A Brief Note on Modal Access Across America

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Introduction

The Accessibility Observatory at the University of Minnesota is one of, if not the, leading center for the research and application of accessibility-based transportation system evaluation. They have harnessed the growth of big data in transportation, along with cloud computing resources, to conduct multiple groundbreaking accessibility studies that are unprecedented in scope. As part of a larger analysis utilizing their published data, this brief note combines the results of their 2015 auto and transit access to jobs studies (1, 2, 3) to examine the differences in access to jobs between transit and auto modes across the United States. This is a very modest application of the data sets developed through the extensive work conducted by Andrew Owen and Brendan Murphy at the Accessibility Observatory and David Levinson now at the University of Sydney. Any errors in this white paper are the responsibility of the author, however all of the credit for the extensive and indeed, ground-breaking, original accessibility analysis must go to those at the Accessibility Observatory.

Accessibility, also sometimes referred to as access to destinations, is easily understood in general terms, but it is difficult to precisely define and measure it. (4) One definition is "the ease of reaching goods, services, activities and destinations, which together are called opportunities." (5) As shown in Figure 1, four factors affect accessibility: mobility, mobility substitutes (e.g., telecommuting), transportation system connectivity (the directness and degree of connectivity of the components of the transportation system) and proximity (which is a function of land use), since physical proximity typically increases accessibility. (6)

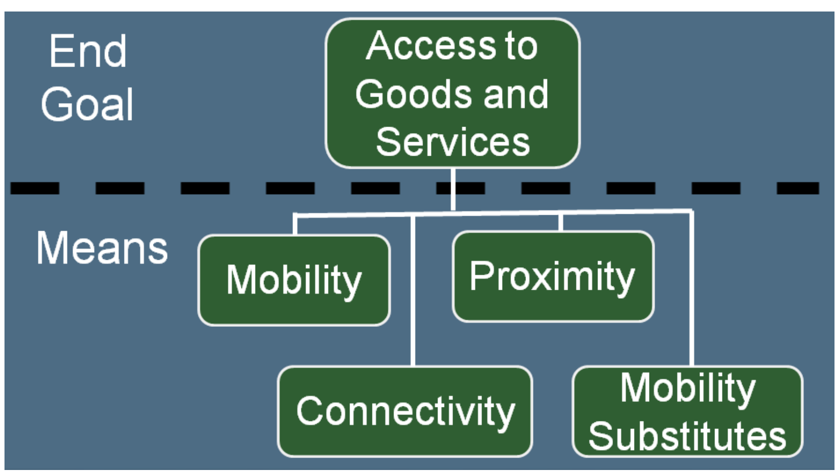

Figure 1 - Major Factors Affecting Access

Accessibility is a powerful concept for use in transportation planning, as it does not depend on the mechanisms used to achieve it. This allows alternative approaches to be considered on an equal footing with one another. For example, improved access to jobs may be provided by reducing congestion, growing the transit network, locating housing closer to work opportunities, or increasing the opportunities for telecommuting. As such, accessibility metrics provide a valuable complement to mobility and congestion metrics, such as average travel speed or delay. Pratt and Lomax state that "By using door-to-door travel time as the time measure, accessibility via alternative modes can be put on an essentially equal footing, as long as it is recognized that acceptability varies by mode. It is apparently as close to an ideal measure for multimodal performance analysis as can be achieved from the user perspective." (7)

Accessibility Metrics

There are many ways to measure accessibility. Handy and Neimeier (8) provide a review of accessibility metrics in the planning field and El-Geneidy and Levinson (9) provide a comprehensive review. The model used in the Accessibility Observatory's studies (1, 2, 3) is called the *cumulative opportunity* model.

