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THE RISE OF THE LOW CARBON CONSUMER CITY

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ABSTRACT

Urban density both facilitates consumption opportunities and encourages individuals to drive less and walk and use public transit more. Using several data sets, we document that high quality of life consumer center cities are low carbon cities. We discuss possible causal channels for this association.

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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 drive more and use public transit less. In growing metropolitan areas, the bulk of employment and population growth tends to take 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 skilled to live downtown (Berry-Cullen and Levitt 1998, 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).

Glaeser, Kolko and Saiz (2001) document the rise of "consumer cities" featuring educated, wealthy people choosing to live downtown even when they work in the suburbs. Urban mayors seeking to attract and retain such taxpayers are investing in local beautification projects, increased policing and other efforts to improve local public goods. When educated, wealthy people cluster, this creates a consumer externality effect such that high quality stores and restaurants will appear nearby to sell to them (Waldfogel 2008). In this sense, the process feeds on itself.

In this paper, we document that a socially beneficial consequence of the rise of consumer cities is to reduce a metropolitan area's transportation carbon footprint. Public transit, walking and center city visits are complementary goods.[2] A more robust center city will increase the desire of all of the metropolitan area's residents to live a lifestyle that is oriented to visiting and spending time in the center city. While many suburban households may work in the suburbs and rely on their cars, they will be more likely to use public transit for discretionary trips to the center city. The center city households will use public transit and walk in their day to day lives.

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). By focusing on the differential in quality of life between the center city and the suburbs within the same metropolitan area, we build on the cross-metropolitan area quality of life literature. Starting with Roback (1982), Blomquist, Berger and Hoehn (1988), Gyourko and Tracy (1991), and through Albouy (2008), researchers continue to use hedonic methods to create index weights to rank metropolitan areas with respect to their bundle of non-market local public goods. In this paper, we use the share of center city residents in a metropolitan area who are college graduates as a proxy for the center city's quality of life.

Controlling for standard urban form variables such as metropolitan area density and the share of metropolitan area jobs that are located downtown, we document that a standardized household creates less greenhouse gas emissions from transportation in those metropolitan areas

[2] 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

with a larger downtown share of college graduates. Using a second data set, we document using public transit panel data from 1991 to 2009 that public transit ridership has increased more in those metropolitan areas where a larger share of downtown adult residents are college graduates. In the final section of the paper, we use another data set to rank public transit systems with respect to the carbon intensity per rider. These new estimates are useful for determining the carbon externality mitigation when riders substitute from private car to public transit.

Main Hypotheses

Throughout this paper, we assume that within metropolitan area quality of life is higher in those areas where the college educated cluster. This outcome is likely to be due to selection and treatment effects. In a Tiebout model of migration, the educated have the information and resources to identify 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. Once the high skilled cluster in a specific geographic area, this area's quality of life is likely to improve. The educated are more likely to vote and to be environmentalists (Moretti 2004, Kahn 2002). This group will engage in political activities to encourage local government officials to provide higher quality services. Spatial clusters of educated, high income individuals will attract better restaurants, shops and culture to locate nearby (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 (Bruekner and Rosenthal 2009). While the urban poor have a comparative advantage at commuting using public transit (Glaeser, Kahn and Rappaport 2008), richer people will be more willing to use this transit mode as street safety increases and downtown opportunities increase.

We recognize that the disutility from commuting will play a key role in determining residential locational choice of the skilled. In recent years, job growth has taken place in the suburbs rather than in the center city. Based on data from the Census Zip Code Employment files covering the years 2000 to 2005, we find that in zip codes less than five miles from downtown, employment growth was -11%, and in zip codes more than five miles from downtown, employment growth was 5%. Major companies such as Google and Facebook that employ many high skilled individuals are located far from center cities. The rise of corporate campuses would tend to re-enforce the suburbanization of the skilled unless there were offsetting center city consumption amenities.

This paper's empirical work focuses on testing the following three hypotheses. We first list them and then discuss some key points.

Hypothesis 1: When the skilled cluster in the center city, the metropolitan area has a lower transport carbon footprint.

Hypothesis 2: If the center city has binding land use regulation that inhibits new construction, then this reduces the carbon reduction effects of center city skill concentration.

Hypothesis 3: The extent of the carbon reduction due to mode substitution from private cars to public transit differs across metropolitan areas because the carbon externality associated with a passenger mile of public transit use varies across cities.

