Urban Policy Effects on Carbon Mitigation

Matthew E. Kahn[1]
UCLA and NBER
June 16th 2010

[1] This paper was prepared for the May 2010 NBER Design and Implementation of U.S. Climate Policy Conference. I thank Varun Mehra, Frank Wolak and Catherine Wolfram for useful comments. Email: mkahn@ioe.ucla.edu .

Urban Policy Effects on Carbon Mitigation

Abstract

The geographical location of economic activity within the United States has important implications for carbon mitigation. If households clustered in California's cities rather than in more humid southern cities such as Memphis and Houston, then the average household carbon footprint would be lower. Such households would consume less electricity and this power would be generated by cleaner electric utilities. Within metropolitan areas, urban economic theory predicts that households create less greenhouse gas emissions when they live closer to the city center. This study uses three data sets reporting on household driving, public transit use and residential electricity consumption to provide evidence in support of the claim of a negative association between center city living and a household's carbon footprint.

Introduction

Suppose that a household was choosing between living in Houston or San Francisco. In each city, what would this household's annual carbon footprint be? Glaeser and Kahn (2010) estimate that a standardized household would create 12.5 extra tons of carbon dioxide per year if it moved to Houston rather than moving to San Francisco. In Houston, the same household drives more, lives in a bigger home, uses more residential electricity – electricity that is generated by power plants with a higher carbon emissions factor. Using data from the year 2000 across 64 major metropolitan areas, Glaeser and Kahn (2010) document that Pittsburgh is the city with the median residential household footprint of 28.3 tons of carbon dioxide per year while San Francisco is the third "greenest" metropolitan area and Houston is the third "brownest" metro area. This cross-sectional descriptive work creates a benchmark for comparing cities' household carbon emissions from transportation, electricity consumption and home heating, at a point in time and tracking city trends over time.

Given that greenhouse gas emissions are a global externality, households are unlikely to internalize the carbon consequences of moving to a city such as Houston rather than San Francisco. Why is San Francisco "greener" than Houston? San Francisco is blessed with a temperate climate. Northern California's electric utilities emit less greenhouse gas emissions than their Texas counterparts. Due to its amenities, land prices are higher in San Francisco and its residents live in smaller homes than their Houston counterparts. Land prices are highest downtown and this encourages economy activity to be highly compact. Such population density in San Francisco encourages households to live a walking, "new urbanist" life. This "low carbon" lifestyle would be rare in sprawling Houston.

Over the last 100 years, people and jobs have been moving away from center cities. The average person who lived in a metropolitan area lived 9.8 miles from the City Center in 1970 and this distance grew to 13.2 miles by the year 2000. While privately beneficial, this trend has helped to exacerbate the challenge of mitigating greenhouse gas production. Suburbanites drive more, and live in larger homes that require more heating and cooling than their urban counterparts.

This paper uses three different data sets to document that households who live in center cities drive less, use public transit more, and consume less electricity than observationally similar households who live in the suburbs. This center city/suburban differential is largest in the

Northeast's monocentric cities such as New York City. Given that households choose where to live, this differential could be caused by both residential self selection and a true causal "treatment effect" of urban living. If these correlations are due to a "treatment effect", then any pro-center city policy, such as policies directed towards reducing inner-city crime, is likely to reduce a metropolitan area's carbon footprint.

Urban Transportation

Miles Driven as a Function of Urban Form

The Department of Transportation has recently released the 2009 National Household Transportation Survey (NHTS) micro data.[2] This micro data set is distinctive because it reports household vehicle mileage for a large representative sample of households. Using a special version of the data set that has census tract identifiers, I restrict the sample to households living within 35 miles of a major city center. For each household, I observe which metropolitan area it lives in, its distance to the City Center and its distance to the closest rail transit station using data from Baum-Snow and Kahn (2005). I estimate ordinary least squares regressions using observations on over 92,000 households based on equation (1):

$$Miles = MSA + B_1 * Demographics + B_2 * Urban\ Form + U \qquad (1)$$

In this regression, the dependent variable is the household's total miles driven in the last year. I trim the dependent variable and set the dependent variable equal to the 99th percentile of the empirical distribution for observations in the top percentile. In Table One, columns (1) and (2) are identical except that the results in column (2) include metropolitan area fixed effects. In these regressions, I control for household income, the number of people in the household and the age of the head of the household. Controlling for these demographic factors, my primary interest is to measure the association between a household's total miles driving and its location within the metropolitan area, the population density where it lives, and whether it lives close to a rail transit station. The results are roughly similar with and without metropolitan area fixed effects. As shown in Table One, distance from the city center is positively correlated with miles driving. Moving a household from the 25th percentile of the distance to the city center