<u>Cumulative Opportunity</u>:

$$C_i = \sum O_j B_j$$

- C_i Opportunities (jobs in these studies) reachable from zone i
- O_j Opportunities (jobs) at zone j
- B_j A binary value equal to 1 if zone j is reachable within a predetermined time from zone I, otherwise equal to 0

This measures the number of jobs available to the residents of a given small zone (census block in the Accessibility Observatory studies) within a given upper bound on door-to-door travel time. It has the advantages of being both simple to calculate and easy to understand. The units are the number of jobs. However, the function uses a step function: all jobs within the travel time limit are counted equally, regardless of how quickly they can be reached, and jobs just one minute beyond the travel time limit are not counted at all. To address this limitation, the Accessibility Observatory studies looked at time thresholds of 10, 20, 30, 40, 50, and 60 minutes. For each time threshold, they then computed worker-weighted average number of jobs across the city as a whole (e.g., if one zone had 50 workers, another had 100, and a third had 200, then the second zone would have twice the weight of the first zone, and the third zone would have four times the weight of the first zone).

Once a worker-weighted average was computed for entire region for each time slice, a weighted sum of the time slices was computed to obtain an accessibility score for each region. The weighted sum was calculated as: (3)

$$a_w = \sum_t \left((a_t - a_{t-10}) \text{ x } e^{\beta t} \right)$$

$$a_w = \text{ Weighted accessibility ranking metric for a single metropolitan area}$$
$$(a_t = \text{Worker} - \text{weighted accessibility for threshold } t$$
$$\beta = -0.08$$

The Modal Accessibility Gap (MAG), introduced by Kwok and Yeh (10) is a measure of the difference in accessibility between transit and personal automobiles. The formula for computing the MAG is:

$$\text{MAG} = \frac{\text{A}^P - \text{A}^C}{\text{A}^P + \text{A}^C}$$

A^p Transit Accessibility
A^c Automotive Accessibility

The values for the MAG range between -1 and +1. At zero the two modes provide equal accessibility, a value of 1 would mean that there was no access via private automobiles, while a value of -1 would mean there was zero access via transit.

Comparison of Transit vs. Auto Access to Jobs for Forty-Nine Regions across America

The Accessibility Observatory conducted auto access to jobs analyses for 50 of the largest (by population) metropolitan areas in the US and conducted transit access to jobs analyses for 49 of them (Memphis, TN could not be included due to the lack of available GTFS-formatted transit schedules for Memphis). As described above, they computed a weighted access score combining the results from multiple isochrones, and the rank order varies depending upon which individual isochrone one examines. Using those scores, Figure 2 plots the MAG for each of the 49 cities, beginning with New York, New York which has the highest MAG score of -0.84, and ending with Riverside, California, which has the lowest score of -0.98. While it is not at all surprising that New York City's score is significantly better than any other city, and San Francisco is significantly better than all cities except New York, it is important to note how low even New York City's score is. On this scale, 0 would be equal access and -1.0 represents no transit service. Even New York City scores below -0.8. The ten cities with the best MAG scores are:

1. New York
2. San Francisco
3. Boston
4. Washington

5. Chicago
6. Seattle
7. Philadelphia
8. Portland
9. Pittsburgh
10. Milwaukee

While the weighted scores and the resulting MAG scores provide a more complete and likely more accurate representation, it is hard to have an intuitive feel for what the scores mean. If one picks a particular isochrones, say, for example, jobs reachable within 60 minutes, one can also simply compute the ratio of jobs reachable by transit versus jobs reachable by auto. Figure 3 shows these ratios for both 30 minute and 60-minute isochrones. The order of the cities is the same MAG score ordering used in Figure 2. Figure 3 clearly illustrates how the results vary by the selection of the isochrone one uses for this approach. In particular, while the 30-minute order is approximately the same as that for the MAG scores that use the combined weighted scores, the 60-minute isochrones ratios show dramatically different results.

