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 thus 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. While in 1960 50 percent of working residents of MSAs over 250 thousand people lived in their central regions, this had fallen to just 23 percent by 2000. During the same period, the fraction of metropolitan area jobs in central cities also fell by 28 percentage points, from 0.60 to 0.32. As is evident from these numbers, most commutes of MSA residents in 2000 did not 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.

Results presented in Section III confirm indications from these trends and the estimates in Baum-Snow (2007) that radial highways caused the decentralization of both residences and

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employment. Using planned portions of the interstate highway system as a source of exogenous variation, estimates indicate that radial highways primarily increased the number and fraction of commuting flows within suburban areas at the expense of commutes within central cities. Estimates also indicate that radial highways caused declines in commuting flows from suburbs to cities and vice-versa, though these flows together represent only 23 percent of commutes, up from 22 percent in 1960. Because within suburb commutes are longer than other types of commutes on average, these results are consistent with Gilles Duranton & Matthew Turner's (2009) evidence that the elasticity of kilometers driven with respect to lane-kilometers of highways in urban areas is about one.[1]

This evidence on changes in commuting patterns points to some mechanisms by which urban decentralization may have occurred. The extent of employment decentralization makes it clear that the non-monocentric land use models of Fujita & Ogawa (1982) and Lucas & Rossi-Hansberg (2001) have become increasingly relevant for describing the distribution of economic activity in urban areas. However, the fact that employment remains more centralized than residences indicates that spatial agglomeration forces are still important inputs to many firms' location choices.

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 central city, suburban and ex-metropolitan area destinations.[2] I fill out commuting flow data between central cities and suburbs for the 42 of 152 metropolitan areas of over 100 thousand

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

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

residents that were not fully tracted in 1960 with data from printed census volumes.[3] 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 published 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.[4] With this information, I build counts of commuters between and within central cities and suburbs of 1960 definition central cities.

Using these data, Table 1 presents some facts about the evolution of the spatial distribution of employment and residences for the 99 metro areas with at least 250 thousands residents in 1960. This table only includes counts of workers. Table 1 indicates that employment and working population decentralized at about the same rate between 1960 and 2000. While in 1950 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.[5] Remarkably, the fractions living and working in contemporaneously defined central cities both declined by 21 percentage points. Because jobs started out being more centralized, this amounts

[3] The 2000 CTPP data imputes non-reported work locations using the distribution of reported work locations from each residential location. To be consistent, we impute work locations from tract data in the same way for 1960.
[4] The most common such census geography in 2000 is the Traffic Analysis Zone but in some states commuting data is tabulated to census tract or block group pairs instead.
[5] Due to data limitations, in 2000 we measure metropolitan areas as county agglomerations. This does not affect results much because MSAs have expanded spatially with their populations.

to a 14 percent increase in central city jobs but a 7 percent decline in central city working population. 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 constant over time for understanding trends. Absent this adjustment, central cities appear to grow rapidly, despite declining employment and population shares.

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

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

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 respectively.[6] 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, this had fallen to just 15 percent by 2000. To compensate, the fraction living and working in the suburbs almost doubled from 0.34 to 0.62, almost tripling in

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

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

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

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

Notes: Suburbs are the regions outside of central cities according to contemporaneous MSA definitions. 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 the 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.

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.

II. Measuring Transportation Infrastructure

Highway data used for this analysis is similar to that used in Baum-Snow (2007). 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 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 highways actually constructed to each city. As in this paper, Baum-Snow (2007), Guy Michaels (2007) 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, commuting data availability 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 a ray 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.[7] Analogous regressions that count a ray as being open in 1960 if at least 4 miles of the highway was

[7] 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.

operational consistently yield statistically significant first stage coefficients of 0.20. This estimate is remarkably robust, even to the exclusion of central city radius.

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 area. A robustness specification also controls for income and employment changes causing no meaningful changes to coefficients of interest. Panel A shows flows of central city residents while Panel B shows those of suburban residents. Estimates indicate that highways caused declines in all types of commutes involving central cities with the most precise estimates for within-central city commutes. Highways caused commensurate increases in commutes of suburban residents to suburban or ex-MSA areas.

Table 3 indicates that each highway ray received by a city causes an 18 percent decline in the number of people who both live and work in that city and a 10 percent decline in reverse commuters. This amounts to a 16 percent decline in central city working residents. 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 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 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: Effets 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	0.10***	0.10***	0.07***	0.06***
Central City Area	(0.02)	(0.01)	(0.01)	(0.02)
Change in Simulated		2.07		-0.94
Income		(1.44)		(1.57)
Change in Log		0.35***		0.63***
MSA Employment		(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
r2	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	0.10	0.08	-0.04	-0.06**
Central City Area	(0.06)	(0.05)	(0.03)	(0.02)
Change in Simulated		0.64		-0.03
Income		(2.19)		(2.94)
Change in Log		1.05***		1.23***
MSA Employment		(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
r2	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.

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. The reductions in all three types of commutes involving central cities due to highways are balanced by an associated

increase in suburban commutes. Each ray is estimated to cause the number of suburban commutes 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. [8]

Coefficients on rays in the second specification in Table 3 demonstrate that the number of rays in the 1947 national plan is orthogonal to other potential predictors of changes in commuting flows. Furthermore, closed city land use models dictate inclusion of MSA income and employment as regressors. While such models do not have a clear prediction about the effects of income on residential or firm location choice (see Glaeser & Kahn (2003) for example), 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 further evidence that highways were not the only reason for decentralization of jobs and residences.

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

[8] These numbers are calculated by multiplying estimated coefficients by 1960 shares from Table 2.

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.[9]

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 with each other and that highways primarily led within-central city commuters to become within-suburb commuters.

These results provide some 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 increases because of new highways have thus potentially come from higher wages reflecting this increased productivity in addition to faster commutes and lower housing costs.

[9] 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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