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August 9, 2016

VIA ECFS

Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

Re: *WC Docket Nos. 16-143, 15-247, and 05-25* and *RM-10593*; "Response to the FCC Further Notice: Regulation of DS1 and DS3 Services," Prepared By Mark Schankerman and Pierre Régibeau

Dear Ms. Dortch:

Enclosed for filing in the above-captioned proceedings is a report entitled "Response to the FCC Further Notice: Regulation of DS1 and DS3 Services," prepared by Dr. Mark Schankerman and Dr. Pierre Régibeau.

Please contact the undersigned with any questions regarding this filing.

Sincerely,

WILKINSON BARKER KNAUER, LLP

Russell P. Hanser

Enclosure

Response to the FCC Further Notice: Regulation of DS1 and DS3 Services

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1 The views expressed in this report are those of the authors and do not represent those of Imperial College, the LSE or CRA.

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1. INTRODUCTION

1. We were asked by CenturyLink to comment on the design of the price cap, including a reset of initial prices for the price cap if the FCC decides to adopt one, for the regulation of BDS services, in particular DS1 and DS3 offerings.

2. Since 2005, DS1 and DS3 prices in price cap areas have essentially been subject to a system of "regulation by default," where the prices of services have been frozen in nominal terms and significantly reduced in real terms. The FCC has expressed the view, justly, that this approach is not compatible with the overarching goal of ensuring that the pricing of BDS remains "competitive" in the sense that they compensate suppliers for economic costs. To ensure that prices are set at a "competitive" level, two conditions need to be satisfied. Firstly, the initial price level should be set to allow suppliers to earn a "normal" economic return on their investments. Once this is done, the evolution of prices over time should simply reflect changes in the costs of supplying the relevant services. There is, of course, no reason to believe that simply freezing the nominal prices from 2005 onwards would have reflected the relevant changes in costs accurately. There are also questions about whether the prices in 2005 were themselves at appropriate levels, given that the 6.5% X-factor set in 1997 was rejected by a reviewing court as empirically unsupported[2] yet generally remained in place through 2003.[3]

3. This leaves the FCC with three potential tasks. The first task is to determine which geographic market areas are actually in need of regulation. The second task is to assess whether it is appropriate to "reset" prices in those markets, and, if so, design an evidence-based methodology to do so. The third task is to establish a price cap mechanism to ensure that further adjustments to regulated prices reflect changes in the relevant economic costs of the services concerned. Our report focuses on the last two tasks.

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2 *See United States Tel. Ass'n v. FCC*, 188 F.3d 521, 526 (D.C. Cir. 1999). The Court found that the Commission "failed to state a coherent theory supporting its choice" of X-factor.

3 *See* Tariff Investigation Order and Further Notice of Proposed Rulemaking, *Business Data Services in an Internet Protocol Environment*, WC Docket No. 16-143, at 141-142, ¶¶ 359-360 (FCC 2016) ("*FCC Further Notice*"). The FCC imposed a 6.5% X-factor applied each year through 2003, with the exception of 2000, when it was temporarily placed at 3.0%.

2. EXECUTIVE SUMMARY

4. We begin with the underlying logic of the price cap approach to regulation. This approach relies on two main principles. The first principle is that it attempts to track the behavior of "competitive" prices (i.e., prices that compensate for relevant economic costs including a normal return to capital investments). This is done in two steps: first, by setting the initial price at a competitive level and, second, by tying the evolution of this price to changes in the determinants of costs, namely changes in input prices and total factor productivity. The second principle is that, in order to preserve the regulated firms' incentives to invest in cost reduction, the measures of costs used to track the competitive price should not be under the direct influence of the regulated firm, but should accurately reflect the change in their own cost conditions related to the regulated services. We then explain that the capped level of prices can be calculated by either one of two established methodologies: the "direct" and "indirect" approaches. Although presented in a rather ad hoc manner, the FCC's own methodology is equivalent to the "direct" approach.

