Comparative Analysis of Fixed Broadband Speeds in Cities Across the World

Article *in* SSRN Electronic Journal · January 2022

DOI: 10.2139/ssrn.4159788

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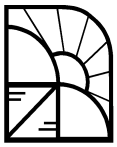

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PHOENIX CENTER POLICY BULLETIN NO. 54

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February 2022

A COMPARATIVE ANALYSIS OF FIXED BROADBAND SPEEDS IN CITIES ACROSS THE WORLD

Abstract: In this BULLETIN, I compare fixed broadband speeds for a sample of thousands of U.S. and foreign cities. My analysis reveals that download speeds are typically faster in the United States and often materially so. Comparisons of upload speeds are mixed, but the differences are small and statistically no different in most comparisons. With average download speeds of about 200 Mbps and upload speeds of 60 Mbps, the broadband market in the United States is performing well relative to its foreign comparators. The average download in the U.S. ranks in the top 5% of download speeds and is only about 10% less than the fastest observed average speed across all countries.

I. Introduction

An assessment of the performance of the broadband marketplace in the United States is often conducted by comparing availability, adoption, prices, and speeds against other nations. In fact, Section 103(b) of the Broadband Data Improvement Act ("BDIA") requires the Federal Communications Commission ("FCC") to conduct and report comparative international information on broadband services.[1] History has shown that international price comparisons are, for a variety of reasons, difficult to execute correctly and most studies attempting these

[1] *See, e.g., In the Matter of International Comparison Requirements Pursuant to the Broadband Data Improvement Act, International Broadband Data Report,* DA 18-9933, SIXTH REPORT, FCC Rcd 978 (rel. February 2, 2018) (available at: https://www.fcc.gov/reports-research/reports/international-broadband-data-reports/international-broadband-data-report-4).

comparisons are poorly conducted.[2] Comparing broadband speeds, in contrast, is more feasible, since constructing comparable data on speed is not as nuanced as developing comparable data on prices. But note that most speed testing performed by users is done on a non-random basis, which, if not similarly non-random across countries, may reduce the validity of comparisons.

In this BULLETIN, I compare fixed broadband speeds in U.S. cities to speeds in cities in other, higher-income nations. The data include fixed broadband speeds for 4,480 cities across the globe (910 in the U.S.) from 98 nations. Across multiple comparisons, I find that the U.S. has equal or higher download speeds—often much higher—than do other comparator countries. Of the 98 countries in the sample, average speeds in the U.S. are in the top 5% of all countries' average download speeds, and in the top third of upload speeds. But even this lower ranking in upload speeds is unconcerning because upload speed differences are typically small. In any event, since average download speed exceeds 200 Mbps and upload speeds in the U.S. exceed 65 Mbps, claims that the "Internet in the United States is far slower [] than most other advanced countries" are false.[3]

II. Data

The purpose of this analysis is to compare broadband speeds between cities of comparable size in countries of comparable economic development. Only nations listed by the Organisation for Economic Cooperation and Development ("OECD") as "high income" or "upper middle income" are included in the sample. City population, centroid coordinates, and square mileage data are obtained for 4,480 cities (including 910 in the U.S.) with at least 50,000 persons and a maximum of about 36 million persons. Cities are in 98 countries in the full sample with 52 countries in the "high income" group. Six geographic regions are represented: East Asia & Pacific; Europe & Central Asia; Latin America & Caribbean; Middle East & North Africa; North America; and Sub-Saharan Africa.[4] There are two other nation groups of interest: (1) member

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[2] *See, e.g.*, M. Israel, M. Katz, and B. Keating, *International Broadband Price Comparisons Tell Us Little About Competition and Do Not Justify Broadband Regulation*, White Paper Commission by NCTA (May 11, 2021) (available at: https://www.ncta.com/sites/default/files/2021-05/international-price-comparisons-paper-11-may-2021.pdf); G.S. Ford, *Be Careful What You Ask For: A Comment on the OECD's Mobile Price Metrics*, PHOENIX CENTER PERSPECTIVE No. 09-03 (September 16, 2009) (available at: https://www.phoenix-center.org/perspectives/Perspective09-03Final.pdf); G.S. Ford, *The Open Technology Institute's Cost of Connectivity 2020 Report: A Critical Review*, PHOENIX CENTER PERSPECTIVE No. 20-06 (July 20, 2020) (available at: https://www.phoenix-center.org/perspectives/Perspective20-06Final.pdf).