With regards to the second hypothesis, in an unconstrained housing market, improvements in center city quality of life would encourage housing developers to build more housing units in this increasingly desirable area. Such increased compactness would encourage overall sustainability as more of the population would be living at higher density. The emerging literature on housing supply regulation has noted that leading consumer cities such as Boston (Glaeser and Ward 2008), San Francisco (Kahn 2011) and New York City all inhibit new construction (Quigley and Rosenthal 2005). An open question concerns whether these cities are vibrant consumer cities because of their housing regulation. From a sustainability point of a view, a consequence of this housing regulation is that it may be difficult to scale up urban development in those consumer cities with binding regulation.

Empirics

In this section, we present three pieces of empirical work that test the hypotheses stated above. Our first data source is the Department of Transportation's 2009 National Household Travel Survey (NHTS). The NHTS is a distinctive micro data set because it 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. Our primary 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).[4]

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[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.

[4] 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

$$GHG_i = \sum_j \beta_j Z_k^j + \sum_q \gamma_q X_i^q + \mu_k + \varepsilon_i \qquad (1).$$

In this regression, the dependent variable is the level of annual household GHG emissions produced by household i, Z_k^j refers to the value of characteristic j in tract k, β_j refers to the impact of those variables, X_i^q refers to the value of individual characteristic q for household i, γ_q is the coefficient on that characteristic, and the last two terms are tract and household level error terms, respectively.

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 Department of Energy is 19.64;[5] 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.[6] 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.

The results from estimating equation (1) are reported in Table 1. This table does not report the income fixed effects; the estimated coefficients on these variables were monotonically

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households whose head is between the ages of 18 and 65, and for whom we have complete demographic and geographic data.

[5] 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

[6] "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.

increasing with income. The standard errors are clustered by MSA. In Table 1, the key explanatory variable is the downtown's share of adult residents who are college graduates. We calculated this measure using tract-level data from the 2000 Census. Here, as with the other "downtown" variables, we define downtown as the area within five miles of the CBD. This is a revealed preference measure of the desirability of the center city because the college-educated could afford to live anywhere in the metro area. We also include the share of other metro area adults (beyond five miles from the CBD) who are college graduates. The correlation between the downtown 2000 share and the suburban share is 0.46. We include both to highlight that our results do not simply reflect a "skilled metro area" effect. A second downtown vibrancy measure captures downtown employment, specifically the fraction of all MSA jobs downtown. This data comes from the 2005 Zip Code Business Patterns (ZBP).[7]

We recognize that the observed effects of urban form on travel behavior are not due exclusively to the effects of density, transit access, or centrality *per se* but also to the fact that those who have an innate preference for certain travel behaviors self-select into communities that permit these preferences to be expressed.[8] Concerned about the endogeneity of the within metropolitan area residential choice decision, we present our estimates of equation (1) with and without the within metro area locational choice variables.

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. To address concerns that low density cities may be home to political conservatives while liberals concentrate

[7] Zip code geocodes were obtained from the ESRI Data and Maps CD.
[8] 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).

in more compact metropolitan areas, we control for the metropolitan area 2008 share of voters who voted for President Obama.

Table 1 reports five 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. 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 negative and statistically significant coefficient on the percent of downtown adults who have a college degree.[9] Based on column (2), all else equal, a household who lives in a metro area with a 10 percentage point larger downtown share of college educated households produces 911 fewer pounds of CO_2 per year. Given the summary statistics for household carbon dioxide emissions, this represents 1/20th of a standard deviation. In contrast, the suburban share of college educated households is much smaller in absolute value and is not statistically significant in any of the regressions. Other coefficients on urban form have the standard interpretation. Northeast households have a smaller carbon footprint than other regions, while households in the South have a much larger transport footprint.

As shown in column (3), when we restrict the sample to metropolitan areas with more than 500,000 people the downtown job share coefficient is negative and statistically significant. Metropolitan areas with one more standard deviation of employment downtown (19%) and one more standard deviation of college graduates downtown (10.2%) are associated with 1/8th of a

[9] Recall that this variable represents the ratio (count of adults with a college degree in the year 2000 who live within five miles of the metro area's CBD)/(count of adults in the year 2000 who live within five miles of the metro area's CBD). We also include the metropolitan area's percent of remaining adults who have a college degree. This is defined as the ratio (count of adults with a college degree in the year 2000 who live more than five miles from the metro area's CBD)/(count of adults in the year 2000 who live more than five miles from the metro area's CBD).

standard deviation reduction in the average metropolitan area resident's carbon emissions from transportation. 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. Columns (4) and (5) stratify the sample into metropolitan areas where President Obama received less than 50% of the vote in the 2008 election and more than 50% of the vote. We present this stratification to test whether liberal and conservative areas exhibit different relationships. The downtown college graduate share has a negative coefficient in Republican metro areas but the coefficient shrinks towards zero. Interestingly, as shown by column (4), households create more carbon emissions when more jobs are downtown in the conservative metropolitan areas while the coefficient remains negative in the liberal areas.

