P E R S P E C T I V E S

PHOENIX CENTER FOR ADVANCED LEGAL & ECONOMIC PUBLIC POLICY STUDIES

Reclassification and Investment: A Statistical Look at the 2016 Data

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A regulatory revival at the Federal Communications Commission ("FCC") during the Obama Administration dramatically curbed capital spending on broadband infrastructure. Since the specter of reclassification was first introduced by then-Chairman Julius Genachowski in 2010, investment has consistently been at least 20% below expectations.[1]

More recently, significant attention has focused on the reductions in infrastructure investment following the *2015 Open Internet Order* (adopted on February 25, 2015).[2] Data from USTelecom and CTIA, for instance, show sizeable declines in capital spending in 2016, the year following the decision.[3] Even Free Press, an advocate for Title II, offers evidence that real investment declined in 2016.[4] Given the importance of broadband infrastructure deployment in the modern economy, the decline in capital spending will almost certainly play a role in the current FCC's proposal to reverse the reclassification decision and the legal defense of that decision.[5]

While the declines in capital spending appear significant, investment in the telecommunications sector changes every year, sometimes by large amounts. Thus, an important question to ask is whether the declines in investment in 2016 reflect standard variability for the industry or are abnormal in their scale. To answer that question, in this PERSPECTIVE I apply some statistical tests to the USTelecom and CTIA data to determine whether the reductions in capital spending in 2016 are abnormally large or merely consistent with random variation. To my knowledge, my analysis is the first to analyze the statistical properties of the investment changes in 2016.

My statistical analysis indicates that the significant investment declines reported by both USTelecom and CTIA in 2016 are abnormally large for the sector. Attributing these shockingly large reductions in capital spending to the 2015 Open Internet Order is not permitted absent a meaningful counterfactual, but the evidence clearly shows something is afoot in the broadband business.

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Capital Spending Data

The observation that capital spending has declined, even by a large amount, tells us little about the effects of a policy change. First, quantifying the true effect of reclassification on capital spending requires a counterfactual (what investment would have been absent the rule change). Of the very few studies that have applied a counterfactual analysis, all show sizeable declines in capital spending and sector employment (and even broadband speeds).[6] Second, each year capital spending by broadband providers undergoes random variation. Looking only at changes, therefore, requires, at a minimum, attention to the size of the change in relation to the typical changes experienced over time.

In this PERSPECTIVE, I test for the presence of an abnormally large change in capital spending in 2016, where the size of the change is measured with formal reference to historical changes in capital spending. Admittedly, for purposes of statistical analysis, there is a paucity of data. Both USTelecom and CTIA offer short time series of investment data and there is only one year of capital spending data following the *2015 Open Internet Order*. The dot-com bubble, following an investment frenzy after the Telecommunications Act of 1996, further taints the data. Practically, the data is limited to 2003 through 2016, or 14 observations, and 2009 was a recession year. Given these limitations, my analysis necessarily uses simple and mostly non-parametric tests to determine whether reductions in capital spending as large as those seen in 2016 are consistent with historical changes in capital spending over the past decade or so.

Here, I employ the investment data from 2003 through 2016 from both USTelecom and CTIA. These data are adjusted for inflation.[7] My interest is in the change in investment, so in what follows I let d equal the percentage change in real investment between years (the log difference). My analysis focuses on the statistical behavior of the series given by d.

Preliminary analysis of the data helps choose the right statistical approach. I begin by noting that statistical tests on the USTelecom and CTIA data indicate that the d series are stationary.[8] While the samples are small, the analysis of larger datasets indicate that telecommunications investment is stationary in first differences.[9] For neither d series can I reject the null hypothesis that the data is normally distributed (by the Shapiro-Wilk test).[10] The d series for the two datasets do not have a statistically-significant, deterministic time trend.[11] Finally, regressing d on its lagged value indicates that the observations are temporally independent.[12] Overall, the properties of the data point to some rather simple procedures to test for an abnormally large change in capital spending in 2016, the year following the *2015 Open Internet Order*.

According to the USTelecom data, real capital spending in 2015 was $77 billion. On average, we would expect capital spending in 2016 to be about the same. Instead, spending was $72.5 billion, indicating an investment decline of $4.5 billion from expectations. This figure is almost identical to that cited by Chairman Ajit Pai (about $5 billion) when announcing his plan to revisit the 2015 Open Internet Order.

Statistical Analysis

As discussed above, the d series are well behaved in a number of important respects, which supports some rather basic statistical tests. Still, in light of the small samples, I will employ (at first) a non-parametric approach to analyze the data, constructing the empirical distributions of the two series by way of the bootstrap. By visual inspection and reference to the confidence intervals, much can be said about the sizes of the declines in capital spending in 2016.