[3] T.M. Hanna and C. Mitchell, *United States: Communities Providing Affordable, Fast Broadband Internet*, in THE FUTURE IS PUBLIC: TOWARDS DEMOCRATIC OWNERSHIP OF PUBLIC SERVICES (S. Kishimoto, L. Steinfort, and O. Petitjean, eds.) (2020) at Chapter 9, p. 140 (available at: https://www.tni.org/files/futureispublic_chapter_9.pdf).

[4] The regions and countries include: North America (Canada , United States); Europe & Central Asia (Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia,

(Footnote Continued….)

nations of the OECD; and (2) the group of nations used to benchmark U.S. broadband performance in the FCC's 2018 *International Broadband Data Report*.[5] About 85% of the observations from OECD nations and the FCC's set of nations are found in the East Asia & Pacific or the Europe & Central Asia regions.[6] The FCC's benchmark nations are all OECD members (26 countries of the OECD's 34 non-US members at the time of its study).

Speed data are obtained from Ookla's (speedtest.com) Open Data Initiative (3rd and 4th Quarter 2021) for fixed broadband service.[7] Ookla is the world's preeminent speed-test firm.[8] Ookla's data are made publicly-available as averages for "geographic tiles," which are rectangular areas of varying sizes based on latitude-longitude but not linked to census cartographic boundaries (e.g., census blocks). For the Open Data Initiative, the fixed speed-test data are obtained from Android and iOS mobile devices (permitting location accuracy) using the Speedtest application. This selection of operating systems results in all tested devices connecting to the internet via a Wi-Fi connection, the effect of which is to likely bias downward all measured

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Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Kosovo, Latvia, Lithuania, Moldova, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Turkmenistan, United Kingdom); East Asia & Pacific (Australia, Brunei Darussalem, China, Fiji, Hong Kong, Japan, Malaysia, New Caledonia, New Zealand, Singapore, South Korea, Thailand); Latin America & Caribbean (Argentina, Bahamas, Barbados, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Guyana, Jamaica, Mexico, Panama, Paraguay, Peru, Puerto Rico, Suriname, Trinidad and Tobago, Uruguay); Middle East & North Africa (Bahrain, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Oman, Qatar, Saudi Arabia, United Arab Emirates); Sub-Saharan Africa (Botswana, Equatorial Guinea, Gabon, Mauritius, Namibia, South Africa).

5 *Supra* n. 1.

6 OECD members include: Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, and, United, Kingdom. FCC nations include: Australia, Austria, Belgium, Canada, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Japan, Latvia, Netherlands, New, Zealand, Norway, Portugal, South Korea, Spain, Sweden, Switzerland, United Kingdom, Mexico, and Chile.

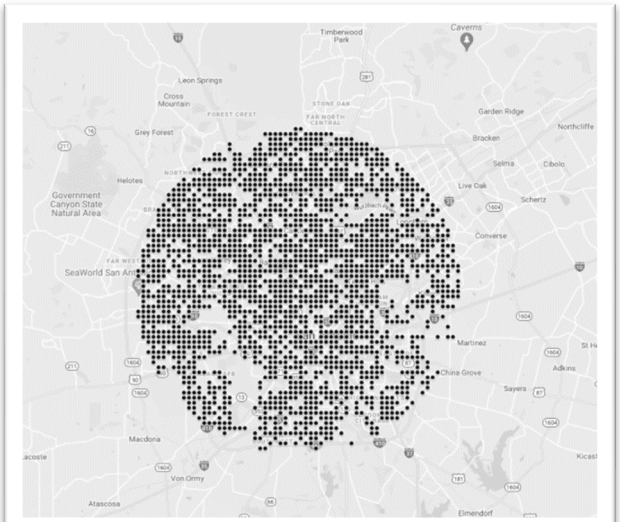
7 For a discussion of the limitations of speed test data, *see* G.S. Ford, *Form 477, Speed-Tests, and the American Broadband User's Experience*, PHOENIX CENTER POLICY PERSPECTIVE No. 21-03 (March 31, 2021) (available at: https://www.phoenix-center.org/perspectives/Perspective21-03Final.pdf); N. Feamster and J. Livingood, *Measuring Internet Speed: Current Challenges and Future Recommendations*, White Paper (2020) (available at: https://arxiv.org/abs/1905.02334); *see also Will Different Ethernet Cable Speed Affect My Network?*, FIBER OPTIC COMPONENTS BLOG (December 14, 2018) (available at: http://www.fiber-optic-components.com/will-different-ethernet-cablespeed-affect-network.html).