5. The report deals both with the issue of resetting (or reinitializing) the regulated prices, if the FCC decides to do so, and the issue of adopting an X-factor for ongoing price cap regulation.

2.1. The Potential Reset: Initializing the price to reflect past productivity performance

6. The FCC proposes three "methodologies" to determine the level at which "regulated" prices (i.e., DS1 and DS3 rates in areas deemed non-competitive) should be reset at the onset of the new regulatory regime. In fact, these three approaches differ mostly in the type of data that is used. In agreement with other economists with submissions in this proceeding, such as Sappington and Zarakas, and Christensen Associates, we believe that the approach based on KLEMS data is the only one which is both sufficiently reliable and internally consistent. The other two proposed methodologies should be discarded.

7. Relying on the same U.S.-KLEMS data as the FCC, we compute the overall level of price adjustment that is needed to start the new regime. For the period 2005-14, and taking changes in capacity utilization over the business cycle into account, we conservatively estimate that current regulatory prices would only need to be decreased by 0.1% in nominal terms (in this report, regulated "prices" refer to nominal prices unless otherwise stated). If we go farther back in time and use the period 2000-14, taking changes in capacity utilization over the business cycle into account, we find that current regulatory prices would need to be raised by 6.45%**.** Those prices would also need to be raised if we extend the period even further back to 1997, the year in which the FCC imposed its 6.5% X-factor, which a court later invalidated and which is, in fact, demonstrably much larger than actual productivity growth over that period.

8. However, the preceding estimates are likely to overstate very significantly the cost reductions that suppliers of DS1 and DS3 services experienced because they are based on total factor productivity of the telecommunications sector as a whole. Limited data availability makes it hard to compute price caps that would be closely tailored to the evolution of costs of supplying DS1 and DS3 services. Even if one uses data on productivity and input costs which are specific to the telecommunication sector, we know very well that this sector is characterised by very different segments facing different cost conditions. For example, there is no reason to believe that the change in cost for wireless services closely tracks the changes in DS1/DS3 costs. In a similar vein, the cost of providing cable service is unlikely to evolve in the same manner as the cost of DS1/DS3, which rely much less on fiber technology. Finally, as DS1/DS3 services use old, legacy technologies, potential sources of productivity gain seem much less likely than in more fluid parts of the telecommunication sector. In our view, the rate of productivity growth used to determine the price cap for DS1 and DS3 services should be lower than the rate computed from the KLEMS data, which applies to the whole Telecom and Broadcasting sectors. Since productivity measures specific to DS1 and DS3 services are not available, we cannot precisely quantify this discrepancy. However, this does mean one should ignore this likely difference in productivity growth. For that reason we also consider a scenario where DS1/DS3 services have experienced only 75% of the TFP growth of the sector as a whole. Over the period 2005 – 2014, this would imply that the regulated price be reset upward by an additional 4%. If one considers the period 2000 – 2014, the additional reset would be +10.5%.

9. For all of these reasons, we emphasize that any productivity estimate based on KLEMS data (and the X-factor that uses the estimate) is almost surely an *over-estimate* of the true TFP growth for DS1 and DS3 services which are to be regulated. This overestimate of the X-factor translates into an incorrectly large downward adjustment for any potential "reset" based on the KLEMS data. In other words, *1) if the computed reset is to reduce prices, the true reset should be a smaller reduction (and possibly an increase) and 2) if the computed reset is to raise prices, the true reset should be a larger increase than the one we compute on the basis of the KLEMS productivity data.*

10. We also show that, because ILECs have seen their relative position in the supply of DS1 and DS3 services using legacy TDM technology erode over time due to competition from new, superior technologies and because these services are characterised by economies of scale, traditional computations are likely to overstate the size of the adjustment required in the level of regulated price. We demonstrate that the magnitude of this bias is material, implying an additional upward adjustment of the regulated price by between 0.36% and 0.81%. This reinforces our conclusion that the new regulatory regime does not require any downward adjustment at all in the current level of regulated prices.