I will begin with the USTelecom data, which includes investment in wireline and wireless broadband infrastructure. For 2016, the percentage change in real investment from the USTelecom data is -6%, which is second largest decline in the series since 2003. The largest decline in capital spending occurred in 2009 (-11%), a recession year. This large decline in response to the recession suggests that capital spending can reflect changing economic and regulatory conditions somewhat quickly. Over the entire sample, the average *d* is very close to zero. Excluding the 11% drop in investment in 2009 (reflecting the recession and an outlier in the series), the average change in investment is 0.8% annually, also close to zero.

Figure 1. Empirical Distribution, *d* (UST)

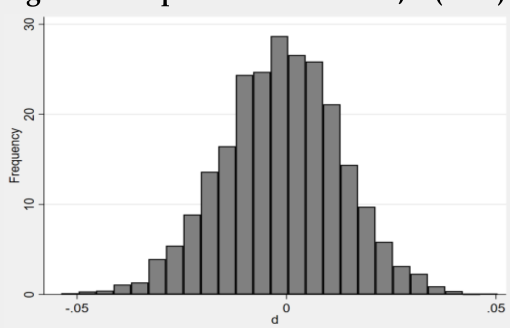

Figure 1 provides the empirical distribution of *d* for the USTelecom data (5,000 simulations). There is no requirement for symmetry, but the distribution is approximately symmetric. The 90% confidence interval is bounded by -2.5% and 2.6%. As shown in the figure and by the confidence interval, the 6% drop in capital spending for 2016 is well into the negative tail of the distribution. The probability of a -6% change in capital spending has a near zero probability, so a 6% drop in investment is statistically rather rare in this data.[13]

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For the CTIA data, the average *d* is 0.6%, so the average change in real capital spending in the wireless industry is also close to zero. For 2016, the percentage change in real investment is -20.5% which is the largest reduction in the sample. The large drop in 2016 is unprecedented in the data, so it is most certainly "abnormal."

Figure 2. Empirical Distribution of *d* (CTIA)

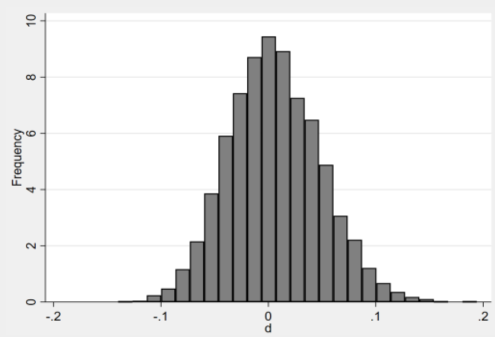

Figure 2 provides the empirical distribution of *d* for the CTIA data. The 90% confidence interval is bounded by -6.2% and 9.5%. Without question, a 20% drop in capital spending is extraordinary for this data series. The probability of such a sizable reduction is near zero.[15]

According to the CTIA data, real capital spending for the wireless industry in 2015 was $32.4 billion, and should have been close to that in 2016 (on average). Instead, spending was a shockingly low $26.4 billion, indicating an investment decline of $6 billion from expectations.

Spending Changes

Like the percent changes in capital spending, the time-series properties of the first differences likewise exhibit properties suitable for this sort of analysis. In 2016, the change in USTelecom's capital spending figure for 2016 was -\$4.5 billion. The bootstrapped 90% confidence interval is -\$1.9 billion to \$2.0 billion. For the CTIA data the change was -\$6 billion in 2016, yet the bootstrapped 90% confidence interval is -\$1.8 to \$2.7 billion. With respect to capital spending over the last decade or so, the changes in 2016 are very large and statistically quite rare.

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Prior Analysis of the USTelecom Data

Michael Horney, in a blog released by the Free State Foundation, employed a simplistic counterfactual analysis to the USTelecom data.[16] The blog was released prior to the release of the 2016 data by USTelecom, so 2016 investment was estimated by Mr. Horney. USTelecom has since released its official numbers for 2015, so my replication and extension of Mr. Horney's work proceeds with the official numbers. Consequently, there may be slight differences in the values computed here and those reported by Mr. Horney (though I can replicate his results using his estimates of investment).