In Table 2, we report additional estimates of equation (1). In columns (1) and (2), we contrast OLS and instrumental variables estimates for the same subsample. Recall that the NHTS data are from the year 2009 and that we use year 2000 Census data to create the human capital shares. 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 in 2000 could be correlated with unobserved determinants of carbon dioxide emissions in 2009. 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 2000 college share.[10] This 1930 variable is not available for every metropolitan area. In Table 2'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 percent of downtown adults who have a college degrees are negative and statistically significant. The IV estimate is roughly 40% larger in absolute value than the OLS coefficient.

To test hypothesis #2, we use data from the Wharton Land Use Regulatory Index and merge for each metropolitan area the index for the center city (Gyourko, Saiz, Summers 2008). We create a dummy variable that equals one if the center city's regulation is greater than the median WRLURI score for the full sample of center cities and this dummy equals zero otherwise. We interact this dummy with the downtown and suburban college graduate shares. If regulation makes the downtown costly by limiting supply and college graduates downtown bid up demand then high real estate price should lead to a deflection effect such that more people live further from the city center and drive more.

Since we do not have WLURI data for all the metro areas, in Table 2's column (3), we estimate the same specification of equation (1) that we reported in Table 1's column (2) but in this case we focus on the subset of observations for which we know the metro area's center city WLURI index. The estimates in Table 2's column (3) are qualitatively quite similar to the results reported in Table 1's column (2). In Table 2's column (4), we include the three additional regulation variables. All else equal, we find that metropolitan areas featuring less downtown housing regulation have a smaller carbon footprint as the share of downtown college graduates increases. For metropolitan areas whose center cities feature high regulation, the marginal effect

[10] 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 $R2 = .031$.

of downtown college graduates is (-13,039 + 6,810) while in the low downtown regulation metropolitan areas this marginal effect is -13,039, or roughly 50% larger in absolute value. This finding is intuitive. If the downtowns where the college graduates cluster is desirable and if the center city features low regulation, then more housing can be built downtown and close to this area.

Time Trends in Public Transit Use and Downtown Human Capital Agglomeration

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 cities 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:

$$\log(PMT_{it}) = \alpha_i + \beta_1 t + \beta_2 t\,\delta_i + \varepsilon_{it} \qquad (2).$$

In equation (2), α_i is the urban area fixed effect, t is the time trend (1991 is set equal to 1) and β_1 is the coefficient on this variable, γ_i is an indicator variable equal to one if the

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

population of the urban area is greater than one million and β_2 is a coefficient to be estimated, δ_i is a vector of metropolitan area attributes, and ε_{it} 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 3 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 3, we report two estimates of equation (2). In both regressions, we include urban area 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.

Which Major Urban Areas Feature Low Carbon Public Transit?

The final hypothesis we test focuses on the inter-city variation in the public transit system's carbon intensity. Across cities, there is variation in public transit trip modes (i.e. subway versus bus) and the inventory of capital that cities have (i.e. bus size and vintage and fuels used for bus trips). Subways, in urban areas that have them, rely heavily on electricity. The carbon emissions from such consumption hinges on the local emissions factor of the state's electric utilities. If the state's power is generated using coal, then the same amount of electricity creates more carbon than if the state uses renewables or natural gas. Most bus systems use fossil fuels to power their vehicles. Depending on a public transit system's inventory of buses, the carbon emissions per passenger mile of bus use will differ.

In this section, we quantify the average carbon dioxide production per mile of passenger travel using public transit data for urban areas. The 2011 National Transit Database provides aggregate system wide information by urban area by public transit mode on energy consumption and passenger miles travelled.[12] We use the following equation to calculate total pounds of carbon dioxide from fossil fuels (measured in gallons).[13]

$$CO2 \text{ from fuel} = 22.38*Diesel + 19.64*Gasoline + 13.23*LPG + 16.11*LNG + 9.06*Methane + 12.67*Ethanol + 16.11*CNG + 26.011*Bunker + 21.52*Kerosene + 19.64*Grain + 20.13*Biofuels + 19.64*Other \quad (3)$$