11. Overall, in our view, there is a strong empirical argument for adjusting the regulated price by between -0.1% and +4.4% if one only considers the period from 2005 to 2014 and by between 6.45% and 17.5% if the longer 2000 – 2014 is considered instead. The lower number does not include an adjustment for lower productivity growth for DS1/DS3, while the higher number does include it.

12. If initial prices are reset without taking into account these differences between the potential for productivity gains in DS1/DS3 services as compared to the sector as a whole, the regulated prices of DS1 and DS3 will be set too low. This, in turn, will discourage the rapid adoption of superior technologies and undermine effective competition between new information technologies and these legacy services. This outcome does not seem consistent with the objectives of the FCC to promote diffusion of new information technology. Finally, because the telecommunications market is characterized by economies of scale and density, prices differ significantly according to the business density of each market. For this reason, we conclude that regulated prices for DS1 and DS3 should be differentiated across broad categories of markets, grouped according to their business density which varies substantially across local geographic markets. We explain how this can be easily implemented.

13. Because any mistake made when resetting the regulated price will carry over into the new regulation period, it is especially important to get this initial level right in any re-initialization exercise. Any error in this initialization will be cumulative, and we will show that the total losses from an initial mistake can be quite important.

2.2. Ongoing Price Cap Regulation

14. We believe that the rate of the productivity adjustment factor to be used in the proposed regulatory regime going forward is best obtained by applying the KLEMS-based “direct” or “indirect” approaches to data that relate to a period recent enough to capture current productivity trends accurately. Because this relatively short reference period cannot guarantee that differences in utilization rates over the business cycle are “smoothed” out, the productivity adjustment factor should be adapted to take into account such fluctuations in the rates of utilisation at the sector level over the estimation period. This is completely separate from the effects of the secular decline in demand for legacy services provided by the ILEC’s (due to competitive erosion), including DS1 and DS3. With economies of scale, these declines imply higher unit costs and a separate adjustment, which we develop in the report. Using U.S. KLEMS data for the period 2011-14, and taking changes in capacity utilization over the business cycle into account, we find that going-forward the allowable change in the price cap for DS1 and DS3 services should be *increase at an annual rate of 0.5%. In the FCC’s methodology – and starting from an average annual change in GDDPI equal to 1.56% from 2011 to 2014, this corresponds to an “X factor” equal to 1.06%.*

15. It is possible that the productivity adjustment factor chosen initially might fail to track competitive prices accurately as circumstances change. To mitigate this risk – which *both* the providers *and* consumers of the *regulated* services face – the Commission might consider adopting pre-specified in-depth reviews every 5 years, and perhaps more sporadic checks based on the prices charged in the markets that the FCC deems to be competitive. This would, of course, impose greater administrative burden on the Commission and the parties involved. We think it would be ill-advised to allow service providers or consumers the ability to request interim reviews, as this would invite ongoing disputes and lobbying, and impose unpredictable administrative costs on the Commission and other parties.

16. However, it would be economically unwarranted and unwise to address this two-sided risk by introducing a "consumer dividend" (or a dividend for service providers, for that matter). From our perspective, a one-sided "dividend" to either service providers or consumers amounts to acknowledging that one is making a systematic error in computing the productivity adjustment factor in the price cap. If this is the case, then the methodology used to compute the adjustment factor should just be adapted to eliminate this systematic bias. Relying on a completely *ad hoc* consumer dividend is only likely to encourage unproductive rent-seeking behavior on both sides.

2.3. The Sappington and Zarakas Study

17. While there seems to be broad agreement across economic experts in this proceeding as to the methods that should appropriately be used both for potentially resetting the regulated price and designing the future regulatory regime, we are concerned with the use of data in the Sappington and Zarakas testimony.[4] Rather than rely on the US KLEMS data used by the FCC and most other economic experts, the authors use the European Union (EU) version of KLEMS because it has a narrower definition of the telecommunication sector. Unfortunately, their use of this data appears to be inconsistent and at times less than transparent.