---

[2] http://nhts.ornl.gov/download.shtml#2009

distribution to the 75th percentile of this distribution is associated with driving an extra 1,300 miles per year. A household's census tract's population density is negatively correlated with miles driving. Moving a household from the 25th percentile of the population density distribution to the 75th percentile of this distribution is associated with a driving 2,400 fewer miles per year. In both regressions, proximity to a rail transit station has a negative but statistically insignificant effect on driving.

These correlations are suggestive about the role that urban policy plays in encouraging driving less. If households were randomly assigned to homes, then OLS estimates of equation (1) would be of immediate use to policy makers in determining how urban policies affect an important part of the household carbon footprint (miles driven). But, we know that households self select where they want to live. Liberal/environmentalists are likely to self-select and choose to live in the high density areas, close to center city and close to subway stations (Kahn and Morris 2009). An active research agenda in urban planning examines the importance of attitudes, beliefs and preferences in determining residential location choice and travel behavior (e.g. Cao, Handy, and Mokhtarian, 2006; Cao, Mokhtarian, and Handy, 2007; Krizek, 2003).

Public Transit Use from 1970 to 2000

In previous research, I have examined how worker public transit varies across cities and over time for cities that have expanded their rail transit systems (Baum-Snow and Kahn 2005). This work has public policy implications because rail transit construction is a favorite urban policy for encouraging center city growth and compact urban development.

Communities differ with respect to their distance to the CBD and their distance to rail transit stations. Rail transit is a fast means for commuting to the city center. As discussed in Glaeser and Kahn (2001 2004), a fundamental challenge for urban policy in battling climate change is that jobs continue to suburbanize. When people work in the suburbs, they do not use public transit to commute there. But, in cities such as New York City with a vibrant center city core, public transit remains an important commuting mode.

To examine how rail transit access affects commute mode choice, I use census tract level data for 42 major metropolitan areas. I examine how proximity to the CBD and proximity to rail transit correlates with public transit use. I use a geocoded census tract panel data set from 1970, 1980, 1990 and 2000 and observe public transit use by workers (the percent of the census tract who commute using public transit), while restricting the sample to tracts within 35 miles of a major city's CBD.

In Table Two, the dependent variable is a tract's public transit use share. Each column reports a separate regression. I include all metropolitan areas that are within 35 miles of a city center that has a rail transit system. Controlling for metropolitan area fixed effects, several facts emerge. Relative to the omitted category (1970), the propensity to commute by public transit has declined each decade. The propensity to commute by public transit declines with distance from the city center and increases if a tract's centroid is within one mile of a rail transit station. These results are robust to controlling for tract demographics such as the share black and the share college graduate (see column 2).

Differences in Residential Energy Consumption between Urban and Suburban Households

In this section, I examine household residential energy consumption for center city versus suburban residents and I compare how energy consumption varies across geographical regions of the nation. I use micro data from the 2005 Residential Energy Consumption Survey (RECS) for households who live in urban and suburban areas.[3] While the RECS data does not provide information on the exact metropolitan area where a household lives, it does provide information on the household's Census Division, cooling degree days where the home is located, and the household's urban versus suburban status. I estimate versions of equation (2).

$$\ln(energy) = c + B_1 * Demographics + B_2 * Suburb + U \qquad (2)$$

[3] http://www.eia.doe.gov/emeu/recs/recspubuse05/pubuse05.html

Controlling for a household's income, and the number of people in the home, why would electricity consumption differ for suburban versus urban households? In a classic monocentric city, all jobs are located in the Central Business District. Land prices decline with distance from the city center to compensate households for longer commutes. If land prices are lower in the suburbs, then suburban homes will be larger and the households who live there will consume more energy. As documented by Glaeser and Kahn (2001, 2004), employment has been suburbanizing but major center cities such as New York City and others in the North East continue to be major employment centers. I predict that suburbanites in regions where a large share of employment continues to be downtown (and thus the monocentric model has more predictive power) will feature a larger center city/suburb energy consumption differential.