In order to further investigate the occasionally striking differences in the rankings between the overall MAG score, the 30-minute isochrones, and the 60-minute isochrones, we can take a somewhat deeper dive into Salt Lake City and Las Vegas. These cities would rank 2nd and 5th in comparative transit accessibility if one looks only at the 60-minute isochrones ratios, whereas they rank 14th and 37th using the MAG scores and 14th and 42nd using the 30-minute isochrone ratios. When one looks at the ratio between jobs accessible by auto within 30 minutes vs. 60 minutes, the average across all 49 cities is 51%. However, that ratio is highest (97%) for Las Vegas, and 4th highest (68%) for Salt Lake City. Similarly, when comparing the ratio of jobs accessible by transit, one finds that Las Vegas has the largest percentage increase in jobs reachable by transit within 60 versus 30 minute, and Salt Lake City has the 6th largest increase. What is happening in these two cities is that as you go further out from the city center, the number of jobs drops off far more rapidly than it does for the average metropolitan region. Therefore, increasing the auto catchment area from a 30 minute to a 60-minute isochrone adds far fewer additional new jobs than in the average city. On the other hand, many of the jobs reachable within 30 minutes by auto but not by transit *are* reachable by a 60 minute or less transit trip. Therefore, the modal access gap decreases significantly for the larger 60-minute catchment areas. In addition to providing a satisfactory explanation for these discrepancies, this is an example of the types of “deeper dives” one can take using the data provided by the Accessibility Observatory.

Conclusions

Even in New York, the most transit-friendly city in terms of transit vs. auto access, a 30-minute transit ride provides access to less than 8% as many jobs as are accessible by auto. The situation is somewhat better when one compares 60-minute trips, as the ratio increases to almost 19%. Even so, access to an automobile provides the average New Yorker with the ability to reach far more potential jobs than does transit. In many of the largest U.S. cities, transit provides the average resident with access to less than 5% of the potential jobs that an auto provides access to. Clearly there are opportunities to expand the utility of the transit systems in the U.S. This involves a combination of increased service, better alignment of service with needs, and with land-use changes to increase access. Doing so will reduce the modal access gap, which is a desirable goal. At the same time, the accessibility gap is so large that it is unrealistic to expect the modal gap to shrink to zero in any U.S. city. Transit can be more competitive but is not an adequate total replacement for auto access for most urban residents. The only way parity could be achieved would be by putting extremely large regulatory restrictions on auto use, which would have large negative effects on the regional economy.

