Changes in Transportation Infrastructure and Commuting Patterns in U.S. Metropolitan Areas, 1960-2000

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Population decentralization has been a salient feature of the landscape of most U.S. urban areas since 1950. Nathaniel Baum-Snow (2007) documents that the aggregate population of central cities of the 139 largest metropolitan areas (henceforth, MSAs) declined by 17 percent between 1950 and 1990 while aggregate MSA population growth was 72 percent during this period. Expansion of the highway network in urban areas accounts for about one-third of the gap in central city and MSA population growth rates. While transport network expansions clearly generated urban population decentralization, there is little evidence to date on how this decentralization manifested itself as changes in employment locations and commuting patterns.

In this paper, I present evidence indicating that employment decentralization occurred apace with residential decentralization between 1960 and 2000 such that their relative spatial concentrations remained remarkably unchanged. A byproduct has been that most commutes of MSA residents no longer involve central cities at all. Central cities as defined by their geographies in 1960 were the origin and/or destination of only 38 percent of commutes made by MSA residents in 2000, down from 66 percent in 1960. Using planned portions of the interstate highway system as a source of exogenous variation, estimates reported in Section III indicate that urban highway construction played a pivotal role in generating this shift. New highways primarily increased the number and fraction of commuting flows within suburban areas at the expense of commutes within central cities. Because within suburb commutes are longer than other types of commutes on average, results are consistent with Gilles Duranton & Matthew

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Turner's (2009) evidence that the elasticity of kilometers driven with respect to lane-kilometers of highways in urban areas is one.[1]

I. Changes in Commuting Flows Over Time

This analysis utilizes data on aggregate commuting flows from the 1960 and 2000 censuses of population. Census tract data from 1960 report the number of commutes from each tract to that MSA's central city and various other destinations.[2] I fill out commuting flow data between central cities and suburbs for the 42 of 152 metropolitan areas of over 100 thousand residents that were not fully tracted in 1960 with data from printed census volumes. For the 99 metropolitan areas of at least 250 thousand residents, this analysis uses data on the total number of workers in central cities and SMSAs regardless of their residential locations from printed journey to work 1960 census volumes.

The largest challenge in building analogous data for 2000 is that most central cities annexed considerable land over time. To handle this, 1960 definition central city geographies were digitized into polygons and each 2000 definition micro-geographic census region for which commuting data is available was allocated inside or outside of these polygons using centroid locations. The 2000 Census Transportation Planning Package (CTPP) tabulations of census data indicate commuting flows between micro-geographic regions nationwide. With this information, I build counts of commuters between and within central cities and suburbs of 1960 definition central cities.

[1] In 2000, within central city commutes were on average only 11 percent as long as commutes within suburban areas, with suburb to central city commute lengths in-between. Reverse commutes were the longest type, though they represented only 7 percent of total commutes.

[2] 1960 was the first year in which the census asked about place of work.

Table 1: Changes in Residential and Work Locations, 1960-2000
99 Metropolitan Areas of Over 250,000 in 1960

Data Year	Central City Geography	Live in Central City	Work in Central City	Live in (S)MSA	Work in (S)MSA
1960	1960	17.8	21.1	35.5	35.2
(Fraction of MSA)		(0.50)	(0.60)		
2000	2000	21.4	29.1	73.0	75.2
(Fraction of MSA)		(0.29)	(0.39)		
2000	1960	16.6	24.1	73.0	75.2
(Fraction of MSA)		(0.23)	(0.32)		
Percent	2000	0.21	0.38	1.06	1.13
Change	1960	-0.07	0.14	1.06	1.13
Change in	2000	-0.21	-0.21		
Fraction	1960	-0.27	-0.28		

Note: Counts are in millions of workers. Counts are calculated using 1960 and 2000 census journey to work data using contemporaneous SMSA/MSA definitions. Those contributing to counts in Columns 1 and 3 may work anywhere. Those contributing to counts in columns 2 and 4 may live anywhere. Data from 1960 incorporate the author's imputations for nonreported work locations while the 2000 data incorporates such imputations done by the Census Bureau and the author.