The energy consumption regressions are reported in Table Three. In column (1), the dependent variable is the log of household electricity consumption. Controlling for the household's income and demographics, the average suburbanite outside of the Northeast region consumes 10% more electricity than the average urbanite. In the Northeast region, this differential is much larger. The average suburbanite in the Northeast consumes 51% more electricity than the average urbanite. The divisional dummies show the spatial variation in energy consumption with the East South Central division having the highest residential electricity consumption.[4] Column (2) shows a similar Northeast urban/suburban differential for natural gas consumption. This suburban/center city differential could simply reflect selection rather than a "treatment effect". In column (3), the dependent variable is a dummy that equals one if the household lives in a single detached home. Single detached homes are likely to be larger than apartments in multi-family housing. Larger homes require more electricity. The probability that a household lives in single family home is higher in the suburbs and much higher (23.5 percentage points) in the Northeast suburbs. This evidence supports the claim that the urban/suburban electricity consumption gap is larger in monocentric cities because of the within metropolitan area differences in the housing stock. In a metropolitan area with a uniform distribution of employment and no spatially differentiated amenities, I would not expect to observe spatial differences in residential energy consumption because the price of land would be the same throughout the area.

[4] These states include Alabama, Kentucky, Mississippi, and Tennessee.

Conclusion

The “macro” debate about the costs and benefits of adopting carbon pricing has not discussed how carbon mitigation incentives will affect competition between center cities and their suburbs or between “low carbon” cities such as San Francisco and “high carbon” cities such as Houston. The low carbon city is a city that is compact and dense, and offers fast, frequent public transit that helps people commute to downtown.

Across regions there are large differences in the household carbon footprint. Glaeser and Kahn (2010) find that cities in California such as Los Angeles, San Diego and San Francisco, have the smallest residential carbon footprint while cities in the South, such as Memphis, Oklahoma City, Houston and Nashville, have the largest carbon footprint. Their results suggest that housing development policies that lower barriers to development in California’s coastal cities would “green” the overall national average. Housing economists have ranked cities with respect to the stringency of their anti-growth policies. The “low carbon” cities identified by Glaeser and Kahn tend to be the same cities that have high land use regulation (Glaeser, Gyourko and Saks 2005, and Quigley and Raphael 2005). Glaeser and Kahn (2010) argue that housing regulation does not cause a low carbon footprint. They argue that the anti-growth cities are “green” because of their local climate conditions and their relatively low electric utility emissions factor (using natural gas rather than coal). This claim merits future research.

If carbon legislation is past soon, the residents of the low carbon cities will face less of a tax burden and this will be capitalized into local land prices. Previous incidence studies have focused on geography and income categories but not the center city/suburbs dimension (Hassett , Mathur, and Metcalf 2007). The introduction of a significant carbon tax may help to reverse a fifty year trend in the suburbanization of households and firms (Glaeser and Kahn 2004).

Such a tax could reduce the current carbon gap between cities such as San Francisco and Houston. In the long run, in the presence of such a tax, Houston’s transport infrastructure, residential building stock, and portfolio of electric utilities might resemble San Francisco’s. Urban economists have tried to use the “natural experiment” of the OPEC Oil Shocks to examine whether high gas prices encourage densification (Muth 1984). These short run shocks did not increase the demand for center city living in the 1970s.

