and IV Estimates

	(1)	(2)
	OLS	IV
Explanatory Variables	The Dependent Variable = Pounds of CO2 Emissions	
College Density Within 5 Miles	-0.759***	-1.460***
	(0.123)	(0.559)
% of MSA Vote for Obama	-10,696.241***	-8,943.838**
	(2,894.645)	(3,884.659)
Head of Household Age	20.469	19.987
	(14.399)	(14.450)
Household Size	1,090.799***	1,083.631***
	(141.250)	(137.581)
Driver Count in Household	7,032.263***	6,957.985***
	(320.451)	(324.319)
Midwest	1,039.849	-737.558
	(745.160)	(1,812.168)
South	1,399.912**	-317.269
	(672.721)	(1,850.332)
West	393.856	-1,831.255
	(689.306)	(2,152.349)
Log(MSA Population Density)	-314.952	775.437
	(313.630)	(854.184)
Constant	11,990.209***	6,429.632
	(2,582.206)	(4,688.279)
Observations	39467	39467
R-squared	0.395	0.394

*** p<0.01, ** p<0.05, * p<0.1

This table reports two estimates of equation (1) in the text. The omitted category is a household who lives in the Northeast in a metropolitan area. The regression includes control variables for household income categories. Robust standard errors are reported in parentheses. The standard errors are adjusted for metro area clustering.

Table 6

Trends in Metropolitan Area Public Transit Use from 1991 to 2009

	(1)	(2)
Explanatory Variables	Log(Passenger Miles Traveled)	
Time Trend	0.018***	-0.002
	(0.001)	(0.004)
Time Trend*(MSA Population > 1 Million)		0.022***
		(0.004)
Time Trend*(Downtown 1980 % BA)		0.094***
		(0.019)
Constant	15.858***	15.859***
	(0.015)	(0.015)
Observations	3,649	3,649
R-squared	0.933	0.934

*** p<0.01, ** p<0.05, * p<0.1

Metro Fixed Effects	Yes	Yes

This table reports two OLS estimates of equation (2) in the text.