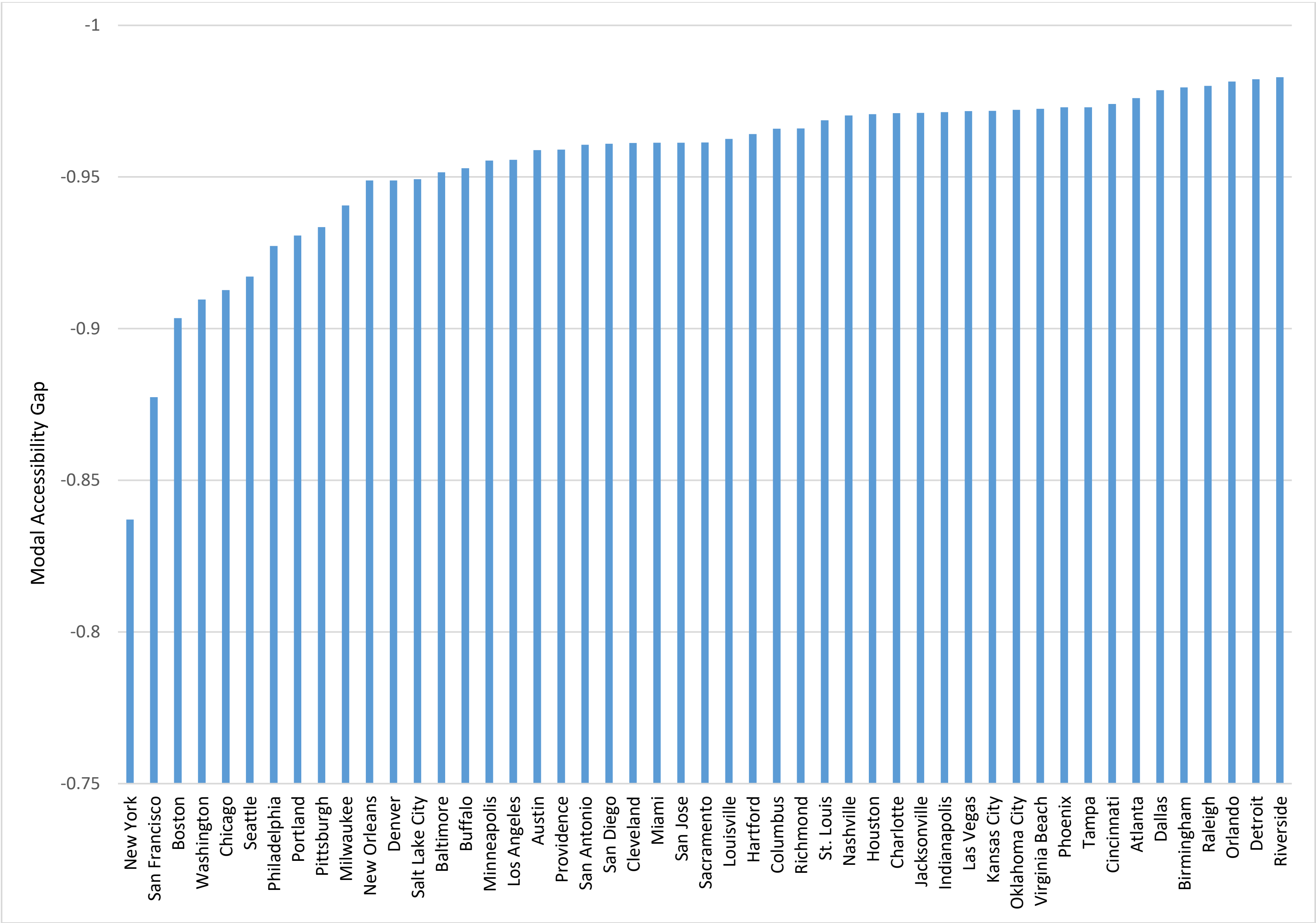

Figure 2 - Modal Accessibility Gap for 49 Urban Areas

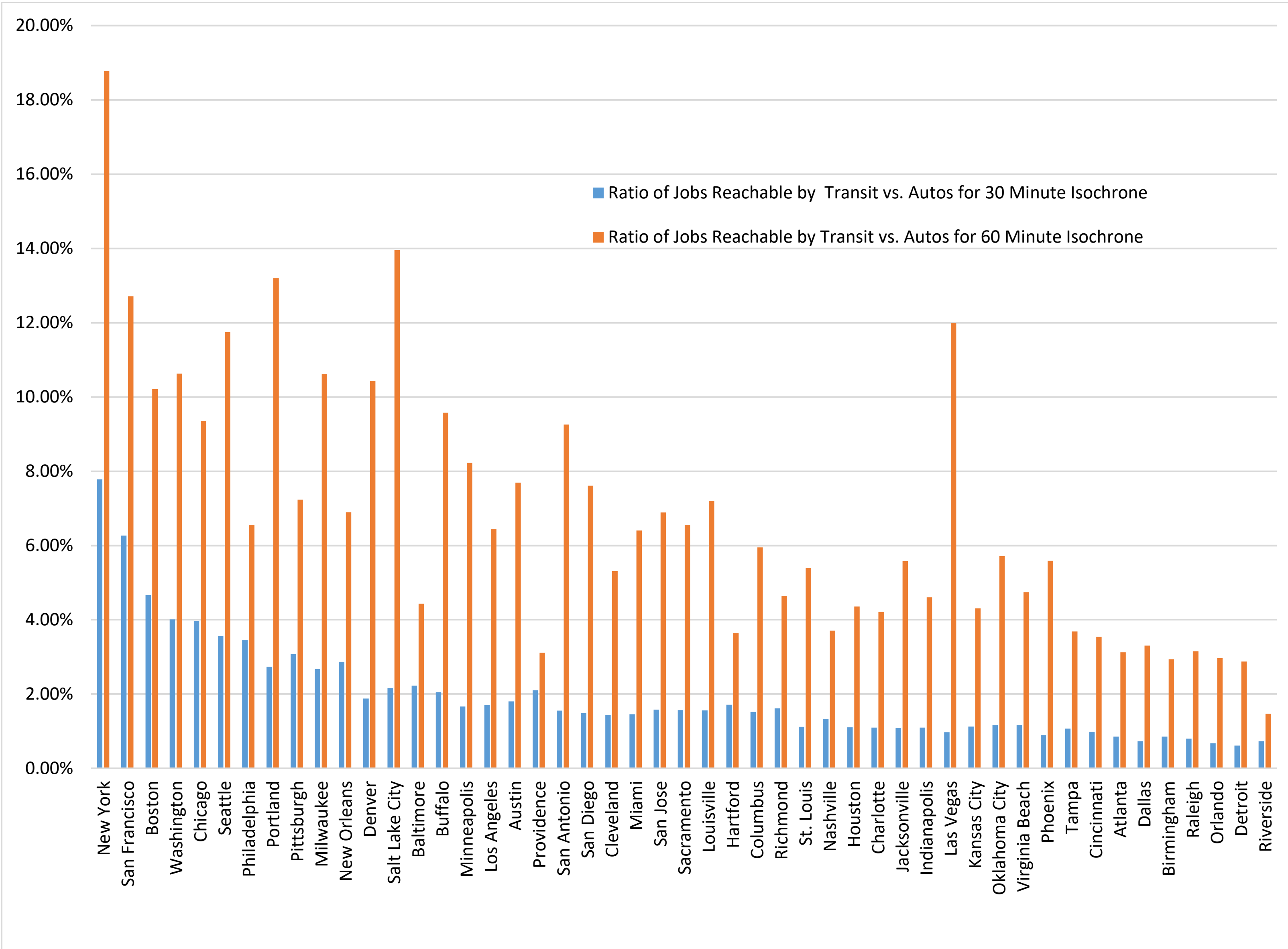

Figure 3 - Ratios of Jobs Reachable by Transit vs. Auto for 30- and 60-Minute Isochrones

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Appendix: Data Used to Produce the Graphs

Note: The 30- and 60-minute transit and auto jobs numbers are taken from (1, 2). The Auto and transit "scores" were calculated using the formula documented by the same researchers in [3]. The other columns are simple arithmetic calculations on the data.

Area	Auto Score	Transit Score	MAG	30 Minute Transit Jobs	60 Minute Transit Jobs	30 Minute Auto Jobs	60 Minute Auto Jobs	Ratio of Jobs Reachable by Transit vs. Autos for 30 Minute Isochrone	Ratio of Jobs Reachable by Transit vs. Autos for 60 Minute Isochrone
Atlanta	158820.51	1925.32	-0.97605	6,869	63,956	804,812	2,046,662	0.85%	3.12%
Austin	126962.60	2664.14	-0.95890	10,808	76,039	600,751	988,117	1.80%	7.70%
Baltimore	168365.04	4177.73	-0.95157	17,669	113,063	795,212	2,549,800	2.22%	4.43%
Birmingham	62777.06	649.05	-0.97953	2,553	17,365	298,483	591,188	0.86%	2.94%
Boston	203507.60	10321.82	-0.90346	43,778	271,810	938,582	2,661,083	4.66%	10.21%