8 There are other speed test organizations including M-Lab, though M-Lab produces poor results. *See, e.g.*, D.D. Clark and S. Wedeman, *Measurement, Meaning and Purpose: Exploring the M-Lab NDT Dataset*, Working Paper (August 11, 2021) (available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3898339); Ford, *Speed-Tests*, *supra* n. 7.

speeds relative to what might be obtained via a wired ethernet connection to the home router. For each tile, the Ookla data include the averages of tested download speed, tested upload speed, and latency, as well as the number of tests and devices used to construct these averages.

Tiles are assigned in a circle around a city center. To do this, tiles are matched to cities where the matching boundary is set equal to the radius of the square-root of the city's total area divided by π.[9] Figure 1 illustrates the assigned tiles to San Antonio, Texas. In all, 4.05 million tiles are in the final sample, incorporating about 135 million tests over 39.3 million unique devices. Note the final sample size is very large, so the national means will be precisely estimated, increasing the chance for statistically-significant results even when the differences between means may be small. As is always the case with statistical analysis, implications of the size of any estimated parameter must be considered along with the precision of the estimate.

Figure 1. Assigned Tiles for San Antonio, TX



To compare cities of comparable size, the sample is divided into quintiles based on population. There are five groups of cities with the first quintile having the smallest and the fifth quintile the largest populations. Table 1 provides some summary statistics on the quintiles. Speeds are weighted by the number of unique devices tested. There is no monotonic relationship

[9] The procedure incorporates tiles in a circle around the city center. Square miles data is obtained from: http://www.worldcitiestool.org. Additional data on U.S. cities are obtained from: https://www.governing.com/archive/population-density-land-area-cities-map.html.

between speeds and population and the speeds are comparable across quintiles, so analysis of the full sample is feasible.

Table 1. Population Quintiles (millions)

Quintile	Mean	Lower Bound	Upper Bound	Mean Download	Mean Upload
1	0.12	0.05	0.20	142.7	54.5
2	0.32	0.20	0.48	126.9	59.8
3	0.80	0.48	1.23	119.6	55.8
4	2.17	1.24	3.61	118.6	50.6
5	11.51	3.63	36.47	133.6	68.8
Full Sample	2.97	0.05	36.47	128.3	59.5

Table 2 provides summary statistics by region and for the U.S., and for the United States and Canada separately (the two countries in the North America region as Mexico is assigned to the Latin America group). In the full sample, speeds are highest in the East Asia & Pacific, the Europe & Central Asia, and the North America regions, and noticeably lower in the Middle East & the North Africa and the Sub-Sahara Africa regions. Download speeds are more comparable in the "High Income" group and this sample is worth evaluating on its own. Several interesting details from Table 2 are worth mentioning. First, the speeds in the high-income group are sometimes faster and other times slower than the full sample. This suggests some upper-middle-income countries have above average speeds. Also, the sample shares change materially across the two samples, especially for the East Asia & Pacific and Latin America & Caribbean regions. Some regions represent small shares of the sample, but with 4.04 million total observations, the samples are not small.