Using these data, Table 1 presents some facts about the evolution of the spatial distribution of employment and residences for the 99 MSAs with at least 250 thousand residents in 1960. This table only includes counts of workers. Table 1 indicates that employment and working population decentralized at remarkably similar rates between 1960 and 2000. While in 1960 50 percent of MSA residents and 60 percent of MSA jobs were in central cities, by 2000 these numbers had declined to 23 and 32 percent respectively for the same geographic regions.[3] The higher spatial concentration of jobs means that while central cities lost residents, they gained jobs over time. The number of central city jobs increased by 14 percent between 1960 and 2000 while working population declined by 7 percent. Since labor force participation rates increased rapidly over this time period, total population in central cities declined at a faster rate than did working population. In addition, note the importance of holding the central city geography

[3] Due to data limitations, in 2000 I measure metropolitan areas as county agglomerations. This does not affect results much because MSAs have expanded spatially with their populations.

constant over time for understanding trends in aggregate counts. Absent this adjustment, the number of workers and jobs in central cities appear to grow by 21 percent and 38 percent respectively. However, the fractions living and working in contemporaneously defined central cities both declined by 0.21, exhibiting a similar pattern as seen in data built using constant geographic units.

Table 2: Changes in Commuting Patterns: 1960-2000
152 Metropolitan Areas of Over 100,000 in 1960

		MSA Working Residents			
Data Year	Central City Geography	Live in CC Work in CC	Live in CC Work Elsewhere	Live in Suburbs Work in CC	Live in Suburbs Work Elsewhere
1960	1960	17.3	2.4	6.1	13.1
(Fraction of MSA)		(0.45)	(0.06)	(0.16)	(0.34)
2000	2000	18.3	6.8	15.8	42.2
(Fraction of MSA)		(0.22)	(0.08)	(0.19)	(0.51)
2000	1960	12.4	6.1	12.7	51.9
(Fraction of MSA)		(0.15)	(0.07)	(0.15)	(0.62)
Percent	2000	0.05	1.89	1.61	2.22
Change	1960	-0.29	1.61	1.08	2.96
Change in	2000	-0.23	0.02	0.03	0.17
Fraction	1960	-0.30	0.01	0.00	0.29

Notes: Regions outside of central cities according to contemporaneous MSA definitions are assigned as suburbs. The 15.8 million who are indicated to live in the suburbs and work in 2000 definition central cities in year 2000 may in fact live inside or outside of an MSA. The 42.2 million living in the suburbs of 2000 definition central cities in year 2000 and working elsewhere is calculated as a residual of the other three commuting flows for this geography and time period.

For a larger sample of 152 metropolitan areas, Table 2 breaks out the working population of central city and suburban metropolitan regions into commuting flows to central cities and other destinations.[4] Evidence in Table 2 indicates that the nature of commutes changed dramatically from 1960 to 2000. While 45 percent of workers living in MSAs lived and worked in central cities in 1960, just 15 percent did in 2000. To compensate, the fraction living and working in the suburbs almost doubled from 0.34 to 0.62, representing a near tripling in number.

[4] Data limitations preclude separate identification of suburban and ex-metropolitan area destinations.

This result is evidence of the rapidly declining relevance of the classic monocentric framework for understanding residential location choices and commuting patterns in cities.

Perhaps the most interesting results in Table 2, however, are in the middle two columns. Consistent with evidence elsewhere (Edward Glaeser, Jed Kolko and Albert Saiz, 2001), the second column shows that reverse commuting rose slightly from 1960 to 2000, though it remains a small fraction of commutes. The third column shows that while the number of traditional suburb to city commutes rose, as a fraction of total metropolitan commutes this flow has remained essentially unchanged. That is, the primarily outlet for the rapid reduction in within central city commutes has been commutes within suburban regions.

II. Measuring Transportation Infrastructure

In order to allow metropolitan areas of different sizes and structures to be compared, I measure MSA transport infrastructure as the number of radial highways (or "rays") that emanate from within 1 mile of central business districts and connect to suburban areas. An additional reason that this measure is attractive is that there is a plausible source of exogenous variation in the number of rays built to serve each city. The fact that much of the Interstate Highway System was planned to serve intercity travel and national defense means that rays planned in the 1940s is a plausible instrumental variable for the number of radial highways actually constructed in each MSA. As in this paper, Baum-Snow (2007), Guy Michaels (2008) and Duranton & Turner (2008, 2009) use information in highway plans from the 1940s to instrument for actual highway construction.