Buffalo	91489.79	2207.99	-0.95287	8,863	57,688	431,900	602,500	2.05%	9.57%
Charlotte	109424.02	1605.89	-0.97107	6,179	46,654	562,123	1,107,895	1.10%	4.21%
Chicago	263921.22	12043.20	-0.91272	50,586	328,034	1,277,622	3,510,329	3.96%	9.34%
Cincinnati	112935.37	1482.95	-0.97408	5,809	42,573	589,391	1,203,539	0.99%	3.54%
Cleveland	119803.72	2369.88	-0.96120	8,660	74,609	602,907	1,405,385	1.44%	5.31%
Columbus	135363.36	2344.24	-0.96595	9,812	64,154	647,442	1,078,674	1.52%	5.95%
Dallas	258742.21	2797.28	-0.97861	9,825	95,130	1,346,253	2,878,685	0.73%	3.30%
Denver	189450.32	4969.26	-0.94888	18,668	159,153	992,037	1,525,933	1.88%	10.43%
Detroit	190620.85	1707.06	-0.98225	6,020	58,067	988,497	2,021,310	0.61%	2.87%
Hartford	123350.80	2253.02	-0.96412	10,091	55,364	588,640	1,520,727	1.71%	3.64%
Houston	225082.08	3348.40	-0.97068	12,666	106,955	1,150,184	2,453,742	1.10%	4.36%
Indianapolis	119733.76	1739.03	-0.97137	6,790	50,708	619,249	1,101,798	1.10%	4.60%
Jacksonville	80282.59	1176.85	-0.97111	4,299	35,635	394,317	638,272	1.09%	5.58%
Kansas City	114950.64	1641.18	-0.97185	6,851	42,695	608,689	990,808	1.13%	4.31%
Las Vegas	167927.09	2409.65	-0.97171	7,469	94,883	768,405	791,240	0.97%	11.99%
Los Angeles	471467.08	10690.02	-0.95566	39,564	358,984	2,323,105	5,577,313	1.70%	6.44%