Table 2. Regional Means

	Full Sample			High Income Sample		
Region	**Download**	**Upload**	**% Sample**	**Download**	**Upload**	**% Sample**
East Asia & Pacific	166.7	80.3	22.5%	131.8	91.5	10.2%
Europe & Central Asia	112.4	59.7	43.2%	125.2	55.8	54.9%
Latin America & Caribbean	90.9	45.0	11.7%	187.3	111.5	1.3%
Middle East & North Africa	112.0	54.2	2.6%	126.0	55.5	2.7%
North America	200.0	66.4	19.0%	200.0	66.4	30.8%
Sub-Saharan Africa	47.5	34.3	1.0%	…	…	…
US	204.7	65.4	82.9%	…	…	…
North America (not US)	179.1	71.0	17.1%	…	…	…
OECD	110.7	50.2	48.5%	…	…	…
FCC Int'l Report Nations	113.9	52.5	43.4%	…	…	…

Irrespective of the sample, download speeds in the U.S. have the highest average. Upload speeds are high in the U.S., averaging over 65 Mbps which is quite adequate for almost all use cases. Mean upload speeds are, however, lower in the U.S. than in the East Asia & Pacific, the Latin America & Caribbean regions (driven by Chile with its high upload speeds), and in Canada.

Both download and upload speeds vary widely within a city and country, so statistical testing for means differences is advised.

III. Statistical Analysis

This empirical analysis compares the mean speeds in U.S. cities to speeds in cities in other countries. A means difference test is conducted by regression analysis to determine whether there are statistically significant differences. Since sampled speeds presumably are correlated within a city (as customers may choose only from local networks), standard errors are clustered at the city level, which can be handled appropriately by the regression model.[10] The simple means-difference regression model is,

$$y_{ic} = \beta + \Delta US_{ic} + \varepsilon_{ic}, \quad (1)$$

where y_{ic} is the outcome of interest for city i in country c, US_{ic} is a dummy variable for cities in the U.S., and ε_{ic} is an econometric disturbance term. The coefficient β is the mean value of y for non-U.S. cities and $\beta + \Delta$ is the mean of y for the U.S. cities. A t-test on Δ permits a test of the null hypothesis that the mean in the U.S. is no different from the mean of other countries.

Table 3. Means Difference Results, All Cities

	Full Sample		High Income Sample	
	Download	Upload	Download	Upload
β	117.31***	58.68***	132.56***	63.92
	(30.81)	(17.05)	(31.41)	(14.29)
Δ	87.41***	6.71*	72.15***	1.47
	(20.62)	(-1.67)	(15.64)	(0.30)
Obs.	4,045,124	4,045,124	2,495,166	2,495,166
Mean not US	117.3	58.7	132.6	63.9
Mean US	204.7	65.4	204.7	65.4
Stat. Sig. * 10% ** 5% * 1%.				

The parameter estimates for Equation (1) are summarized in Table 3, with results for both the full sample and the "High Income" sample. The regression is weighted by the number of unique devices tested and standard errors are clustered on cities. For the full sample, download speeds in the U.S. are much higher (by about 75%) and the difference is statistically different from zero at the 1% level. Upload speeds, likewise, are on average higher in the U.S. by nearly 7 Mbps (11%) and the difference is statistically different from zero at the 10% level. Average population

[10] *See, e.g.*, A. Abadie, S. Athey, G.W. Imbens and J. Wooldridge, *When Should You Adjust Standard Errors for Clustering?* NBER WORKING PAPER NO. 24003 (November 2017) (available at: https://www.nber.org/papers/w24003).

density of U.S. cities is lower than in foreign cities (about 16% so), so these high relative speeds are impressive. For the "High Income" sample, download speeds in the U.S. remain well above that of other countries (54% higher) and this advantage is statistically different from zero. On the other hand, in this high-income group, U.S. and foreign upload speeds are statistically equal.