[12] The NTD was established by Congress to be the Nation's primary source for information and statistics on the transit systems of the United States. Recipients or beneficiaries of grants from the Federal Transit Administration (FTA) under the Urbanized Area Formula Program (§5307) or Other than Urbanized Area (Rural) Formula Program (§5311) are required by statute to submit data to the NTD. Over 660 transit providers in urbanized areas currently report to the NTD through the Internet-based reporting system. Each year, NTD performance data are used to apportion over $5 billion of FTA funds to transit agencies in urbanized areas (UZAs). Annual NTD reports are submitted to Congress summarizing transit service and safety data. http://www.ntdprogram.gov/ntdprogram/ntd.htm and http://www.ntdprogram.gov/ntdprogram/datbase/2011_database/NTDdatabase.htm

[13] Our data sources for these emissions factors are Knittel (2012) and the US Energy Information Administration – Voluntary Reporting of Greenhouse Gasses Program (http://www.eia.gov/oiaf/1605/coefficients.html#tbl2).

We calculate total megawatts of electricity used for public transit. To convert these megawatts of power into pounds of CO_2 we use 2009 EGRID data to calculate each state's average electric utility carbon dioxide emissions factor.[14] The 2009 EGRID provides power plant level data on each utility's emissions factor and power generation. We use these data to calculate a weighted mean for each state. By multiplying the system's total electricity in MW by the state level emissions factor (pounds of carbon per MW), we then can add the fossil fuels consumption from transport to the carbon from electricity. We then calculate each city's carbon dioxide emissions per passenger mile. For urban areas with multiple public transit systems and commuter rail, we sum up the various systems within the jurisdiction.

In Table 4, we present our city specific emissions factors based on the 2011 data for 26 major urban areas. A city can have a high public transit carbon per mile because of fossil fuel used by state's utilities or because using high carbon fuels for buses that don't carry many passengers. If public transit is a constant returns to scale technology, then we can use the estimates reported in Table 4 to infer what is the net environmental gains from substituting a mile of private vehicle travel to a mile of public transit travel. If a car has a fuel economy of 27.5 MPG then it requires 0.036 gallons per mile. Using an emissions factor of 19.64 pounds per gallon yields a per mile carbon production equal to 0.036*19.64 or 0.714 pounds of carbon dioxide per mile. This is roughly six times higher than major public transit systems such as NYC or San Francisco. Table 4 presents the ranking of major city carbon emissions factors. San Francisco and New York City are the top two at 0.122 and 0.136. Perhaps surprisingly, Houston is number 3 at 0.152 while Seattle's public transit has the largest carbon emissions factor at 0.719.

[14] http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

Conclusion

Given that climate change is a global public bad, no metropolitan area has strong 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. 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. Building on past research, we have made the intuitive assumption that downtowns that have a large metropolitan area job share and that have large shares of adults who are college graduates are areas offering opportunities for work and leisure. In short, consumer center cities contribute to creating low carbon metropolitan areas (Glaeser and Kahn 2010).

Throughout this paper, we have taken the spatial distribution of households as given. Future research could consider introducing a general equilibrium model of zoning in which the center city chooses its zoning intensity and this both affects the local public goods bundle and the equilibrium price of housing in the center city and the suburbs. Heterogeneous households would take this pricing gradient as given and choose where in the suburbs to live as developers build in such locations (Anas, Arnott and Small 1998). As center city vitality increases, the model would yield predictions about the new spatial distribution of households throughout the metropolitan area and this could be used in conjunction with estimates such as what we report in Table 1 to predict the carbon emissions reductions.

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Table 1

Household Transportation Carbon Dioxide Emissions in 2009

	(1)	(2)	(3)	(4)	(5)
Explanatory Variables	The Dependent Variable = Pounds of CO2 Emissions				
% of MSA Vote for Obama	-3,097.748	-3,458.414	-4,074.363		
	(2,059.784)	(2,274.324)	(3,672.264)		
% Downtown who have a B.A	-9,287.571***	-9,107.978***	-7,319.899***	-4,700.923**	-9,718.879***
	(1,846.685)	(2,220.837)	(2,617.932)	(2,289.124)	(2,277.494)
% of Suburban who have a B.A	817.547	-60.541	-714.189	3,257.538	-1,374.997
	(2,848.188)	(3,402.744)	(4,319.178)	(5,224.774)	(3,606.390)
% of MSA Jobs Downtown	694.249	-504.871	-6,840.689***	2,045.379**	-2,733.001
	(1,003.509)	(1,150.245)	(2,182.821)	(1,015.380)	(1,811.155)
Subway	-353.440	-569.925	-416.988	6,502.970***	-204.975
	(492.780)	(570.461)	(696.722)	(593.851)	(586.191)
Midwest	1,793.449***	1,996.003***	1,364.458**	-817.074	2,090.957***
	(508.545)	(622.709)	(685.410)	(1,509.723)	(596.809)
South	2,435.119***	3,047.330***	2,539.651***	1,488.834	2,454.058***
	(495.159)	(631.567)	(693.879)	(1,328.581)	(617.437)
West	1,595.900***	1,318.369**	1,302.122**	-1,474.639	1,577.931**
	-515.58	(640.827)	(596.932)	(1,393.903)	(609.803)
Log(MSA Population Density)	-617.156***	-1,353.963***	-1,903.054***	-937.729***	-1,955.105***
	(235.770)	(285.253)	(402.508)	(292.358)	(312.054)
Log(Distance to CBD)	1,086.998***				
	(252.853)				
log(Tract Population Density)	-1,330.395***				
	(135.825)				
Constant	11,598.105***	8,541.564***	14,106.934***	2,763.354	12,338.159***
	(2,793.666)	(2,927.591)	(4,154.392)	(4,528.282)	(3,483.277)
Observations	68685	69502	45482	29742	39760
R-squared	0.409	0.388	0.395	0.360	0.399