Even though highway construction began on a large scale in the late 1950s, availability of commuting data dictates that 1960 be the base year for this analysis. By 1960, 67 of the 152 MSAs in the primary sample had some interstate highway segments open to traffic, relative to

133 in 2000. However, construction progress was not sufficient such that much of this 1960 infrastructure constituted full radial highways connecting cities to suburbs. Therefore, to be conservative, the key explanatory variable used in this analysis is the change in the number of rays constructed between 1950, when only 7 MSAs had highways, and 2000. Experimentation with various alternative measures using different cutoff levels of mileage open to traffic in metro areas as of 1960 to constitute rays always generates point estimates that are larger in magnitude than those reported below. This occurs because the first stage coefficient on planned rays is smaller the more actual rays that were open as of 1960.

The first stage coefficient on rays received by each city as planned in 1947 is 0.47 with a standard error of 0.07. This coefficient changes little as a function of included control variables except that inclusion of square root of 1960 central city area reduces it from 0.65.[5] Analogous regressions that count a ray as being open in 1960 if at least 4 miles of the highway was operational consistently yield statistically significant first stage coefficients of 0.20. This estimate is remarkably robust, even to the exclusion of central city radius. First stage regressions also indicate that central cities with more area and MSAs with greater employment growth also received more rays between 1950 and 2000, all else equal.

III. Results

Table 3 presents IV estimates of the effects of highways on the four types of commuting flows discussed above as measured using 1960 central city geography. Because it is arguably exogenous and it is the only potential control variable correlated with endogenous rays conditional on planned rays, the primary specification controls for the square root of central city

[5] Included control variables are listed in Table 3. In Baum-Snow (2007) I argue that a measure of central city size is a crucial control since spatially larger cities had higher populations and thus received more planned highways. Furthermore, a broad class of land use models predict that magnitudes of responses of commuting flows to transport infrastructure depend crucially upon the spatial size of origin and destination regions.

area. Consistent with standard theories of land use, a robustness specification also controls for simulated MSA mean income and MSA employment growth with no meaningful effects on coefficients of interest. The simulated income measure is built using 1940 MSA employment shares by industry and national skill prices from 1960 and 2000 excluding states that include the MSA of interest. Panel A presents results for central city residents while Panel B shows results for suburban residents.

Point estimates reported in Table 3 indicate that highways caused declines in all three types of commutes involving central cities with precise estimates for within-central city and reverse commutes. Highways caused commensurate increases in commutes of suburban residents to suburban or ex-MSA areas. In particular, each radial highway caused an estimated 18 percent decline in the number of people who both lived and worked in a central city and a 10 percent decline in reverse commuters. Together, this amounts to a 16 percent decline in central city working residents caused by each ray.

These estimates indicate that the average city, which received 2.5 rays, saw the number of workers living there decline by 40 percent as a result of new highways. While this estimate seems large, it only implies a growth in resident workers of 33 percent absent no highway construction, well below the overall growth in metropolitan workers of over 100 percent. Similar to my estimates of the effects of highways on total working and non-working central city population, this calculation indicates that absent highways, about one-third of the gap between central city and metro area working population growth rates would be closed.

Table 3 Panel B indicates that the central city residents that leave because of highway construction do not generally keep jobs in the city. While not statistically significant, the primary specification yields a point estimate indicating that each ray caused an 18 percent decline in the number of commuters from suburbs to central cities.[6] The reductions in all three types of commutes involving central cities due to highways are balanced by an associated increase in the number of suburban commutes. In particular, each ray is estimated to cause the number of commutes within suburban regions to increase by 25 percent.

When accounting for differences in the 1960 fractions of MSA working residents in each commuting group, the results in Table 3 indicate that the reduction in within city commuters caused by each ray is roughly equal to the commensurate increase in suburban commuters at about 8 percentage points. Because commuting market shares for commutes between suburbs and central cities are low, the reductions in these types of commutes caused by highways did not have much influence on commuting patterns overall.[7]

Closed city land use models dictate inclusion of MSA income and employment as additional regressors. However, coefficients on rays in the second specification in Table 3 demonstrate that the number of rays in the 1947 national plan is orthogonal to these other potential predictors of changes in commuting flows. While these models do not have a clear prediction about the effects of income on residential or firm location choice, they do predict that an exogenous increase in total MSA workers should increase all types of flows. This prediction is evident in the coefficients on change in MSA employment in Table 3. Interestingly, however, these coefficients indicate that new arrivals to MSAs were much more likely to settle and work in suburban areas than in central cities holding the number of highways constant. This is evidence that highways were not the only reason for decentralization of jobs and residences.