This paper's evidence suggests that center city residents do produce less carbon emissions than their suburban counter-parts. A productive future line of research could use panel data to disentangle whether the observed correlation between center city living and the low carbon lifestyle represents a self selection effect or a true causal effect.[5] If future research substantiates the causal role of center city living, then this raises the public policy issue of how do we encourage more households to live downtown? Policies that improve the center city's quality of life and local public goods bundle can achieve this goal. The vibrancy of a downtown can be spurred by fighting crime and by improving urban public schools (Berry-Cullen and Levitt 1998).

[5] See Eid, Overman, Puga and Turner (2008) for a recent study that uses panel data to attempt to estimate the impact of urban form on obesity. By observing weight changes for migrants from center cities to suburbs (and vice-versa), they reject the claim that "sprawl is making us fat".

References

Baum-Snow, Nathaniel and Matthew E. Kahn, 2005, The Effects of Urban Rail Transit Expansion: Evidence from Sixteen Cities from 1970 to 2000, Brookings-Wharton Conference on Urban Affairs .Volume, edited by Gary Burtless and Janet Rothenberg Pack.

Berry Cullen, Julie& Steven D. Levitt, 1999. "Crime, Urban Flight, And The Consequences For Cities,"The Review of Economics and Statistics, vol. 81(2), pages 159-169, May.

Cao, X., Handy, S. L., &Mokhtarian, P. L. 2006. The influences of the built environment and residential self-selection on pedestrian behavior: Evidence from Austin TX. Transportation, 33(1), 1-20.

Cao, X.,Mokhtarian, P. L., & Handy, S. L. 2007. Do changes in neighborhood characteristics lead to changes in travel behavior? A structural equations modeling approach.Transportation, 34(5), 535-556.

Eid, Jean, Henry Overman, Diego Puga and Matthew Turner. Fat city: Questioning the relationship between urban sprawl and obesity, Journal of Urban Economics, March 2008

Glaeser, Edward and Matthew E. Kahn 2001, Decentralized Employment and the Transformation of the American City, joint with Ed Glaeser, *Brookings/Wharton Papers on Urban Affairs* Volume 2. 2001.

Glaeser, Edward and Matthew E. Kahn, Sprawl and Urban Growth (Chapter in the Handbook of Urban Economics Volume IV) joint with Edward Glaeser, edited by Vernon Henderson and J. Thisse. Volume 4. North Holland Press. 2004.

Glaeser, Edward and Matthew E. Kahn, 2010. The Greenness of Cities: Carbon Dioxide Emissions and Urban Development ,Journal of Urban Economics, vol. 67(3), pages 404-418

Glaeser, Edward L, Joseph Gyourko, and Raven Saks. 2005. Why is Manhattan So Expensive? Regulation and the Rise in House Prices." Journal of Law and Economics. 48(2): 331-370.

Hassett, Kevin, Aparna Mathur, and Gilbert Metcalf. The Incidence of a U.S Carbon Tax: A Lifetime and Regional Analysis. NBER Working Paper # 13554, 2007.

Kahn, E. Matthew and Eric Morris. 2009. Walking the Walk: Do Green Beliefs Translate Into Green Travel Behavior, *Journal of the American Planning Association*, 2009 , 75(4) 389-405.

Krizek, Kevin. 2003. Residential relocation and changes in urban travel: Does neighborhood-scale urban form matter? Journal of the American Planning Association, 69(3), 265-281.

Muth, Richard 1984. Energy Prices and Urban Decentralization. In Energy Costs, Urban Development and Housing. Edited by Anthony Downs and Katharine L. Bradbury, Brookings Institution.

Quigley, John M., and Stephen Raphael, 2005 "Regulation and the High Cost of Housing in California," American Economic Review. 95(2), pages 323-328

Table One: Household Miles Driven as a Function of Urban Form

	(1)	(2)
Log(Distance to City Center)	1255.15	1167.24
	[216.605]***	[253.444]***
Log(Census Tract Density)	-1243.96	-1118.40
	[124.807]***	[148.417]***
Within 1 Mile of Rail Transit	-778.54	-1495.15
	[767.834]	[950.126]
Household Size	4999.03	5049.01
	[224.309]***	[209.100]***
Age of Head of Household	-77.38	-77.58
	[12.070]***	[11.575]***
Constant	7222.00	4811.92
	[2730.142]***	[3360.468]
Observations	92597	92597
R-squared	0.26	0.27
Geographical Fixed Effect	No	Metro
Household Income Fixed Effect	Yes	Yes