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

The omitted category is a household who lives in the Northeast in a metropolitan area that does not have a subway. The regression includes control variables
for household income categories, age, household size, number of drivers. Robust standard errors are reported in parentheses. The standard errors are adjusted for metro area clustering.

Table 2

Additional Household Transportation Carbon Dioxide Emissions Regressions

	(1)	(2)	(3)	(4)
Explanatory Variables	The Dependent Variable = Pounds of CO2 Emissions			
% of MSA Vote for Obama	-4,484.279	-1,767.345	-4,636.514*	-3,682.995
	(3,914.048)	(5,338.784)	(2,411.592)	(2,371.855)
% Downtown who have a B.A = X1	-11,535.660***	-15,673.126**	-8,351.127***	-13,039.375***
	(2,445.273)	(6,703.159)	(1,952.534)	(2,608.100)
% of Suburban who have a B.A = X2			-2,719.347	-3,462.011
			(3,178.512)	(4,020.912)
Above Median WLURI Center City = X3				-2,337.109*
				(1,344.368)
X1*X3				6,810.347**
				(3,452.838)
X2*X3				384.197
				(5,230.766)
% of MSA Jobs Downtown	198.159	1,678.099	-1,536.137	-2,169.030*
	(2,016.475)	(2,932.835)	(1,295.633)	(1,279.529)
Subway	-1,084.594	-1,515.774	-367.286	-408.167
	(862.293)	(960.280)	(598.960)	(592.696)
Midwest	2,407.815***	2,375.257***	3,135.207***	3,038.265***
	(617.135)	(586.441)	(616.842)	(659.373)
South	3,758.834***	4,126.784***	4,143.115***	4,232.001***
	(693.096)	(876.765)	(576.932)	(579.293)
West	2,475.537***	2,457.186***	2,583.323***	2,780.108***
	(595.473)	(594.507)	(551.037)	(587.616)
Log(MSA Density)	-970.245**	-681.121	-1,187.579***	-1,164.404***
	(391.704)	(543.178)	(249.878)	(256.494)
Constant	5,798.242	3,227.791	7,597.208***	8,663.995***
	(4,205.558)	(5,696.966)	(2,814.582)	(2,890.150)
Observations	39467	39467	60,058	60,058
R-squared	0.395	0.394	0.393	0.394

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

The omitted category is a household who lives in the Northeast in a metropolitan area that does not have a subway and is below the median WLURI. The regression includes control variables for household income categories, age, household size, number of drivers. Robust standard errors are reported in parentheses. The standard errors are adjusted for metro area clustering.

Table 3

Trends in Metropolitan Area Public Transit Use

Explanatory Variables	(1)	(2)
	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

Years 1991 to 2009

Table 4

2011 Carbon Emissions Factors for Major Public Transit Systems

Metropolitan Area	Pounds of CO_2 per Passenger Mile
San Francisco-Oakland, CA	0.122
New York-Newark, NY-NJ	0.136
Houston, TX	0.152
San Diego, CA	0.260
Chicago, IL-IN	0.267
Atlanta, GA	0.283
Portland, OR-WA	0.290
Sacramento, CA	0.420
Riverside-San Bernardino, CA	0.461
Philadelphia, PA-NJ-DE	0.470
Miami, FL	0.506
Washington, DC-VA-MD	0.515
Los Angeles-Long Beach, CA	0.517
Detroit, MI	0.520
Albany-Schenectady, NY	0.532
Buffalo, NY	0.537
Phoenix-Mesa, AZ	0.558
New Orleans, LA	0.565
Cleveland, OH	0.600
Seattle, WA	0.719