Figure 2. Download Speed Distributions

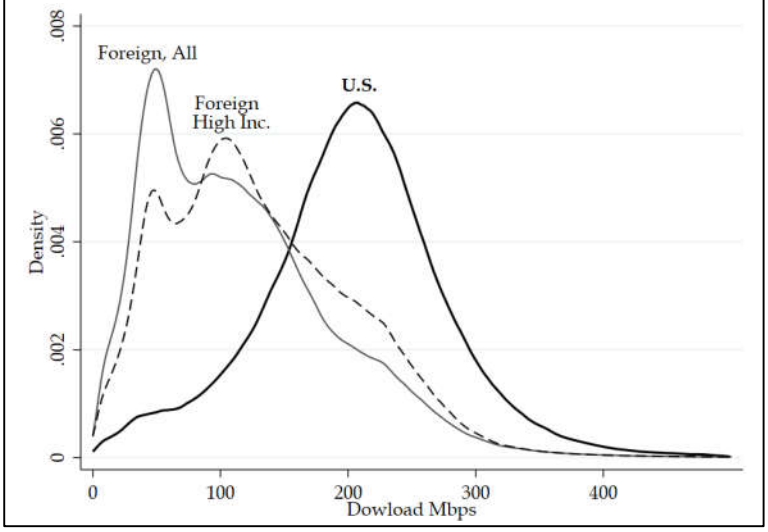


Figure 2 illustrates the (kernel) distributions of download speeds for three groups: (1) the U.S.; the full sample of foreign cities; and the high-income sample of foreign cities.[11] The high-income group's distribution is shifted slightly to the right of all the foreign cities (about 16 Mbps), but the two distributions are similar. Plainly, the U.S. mean is higher than either of the foreign samples. The foreign high-income group has average speeds of 132.6 Mbps download and 63.9 Mbps upload while the upper-middle-income group has average speeds of 105.6 Mbps and 54.6 Mbps. These are not large differences. Of the 98 countries in the sample, the U.S. ranks 5th in download speeds (a mere 10% off the fastest speed).[12] This places the U.S. at about the top 5% of national-average download speeds. For upload speeds, the U.S. ranks 28th of 98 countries, placing the country in the top 30% of upload speeds.

[11] For illustration purposes, the (visually uninformative) right tails of the distributions have been truncated at 500 Mbps.

[12] The nations with the top five download speeds are: Hong Kong (228.2); Singapore (226.3); Chile (215.6); Thailand (212.1); and United States (204.7).

Table 4. Means Difference Results by Quintile

Quintile	Type	Speed US	Speed Not US	Diff	Cities US	Cities Not US	Obs.
1	Download	201.2	97.3	104.0***	782	1,949	809,206
1	Upload	57.2	52.5	4.7*			
2	Download	202.8	111.5	91.4***	88	952	814,764
2	Upload	70.9	57.5	13.4*			
3	Download	205.7	107.3	98.4***	30	470	812,831
3	Upload	73.3	53.3	19.9*			
4	Download	212.3	113.5	98.8***	8	179	801,199
4	Upload	76.4	49.2	27.3*			
5	Download	216.7	130.6	86.2***	2	75	807,124
5	Upload	70.9	68.7	2.2			

Stat. Sig. * 10% ** 5% * 1%.

Table 4 summarizes the results by quintile. Mean speeds and their differences are provided along with an indicator for statistical significance. Sample characteristics are likewise summarized. Note that mean speeds are not much different across quintiles. Download speeds for U.S. cities are consistently higher than those in cities of other nations and these differences are large and statistically different from zero at the 1% level. Average upload speeds in the U.S. are always higher than their foreign counterparts though statistical significance is only at the 10% level. But in several cases, U.S. upload speeds are much higher.

Table 5. Means Difference Results by Quintile, High Income Group

Quintile	Type	Speed US	Speed Not US	Diff	Cities US	Cities Not US	Obs.
1	Download	201.2	115.9	85.3***	782	343	556,114
1	Upload	57.2	55.5	1.7			
2	Download	202.8	121.7	81.1***	88	291	539,861
2	Upload	70.9	58.6	12.3*			
3	Download	205.7	127.6	78.0***	30	136	500,313
3	Upload	73.3	59.6	13.7*			
4	Download	212.3	130.5	81.8***	8	65	523,726
4	Upload	76.4	51.0	25.5*			
5	Download	216.7	145.6	71.1***	2	25	375,152
5	Upload	70.9	81.3	-10.4**			

Stat. Sig. * 10% ** 5% * 1%.