Mr. Horney calculated a counterfactual using a linear trend based on nominal capital expenditures between 2003 and 2014.[17] This trend was then extrapolated the level of capital expenditures in 2015 and 2016, assuming capital expenditures would follow this linear trend. He then compares the predictions from the trend to actual capital expenditures in 2015 and 2016, concluding that capital expenditures were \$300 million below the trend in 2015 and \$5.3 billion less than the trend in 2016 (for a total effect of -\$5.6 billion). Mr. Horney conducted no statistical tests, however, of these differences from the trend, so I do so here.

Mr. Horney's analysis relies on a linear trend, which can be computed using the regression equation:

$$y_t = \beta_0 + \beta_1 t + e_t, \qquad (2)$$

where y_t is capital expenditures, t is a time trend, and e_t is a disturbance term. The parameters (β_0 and β_1) are estimated using data from 2003 through 2014, and then those parameters are used to construct a counterfactual for 2015 and 2016.

Using the nominal USTelecom data (as did Mr. Horney), the estimated regression is

$$y_t = 58.4 + 1.40t + \hat{e}_t. \qquad (3)$$

The prediction for 2015 is \$76.5 billion, which is \$0.5 billion above the actual figure. In 2016, the prediction is \$77.9 billion, which is \$5.4 billion above the actual investment level of \$72.5 billion (Horney puts the 2016 number at \$72.7). In total, capital spending in 2015 and 2016 is \$5.9 billion below the trend, which is very close to Mr. Horney's estimate (\$5.6 billion), a difference attributable to the new USTelecom data.

Figure 3. Linear Trend, Nominal

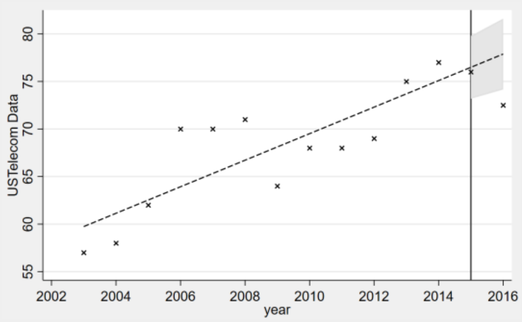


Figure 3 illustrates both the data and the trend. The 90% confidence interval of the forecast for 2015 and 2016 is also provided.[18] To address autocorrelation, the confidence interval is based on Newey-West errors; bootstrapped standard errors provide nearly identical results. As illustrated in the figure, the investment level in 2016 is well below the trend and well outside the 90% confidence interval. While the investment decline in 2015 is close to the trend and within the confidence interval, the investment decline in 2016 is well below the lower bound of the confidence interval. The $5.4 billion difference in 2016 is comparable to my estimate above of $4.5 billion and is also consistent with the figure used by Chairman Pai.

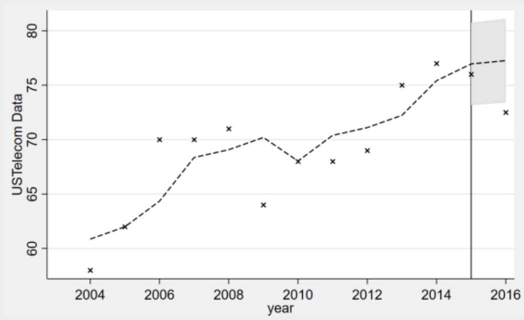
Whether one uses the USTelecom or CTIA data, the reductions in capital spending for 2016 are large and inconsistent with the normal variation in historical spending levels.

An alternative forecast approach is to apply a simple autoregressive trend model of the form,

$$y_t = \beta_0 + \beta_1 y_{t-1} + v_t. \quad (2)$$

Figure 4 illustrates the results of this autoregressive trend. The forecast appears to be a better fit of the variable capital spending data, but the implications for capital spending in 2016 are comparable. Investment in 2016 is materially below the forecast and outside the 90% confidence interval.

Figure 4. Autoregressive Trend, Nominal



As discussed above, the data used by Mr. Horney includes inflation, is non-stationary, has a trend (due to inflation), and is auto-correlated. While the Newey-West errors address, in part, these problems, the first-differenced series have much better properties, so I turn to those.

Table 1. Forecast of Differenced Series
($ Billions, Real)

Investment Change	USTelecom	CTIA
Forecast	0.50	0.84
Actual	-4.50	-5.99
Difference	-5.0	-6.83
Conf. Interval (90%)		
Newey-West	[-3.24, 4.24]	[-4.29, 5.98]
Bootstrapped	[-4.38, 5.39]	[-5.37, 7.05]

Table 1 summarizes the results from applying a linear forecast to the differenced series.[19] Confidence intervals are computed using Newey-West or bootstrapped errors. For the USTelecom data, the forecast change in capital spending in 2016 is $0.50 billion. Given the actual change of -$4.5 billion, the implied reduction in capital spending is -$5.0 billion. The actual change in spending is outside the 90% confidence interval (with a smallest lower bound of -$4.38 billion).[20]

Similarly, the forecast change in capital spending for the CTIA data in 2016 is $0.84 billion. With an actual change of -$5.99 billion, actual spending is -$6.83 billion below trend. Again, the change in investment is well outside the 90% confidence interval (with the smallest lower bound of -$5.37 billion).