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Louisville	93005.27	1773.99	-0.96257	6,932	51,278	443,985	711,930	1.56%	7.20%
Miami	198441.91	3913.26	-0.96132	14,462	122,624	991,891	1,914,507	1.46%	6.40%
Milwaukee	140785.83	4304.40	-0.94067	17,009	126,147	636,663	1,188,778	2.67%	10.61%
Minneapolis	196260.45	4472.47	-0.95544	17,043	139,841	1,023,854	1,700,783	1.66%	8.22%
Nashville	79409.20	1195.99	-0.97032	5,027	30,689	379,632	828,851	1.32%	3.70%
New Orleans	76958.06	2020.84	-0.94883	9,114	43,513	317,668	630,749	2.87%	6.90%
New York	525315.72	46588.27	-0.83708	204,745	1,221,944	2,630,585	6,506,319	7.78%	18.78%
Oklahoma City	86678.07	1225.74	-0.97211	4,794	34,679	413,861	606,913	1.16%	5.71%
Orlando	137113.80	1284.50	-0.98144	4,716	40,633	700,380	1,371,852	0.67%	2.96%
Philadelphia	202822.39	7653.31	-0.92728	34,234	193,921	992,362	2,960,701	3.45%	6.55%
Phoenix	192031.10	2632.14	-0.97296	9,019	94,360	1,006,102	1,687,626	0.90%	5.59%
Pittsburgh	87152.38	2997.65	-0.93350	13,101	77,906	425,627	1,076,698	3.08%	7.24%
Portland	135121.27	4848.44	-0.93072	18,790	145,855	687,220	1,105,569	2.73%	13.19%
Providence	95155.48	1991.60	-0.95900	8,615	48,280	410,653	1,553,681	2.10%	3.11%
Raleigh	115540.82	1161.83	-0.98009	4,528	33,500	566,967	1,062,914	0.80%	3.15%
Richmond	85741.44	1482.40	-0.96601	6,679	32,582	413,263	702,615	1.62%	4.64%
Riverside	130226.18	1120.87	-0.98293	4,238	34,910	583,025	2,378,179	0.73%	1.47%
Sacramento	124995.74	2459.49	-0.96141	9,483	71,009	606,135	1,084,079	1.56%	6.55%
Salt Lake City	150735.78	3923.23	-0.94927	13,970	134,513	645,816	963,767	2.16%	13.96%
San Antonio	127709.79	2566.90	-0.96059	9,533	84,016	614,300	907,807	1.55%	9.25%
San Diego	167990.34	3341.37	-0.96100	11,999	107,182	809,037	1,408,331	1.48%	7.61%
San Francisco	238794.60	15596.46	-0.87738	71,107	374,615	1,134,881	2,946,891	6.27%	12.71%
San Jose	255195.80	5030.06	-0.96134	16,739	184,272	1,060,964	2,673,982	1.58%	6.89%
Seattle	152052.65	6568.96	-0.91717	26,591	178,983	744,695	1,523,327	3.57%	11.75%
St. Louis	125519.60	1997.38	-0.96867	7,284	63,333	653,446	1,176,161	1.11%	5.38%

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Tampa	126527.73	1731.31	-0.97300	6,673	51,745	623,831	1,403,980	1.07%	3.69%
Virginia Beach	80830.81	1126.80	-0.97250	4,433	31,913	381,616	672,709	1.16%	4.74%
Washington	237959.35	11263.46	-0.90961	46,416	328,133	1,157,426	3,087,743	4.01%	10.63%