The unit of analysis is the household. The dependent variable is the household's annual mileage. The sample includes all households in the 2009 NHTS who live in a census tract whose centroid is within 35 miles of a city center. *** indicates statistical significance at the 1% level. Standard errors are reported in brackets. The standard errors are clustered by census tract. The omitted category is a household who lives more than a mile from the closest rail transit station. Dummy variables for the household's income category are included in the regressions but their coefficients are suppressed. Miles driven has a mean of 17,925 and a standard deviation of 19.061.

Table Two: Public Transit Use and Urban Form from 1970 to 2000

	Tract Share of Workers Commuting Using Public Transit		
	(1)	(2)	(3)
Log(Tract Distance to CBD)	-0.119	-0.109	
	[0.001]***	[0.001]***	
1(Within 1 Mile of Rail Station)	0.043	0.038	0.023
	[0.002]***	[0.002]***	[0.001]***
1980 Year Dummy	-0.024	-0.022	-0.011
	[0.001]***	[0.001]***	[0.000]***
1990 Year Dummy	-0.032	-0.033	-0.021
	[0.001]***	[0.001]***	[0.000]***
2000 Year Dummy	-0.032	-0.034	-0.021
	[0.001]***	[0.001]***	[0.000]***
Tract Share College Graduate		0	
		[0.002]	
Tract Share Black		0.148	
		[0.002]***	
Constant	1.329	1.204	0.154
	[0.006]***	[0.005]***	[0.000]***
Observations	74076	74076	74076
R-squared	0.665	0.701	0.969
fixed effects	metro	metro	tract

This table reports three ordinary least squares regressions. The omitted category is a 1970 census tract whose centroid is more than one mile from the closest rail transit station. In columns (1-3), the sample includes all census tracts whose centroid is within 35 miles of a CBD in a city with a rail transit system. *** indicates statistical significance at the 1% level. Standard errors are reported in brackets. The dependent variable has a mean of .16 and a standard deviation of .19.

Table Three: Urban Form and Residential Electricity Consumption

	(1) log(electricity)	(2) log(natural gas)	(3) Single Family Home
Suburb	0.099	0.038	0.05
	[0.027]***	[0.039]	[0.019]***
Suburb*North East Region	0.306	0.348	0.235
	[0.063]***	[0.093]***	[0.044]***
Persons in Household	0.143	0.102	0.062
	[0.008]***	[0.012]***	[0.006]***
Age of Head of Household	0.002	0.007	0.007
	[0.001]**	[0.001]***	[0.001]***
Middle Atlantic	-0.078	-0.321	-0.035
	[0.066]	[0.103]***	[0.047]
East North Central	0.335	0.279	0.26
	[0.063]***	[0.098]***	[0.045]***
West North Central	0.403	0.082	0.261
	[0.074]***	[0.112]	[0.052]***
South Atlanta	0.567	-0.071	0.213
	[0.066]***	[0.106]	[0.046]***
East South Central	0.822	0.09	0.331
	[0.077]***	[0.125]	[0.054]***
West South Central	0.539	-0.042	0.295
	[0.073]***	[0.118]	[0.051]***
Mountain	0.313	-0.085	0.302
	[0.074]***	[0.113]	[0.053]***
Pacific	0.034	-0.571	0.123
	[0.062]	[0.098]***	[0.044]***
Cooling Degree Days in 1000s (base 65)	0.14	-0.242	-0.023
	[0.014]***	[0.026]***	[0.010]**
Constant	9.234	10.722	0.021
	[0.072]***	[0.115]***	[0.051]
Observations	2602	1892	2602
R-squared	0.421	0.273	0.267
Housing Income Fixed effect	Yes	Yes	Yes

*** indicates statistical significance at the 1% level. Standard errors are reported in brackets. The omitted category is an urban household in the New England Census Division. The dependent variable in column (3) is a dummy variable that equals one if the household lives in a single family home.