Conclusion

Capital spending in the telecommunications sector is down significantly in 2016, a year after the FCC's controversial *2015 Open Internet Order*. In this PERSPECTIVE, I apply some basic statistical tests to determine whether the large reductions in capital spending are abnormal or broadly consistent with historical changes. Whether one uses the USTelecom or CTIA data, the reductions in capital spending for 2016 are large and inconsistent with the normal variation in historical spending levels.

For the USTelecom data, capital spending in broadband networks is $5 billion below expectations. For the CTIA data, capital spending in the wireless industry is about $6 billion below expectations, a decline of 20%. Again, attributing these shockingly large reductions in capital spending to the *2015 Open Internet Order* is not permitted absent a meaningful counterfactual, but the evidence clearly shows something is afoot in the broadband business. That said, earlier and more sophisticated counterfactual analysis suggests these changes in 2016 are gross underestimates of the actual investment impact of the Obama Administration's regulatory revival at the FCC.

NOTES:

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1 G.S. Ford, *Net Neutrality, Reclassification and Investment: A Counterfactual Analysis*, PHOENIX CENTER POLICY PERSPECTIVE No. 17-02 (April 25, 2017) (available at: http://phoenix-center.org/perspectives/Perspective17-02Final.pdf); G.S. Ford, *Net Neutrality, Reclassification and Investment: A Further Analysis*, PHOENIX CENTER POLICY PERSPECTIVE No. 17-03 (May 16, 2017) (available at: http://phoenix-center.org/perspectives/Perspective17-03Final.pdf); G.S. Ford, *"Regulatory Revival" and Employment in Telecommunications*, PHOENIX CENTER POLICY PERSPECTIVE No. 17-05 (June 12, 2017) (available at: http://phoenix-center.org/perspectives/Perspective17-05Final.pdf); G.S. Ford, *Below the Belt: A Review of Free Press and the Internet Association's Investment Claims*, PHOENIX CENTER POLICY PERSPECTIVE No. 17-06 (June 20, 2017) (available at: http://phoenix-center.org/perspectives/Perspective17-06Final.pdf); G.S. Ford, *Broadband Speeds Post-Reclassification: An Empirical Approach,* PHOENIX CENTER POLICY PERSPECTIVE No. 17-07 (June 27, 2017) (available at: http://phoenix-center.org/perspectives/Perspective17-07Final.pdf); T.W. Hazlett and A. Caliskan, *Natural Experiments in Broadband Regulation*, 7 REVIEW OF NETWORK ECONOMICS 460-480 (2008) (available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1093393); T.W. Hazlett and J.D. Write, *The Effect of Regulation on Broadband Markets: Evaluating the Empirical Evidence in the FCC's 2015 "Open Internet" Order*, 50 REVIEW OF INDUSTRIAL ORGANIZATION 487-507 (2017) (available at: https://ssrn.com/abstract=2859570); H. Singer, *Three Ways the FCC's Open Internet Order Will Harm Innovation*, PPI POLICY MEMO (May 2015) (available at: http://www.progressivepolicy.org/issues/economy/three-ways-the-fccs-open-internet-order-will-harm-innovation).

2 *Protecting and Promoting the Open Internet*, REPORT AND ORDER ON REMAND, DECLARATORY RULING, AND ORDER, FCC 15-24, 30 FCC Rcd 5601 (rel. Mar. 12, 2015) (hereinafter "*2015 Open Internet Order*"); *aff'd, United States Telecom Association v. FCC*, 825 F.3d 674 (D.C. Cir. 2016), *pet. for rehearing en banc denied*, 855 F.3d 381 (2017).

3 P. Brogan, *Broadband Investment Heads in the Wrong Direction*, USTELECOM BLOG (May 5, 2017) (available at: http://www.ustelecom.org/blog/broadband-investment-heads-wrong-direction). More detail was provided in a telephone conservation with Patrick Brogan (May 19, 2017) including a preliminary estimate for 2016; *Annual Year-End 2016 Top-Line Survey Results*, CTIA (May 2017) (available at: https://www.ctia.org/docs/default-source/default-document-library/annual-year-end-2016-top-line-survey-results-final.pdf?sfvrsn=2).