4 Declaration of David E. M. Sappington and William P. Zarakas, Exhibit E to the Comments of Sprint Corporation, WC Docket Nos. 16-143, *et al*., filed June 28, 2016 before the Federal Communications Commission, Washington, D.C. 20554.

18. We highlight two critical pitfalls. The first, and most important, is that the TFP data in the EU-KLEMS data set is based on value added, not gross output. However, to be translated into the correct gross output TFP, value added TFP must be divided by the ratio between Gross Output and Value added, which is about 1.8 for the telecommunications sector.[5] By failing to make this adjustment, the authors overestimate the true (gross output-based) TFP gains in the sector by almost a factor of two. The second issue is that, while the authors do use the input price index offered by EU-KLEMS, this index does not include inputs such as capital and labour which make up most of value-added and more than half of total costs. This is a concern not only because of the partial character of the index but more importantly because correct economic reasoning compels that there must be consistency between the TFP measure (which is based on value added) and the input price index used.

19. Finally, whatever the source of the much larger productivity gains found in the EU-KLEMS data set might be, it would be imprudent to assign such large gains to legacy technologies such as TDM-based DS1 and DS3 services, which are the targets for regulation, where the scope for potential productivity gains is much more limited than for services at the technological frontier reflected in the EU-KEMS data.

3. THE LOGIC OF PRICE CAPS AND X-FACTORS

Price-cap regulation involves two steps:

- *Setting the initial price at a competitive level in the sense that they compensate suppliers for their economic costs, including the cost of capital.*
- *Determining an annual adjustment rate to ensure that the regulated price remains at a competitive (cost compensatory) level.*

In order to be accurate while preserving the investment incentives of the regulated firms, the annual adjustment factors should be based on the cost conditions of different, but sufficiently similar companies.

5 See Appendix 1.

3.1. "Similar but Different"

20. The basic economic logic of price cap regulation is simple. Provided that prices are initially set at the right "competitive" level, then one can guarantee that prices remain competitive over time by adjusting them to fully reflect changes in the cost of production since competitive firms would fully reflect changes in costs into their prices.[6] We note that throughout this report, we refer to the "price caps," but "price" here refers to whatever object is being regulated – e.g. in practice, this will refer to average revenue across the regulated services.

21. However, in order to provide individual companies with sufficient incentives to keep investing in cost-reducing innovation, the cost-related adjustment must be specified ex ante. Adjusting the prices that a given company can charge ex post (based on the evolution of its own costs) would eliminate all incentives to reduce costs in the first place. In a similar vein, even if specified ex ante, the cost-related adjustment to allowable prices should not rely to any significant extent on the past performance of the regulated company. Doing so would create a "ratchet" effect whereby the company would realise that lowering costs today will eventually result in lower allowable prices tomorrow. This, again, would dilute the company's incentive to invest in cost reduction. In practice, then, *the evolution of the regulated price imposed on a given company should broadly track the changes in costs achievable by the company, but it must not be linked directly to the company's own costs*.

22. The principle stated above can be conveniently summarized as the "similar but different" principle: the adjustment to the maximum allowed price should not depend on the evolution of the company's own costs, or at least on the elements of those costs over which the company has any control. At the same time, it is important to ensure that the factors which are used to adjust the maximum allowed price closely reflect the changing cost conditions (and achievable cost reductions) of the regulated companies. The information used to compute this adjustment should therefore be obtained from similar companies or, at least, similar sectors of activity.

6 The precise nature of the economic costs to be considered depends on the time horizon deemed to be appropriate, since some inputs are quasi-fixed in the short run, and in some cases entirely sunk (i.e., they have no salvage value) even in the long run.

3.2. Direct and indirect approaches

23. There are two traditional approaches to determining the evolution of capped prices. The direct approach is based on tracking changes in costs within the narrowly defined sector of activity to which the regulated company belongs. The indirect approach tracks changes in cost by reference to the evolution of the economy as a whole. Because being clear about the rationale behind these two approaches is essential for the arguments presented in this report, we begin by describing them more formally.