Table 5 summarizes the results by quintile when the sample is limited to high-income countries. Again, download speeds for U.S. cities are much higher than those in cities of other nations and this advantage is statistically different from zero at the 1% level. Average upload speeds in the U.S. are also typically faster than foreign speeds although this advantage is generally only statistically significant at the 10% level. Note, though, that in the fifth quintile, U.S. upload speeds are lower (by about 13%) than foreign speeds, and the difference is statistically significant at the 5% level. But from a policy standpoint this should not be concerning because

the absolute speed difference is only 10.4 Mbps (70.9 Mbps versus 81.3 Mbps) which is likely indiscernible to nearly all users.

Table 6. Means Difference Results by Region

	Download Speeds			Upload Speeds		
Region	**US**	**Not US**	**Diff**	**US**	**Not US**	**Diff**
Full Sample						
East Asia & Pacific	204.7	166.7	38.0***	65.4	80.3	-14.9**
Europe & Central Asia	204.7	112.4	92.3***	65.4	59.7	5.7
Latin America & Caribbean	204.7	90.9	113.8***	65.4	45.0	20.4*
Middle East & North Africa	204.7	112.0	92.7***	65.4	54.2	11.2
North America	204.7	179.1	25.7***	65.4	71.0	-5.6**
Sub-Saharan Africa	204.7	47.5	157.2***	65.4	34.3	31.1*
High Income						
East Asia & Pacific	204.7	131.8	72.9***	65.4	91.5	-26.1**
Europe & Central Asia	204.7	125.2	79.6***	65.4	55.8	9.6*
Latin America & Caribbean	204.7	187.3	17.4	65.4	111.5	-46.1***
Middle East & North Africa	204.7	126.0	78.7***	65.4	55.5	9.9
North America	204.7	179.1	25.7***	65.4	71.0	-5.6**
Sub-Saharan Africa	…	…	…	…	…	…
Other Groups						
OECD	204.7	110.7	94.0***	65.4	50.2	15.2*
FCC Nations	204.7	113.9	90.8***	65.4	52.5	12.9*

Stat. Sig. * 10% ** 5% * 1%.

Table 6 summarizes the results by region. The story is comparable to the earlier analyses: the U.S. has higher download speeds (often much higher), with mixed results on upload speeds. The large difference in upload speeds for the Latin America & Caribbean region is driven by Chile (132.0 Mbps), whose observations account for about 65% of the region (and 73% of the high-income group). Other countries in that region have lower download speeds than experienced domestically within the United States. The results for the high-income countries tell a similar story though the differences in speeds are not identical. Roughly equal download speeds are observed for the Latin America & Caribbean region, but upload speeds are much lower in the U.S. (again, due to Chile).

For the OECD comparison, the U.S. download speeds are much faster on average than for other OECD nations (nearly twice as fast). Upload speeds are similar with U.S. speeds averaging 30% faster than other OECD nations. Finally, for the nations used in the FCC's *International Broadband Data Report*, the U.S. has materially higher download speeds and higher upload speeds.

IV. Conclusion

In this BULLETIN, I use a large sample of speed-test results to compare fixed broadband speeds between cities in the U.S. and cities in other nations using data from Ookla's (speedtest.net) Open Data Initiative. Cities are divided into population quintiles, segmented by geographic groups,

and grouped by OECD member nations and a set of nations used by the FCC to benchmark U.S. broadband performance. The most consistent result is that download speeds in U.S. cities are faster than in other nations, on average, and often materially so. Results for upload speeds are mixed though differences are often small. As for *fixed* broadband speeds (measuring by mobile phones using Wi-Fi networks), the U.S. performs exceptionally well relative to other nations, and certainly the data do not support the claim that the speeds in the U.S. are slower than most other advanced nations.

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