[6] When controlling for log 1960 employment, the estimated effect of each ray on suburb to central city commutes becomes 0.11 but remains statistically insignificant. No other coefficients in Table 3 are appreciably affected after including this additional control variable.
[7] These numbers are calculated by multiplying estimated coefficients by 1960 shares from Table 2.

Table 3: Effects of Highways on Commuting Patterns

Panel A: Central City Residents

	Live in CC Work in CC		Live in CC Work Elsewhere	
Change in Rays 1960 to 2000	-0.18***	-0.17***	-0.10*	-0.11**
	(0.05)	(0.05)	(0.06)	(0.05)
Square Root of 1960 Central City Area	0.10***	0.10***	0.07***	0.06***
	(0.02)	(0.01)	(0.01)	(0.02)
Change in Simulated Income		2.07		-0.94
		(1.44)		(1.57)
Change in Log MSA Employment		0.35***		0.63***
		(0.10)		(0.11)
Constant	-0.74***	-1.61***	0.73***	0.67
	(0.12)	(0.41)	(0.15)	(0.44)
N	152	152	152	152
R-Squared	0.13	0.34	0.09	0.30

Panel B: Suburban Residents

	Live in Suburbs Work in CC		Live in Suburbs Work Elsewhere	
Change in Rays 1960 to 2000	-0.17	-0.18	0.25***	0.23***
	(0.10)	(0.11)	(0.08)	(0.07)
Square Root of 1960 Central City Area	0.10	0.08	-0.04	-0.06**
	(0.06)	(0.05)	(0.03)	(0.02)
Change in Simulated Income		0.64		-0.03
		(2.19)		(2.94)
Change in Log MSA Employment		1.05***		1.23***
		(0.20)		(0.21)
Constant	0.74***	-0.07	1.18***	0.48
	(0.17)	(0.69)	(0.17)	(0.86)
N	152	152	152	152
R-Squared	0.08	0.40	0.05	0.31

Notes: Regressions are of the change in the log of outcomes listed in column headers on variables listed at left. The sample includes the same 152 MSAs used for Table 2. The change in the number of rays is instrumented with rays in the 1947 national plan. Standard errors are clustered by MSA.

The evidence is clear that the primary way that highways serving central cities caused declines in central city population was by inducing those who had lived and worked in central cities to live and work in suburban areas instead. However, it is important to recognize that part of the way radial highways may have brought about this change is by encouraging more commuting by car. In addition, other types of urban transport infrastructure including circumferential highways and transit may have interacted with radial highways to generate a portion of estimated effects.[8]

IV. Conclusions

U.S. cities have decentralized to the point that most working residents no longer have any contact with their MSAs' central cities. Highway construction has played a crucial role in this growth of the suburbs and decline of cities, not just as residential locations but also as work locations. Evidence from this paper indicates that employment and residential decentralization occurred in tandem and that highways primarily led within-central city commuters to become within-suburb commuters. Estimates indicate that had the urban highway systems not been built, the total number of within city commutes would be about double its 2000 number and the total number of within-suburb commutes would be cut by about one-half. This reallocation would change the fraction of total commutes in these two categories to 0.31 and 0.30 respectively, a dramatic shift.

These results provide evidence that declining city transport costs not only allowed commuters to spread out spatially but also allowed firms to attain the same productivity advantages from proximity as before but at further distances. This means that firm productivity has potentially increased because of new urban transport infrastructure even as firms have decentralized. Welfare improvements of new highways for workers have thus potentially come in the form of higher wages that reflect this increased productivity in addition to faster commutes and lower housing costs.

[8] While, Baum-Snow & Kahn (2005) find that the large expansion of rail transit lines in U.S. cities did little to stem the secular trend of declining public transit ridership over time, Baum-Snow (2007) argues that the existence of circumferential highways may augment the negative effect of radial highways on central city population.

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