24. Let us define the maximum price allowed as P_{max} and the competitive price level as $P_c = (1+m)AVC$, where *AVC* is the average variable cost and *m* is a profit margin that compensates those inputs that are fixed over the time horizon considered ("quasi-fixed" inputs), so $m = 0$ in the long run. Let us assume that, in period 0, the initial maximum price has to be set equal to the competitive level, i.e. $P_{max}\,(0) = P_c(0)$. In order to ensure that the maximum allowed price remains at the competitive level over time, one must set the change in the maximum price equal to the change in the competitive price. Expressed in terms of percentage changes (denoted by a "d"), this implies that:

$$dP_{max} = dAVC$$

Or, equivalently,

$$\%\ change\ in\ regulated\ price = \%\ change\ in\ AVC$$

25. In turn, for a company that constantly adjusts its input mix to minimise costs, the change in average variable cost can be decomposed into a change in input prices and a change in total factor productivity. Defining w_i^S as the price of input i in sector *s* (where there are N different inputs) used by the company and s_i as the cost share of this input, we have:

$$dP_{max} = \sum_{i=1}^{N} s_i^S dw_i^S - dTFP_s$$

Or, equivalently:

% change in regulated (output) price =
% change in index of input prices in the sector - % change in sectoral TFP

26. To implement the direct approach, one needs to measure the change in total factor productivity and the change in the index of input prices in the relevant sector (or set of activities that are being regulated). Following our “similar but different” principle, the sector should be defined (among other potential constraints) narrowly enough to face input prices and productivity changes that are similar to those influencing the costs of the regulated services (in this case, these are DS1 and DS3, which are only a subset of the telecommunications sector).

27. It is worth noticing that the direct approach does not require us to specify any “X-factor” since the change in regulated price is obtained directly from the changes in the main determinants of the notional competitive price. The approach does not require any assumption about the effective degree of competition in the sector which is used in the computations. As long as the input price index and TFP reflect the determinants of cost changes for the firm, linking the regulated price to the evolution of these two indexes suffices by itself to ensure that the regulated price remains at an appropriate “competitive” level.

28. The alternative, “indirect” approach links the regulated prices to the change in output prices at the level of the U.S. economy-wide private sector, which is easy to collect, adjusted by an appropriate X-factor. Again, as with the direct approach, it is not necessary to assume that the economy as a whole is competitive (only that the degree of market power is roughly constant over the period of regulation).

29. Following the same logic as above, we can derive the appropriate X-factor by decomposing the percentage change in the maximum regulated price into the percentage change in input prices and the percentage change in productivity, but now we can do that both for the sector/market to be regulated and for the economy as a whole. We index factors referring to the sector with an “S” and those referring to the economy as a whole by “E”:

$$\mathrm{d}P_{Max}^{S} = \sum_{i=1}^{N} s_i^S \, dw_i^S - dTFP^S$$

$$dP^E = \sum_{i=1}^{N} s_i^E \, dw_i^E - dTFP^E$$

30. We now need to assume, reasonably, that the change in the input price faced by the sector to be regulated differs from the change in the index of input prices in the economy as a whole by a constant percentage amount, which we will label as D. Thus we have

$$\sum_{i=1}^{N} s_i^S dw_i^S = \sum_{i=1}^{N} s_i^E dw_i^E + D$$

For example, if D =2% it would mean that the regulated sector's input prices go up by 2% more than for the economy as a whole.