4 G.S. Ford, *Reclassification and Investment: An Analysis of Free Press' "It's Working" Report,* PHOENIX CENTER POLICY PERSPECTIVE NO. 17-04 (May 22, 2017) (available at: http://www.phoenix-center.org/perspectives/Perspective17-04Final.pdf).

5 *In re Restoring Internet Freedom,* FCC 17-60, NOTICE OF PROPOSED RULEMAKING, __ FCC Rcd __ (rel. May 23, 2017) (available at: http://apps.fcc.gov/edocs_public/attachmatch/FCC-17-60A1.pdf); A. Selyukh, *FCC Chief Begins Rollback of Net Neutrality Regulations*, NPR (April 26, 2017) (available at: http://www.npr.org/sections/thetwo-way/2017/04/26/525705253/fcc-chief-begins-rollback-of-net-neutrality-regulations).

6 *Supra* n. 1.

7 ECONOMIC RESEARCH: FEDERAL RESERVE BANK OF ST. LOUIS, Gross Domestic Product: Implicit Price Deflator (GDPDEF) (https://fred.stlouisfed.org/series/GDPDEF).

8 Tests applied include the Dickey-Fuller Test, the Phillips-Perron Test (Newey-West errors, 1 lag), and the Kwiatkowski, Phillips, Schmidt, and Shin test. The null hypothesis of the Dickey-Fuller and Phillips-Perron tests is non-stationarity, while the KPSS test has a null hypothesis of (either no-trend and trend) stationarity. Finding stationarity across the different null hypothesis of these tests (e.g., Dickey-Fuller and KPSS) is encouraging.

9 T.R. Beard, G.S. Ford, and H. Kim, *Capital Investment and Employment in the Information Sector*, 38 TELECOMMUNICATIONS POLICY 371-382 (2014) (available at: http://www.sciencedirect.com/science/article/pii/S0308596113002000); R. Beil, G.S. Ford, and J.D. Jackson, *On the Relationship between Telecommunications Investment and Economic Growth in the United States*, 19 INTERNATIONAL ECONOMIC JOURNAL 3-9 (2006) (available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=422521).

NOTES CONTINUED:

10 The t-statistic and bootstrapped t-statistic for the Shapiro-Wilk test (testing the null hypothesis the date came from a normally distributed population) are: USTelecom (-1.28 and -1.11); CTIA data (0.17 and 0.14). *See, e.g.*, P. Royston, *A Simple Method for Evaluating the Shapiro-Francia W' Test for Non-Normality*, 32 STATISTICIAN 297-300 (1983); N.M. Razali and Y.B. Wah, *Power Comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling Tests*, 2 JOURNAL OF STATISTICAL MODELING AND ANALYTICS 21-33 (2011) (available at: http://www.de.ufpb.br/~ulisses/disciplinas/normality_tests_comparison.pdf).

11 The Newey-West and bootstrapped t-statistics on the trend in real capital spending data are: USTelecom data (-0.06 and -0.06); CTIA data (0.86 and 0.84). For the *d* series, the statistics are: USTelecom data (0.92 and 0.88); CTIA data (-0.65 and -0.61).

12 The Newey-West and bootstrapped t-statistics on the lagged dependent variables are: USTelecom (-0.65 and -0.35); CTIA data (-0.00 and -0.00).

13 The smallest bootstrapped value is -5.3%.

14 *Ajit Pai Announces Plan to Eliminate Title II Net Neutrality Rules*, ARS TECHNICA (April 26, 2017) (available at: http://newsbreakouts.com/ajit-pai-announces-plan-to-eliminate-title-ii-net-neutrality-rules) ("According to one estimate by the nonprofit Free State Foundation, Title II has already cost our country $ 5.1 billion in broadband capital investment").

15 The smallest bootstrapped value is -12.9%.

16 M.J. Horney, *Broadband Investment Slowed by $5.6 Billion Since Open Internet Order,* FSF BLOG (May 5, 2017) (available at: http://freestatefoundation.blogspot.com).

17 R.S. Pindyck and D.L. Rubinfeld, ECONOMETRIC MODELS & ECONOMIC FORECASTS (1991), at Ch. 14.

18 This approach imposes symmetry.

19 There is no meaningful deterministic trend (the regression is not statistically significant), so the analysis is very similar to that presented in the earlier section. ARIMA modeling produced no useful results as there is no autoregressive component in the differenced series.

20 The lower bound of the bootstrapped confidence interval is -5.4 for USTelecom and -4.4 for CTIA.