31. Combining this with the two relationships above for the % changes in output prices at the sector and economy levels, we get the basic formula for the price cap:

$$dP_{Max}^S = dP^E - [dTFP^S - dTFP^E] + D \equiv dP_E - X$$

Or, equivalently:

> *% change in the regulated price = % change in GDPPI – difference between % change in TFP in the sector and in the economy +(constant) difference between the % change in the input price index for the sector and for the economy as a whole*

32. Hence the price cap formula boils down to setting the allowed change in the regulated price equal to the output price index for the economy as a whole (e.g., the GDPPI) adjusted downward by an "X-factor." This adjustment factor represents the difference between productivity gains in the regulated sector and productivity gains in the economy as a whole, plus a factor measuring the additional increase (or decrease) in the input prices in the sector as compared to the economy as a whole. It is only within this "indirect" approach that an explicit "X-factor" should be applied.

33. In addition, this indirect price cap formulation (like the direct one) requires a measure of TFP and a (composite) index of input prices in the regulated sector. While determining such productivity and input price changes is not a trivial exercise, there are well-established methodologies to do so and the U.S. Bureau of Labor Statistics and Bureau of Economic Analysis publish such numbers.

34. Although the manner in which price-cap formula is presented in the Further Notice does not at first appear to follow either of these two traditional approaches, it is actually equivalent to the "direct" approach discussed above. To show this, we use the same notation as above and follow the steps outlined in paragraphs 404 to 408 of the Further Notice. The point of departure is that the annual change in the price cap index is

35.

$$dP^S_{Max} = dP^E - X$$

where the adjustment factor is defined as[7]

$$X = dP^E - \sum_{i=1}^{N} s_i^S dw_i^S + dTFP^s$$

Combining these two equations, we get:

$$dP^S_{Max} = dP^E - \left[dP^E - \sum_{i=1}^{N} s_i^S\, dw_i^S + dTFP^s\right] = \sum_{i=1}^{N} s_i^S\, dw_i^S - dTFP^s$$

36. While it might look like the changes in the aggregate price index might cancel out (yielding the "direct" approach), this is not so in practice because the first change in GDPPI that is used is the actual change in a given period, while the GDPPI term is the X-factor that is used by the FCC is the historical average over the period used to estimate the X-factor. Therefore, if we denote this historical average change in economy-wide output prices as dP^E_{Av} *and* making the *additional* assumption that

$$dP^E_{Av} = dW^E_{Av} - dTFP^E_{Av}$$

where W^E_{Av} is the average growth in the input price index at the economy-wide level, then we get:

$$dP^S_{Max} = dP^E - [(dTPF^S - dTPF^E_{Av}) - (dW^S - dW^E_{Av})] \equiv dP^E - X$$

37. This is equivalent to the "indirect approach" discussed above. So, although the FCC's presentation of its methodology is not explicitly anchored to the "competitive benchmark" that the price adjustment mechanism is supposed to reflect, it does, in the end, achieve the same result as the indirect approach In the following computations and analysis of the appropriate price changes that should be allowed under the price cap, we will present results both for the direct and indirect approaches. This provides a useful double-check on the results.

7 In the definition of the adjustment factor here, we use the *actual change* in the economy-wide output price (GDPPI). This is how it is formally presented in the FCC Further Notice. In practice, an historical average is used for this term and we show below in paragraphs 36-37 that this converts the FCC version into the *indirect* approach.

38. Before moving on, we also note that the FCC states that the X-factor is equal to "the projected difference between the economy-wide rate of inflation and the growth of industry input prices" plus "the projected growth rate of the *firm's productivity level*" (FCC Notice, 31 FCC Rcd at 4876 ¶ 404, italics added). As we have explained above, one should not use firm-specific measures that the firm can influence when setting up the maximum allowable prices. We have therefore re-interpreted the FCC's approach as relying on the evolution of productivity in the corresponding sector of activity.

4. POTENTIAL RESET

39. From 2005 onward, the rate of change in the maximum allowable price was set without explicit reference to changes in input prices or total factor productivity. As the FCC considers a more formal methodology in order to determine future adjustments in price caps, it therefore also makes sense to look back at the period from 2005 to determine whether the ad hoc adjustments made at the time have led to prices which are still in line with the competitive benchmark.

4.1. Small errors in resetting the regulated price can have large cumulative effects

Errors made when (re)setting the initial level of the regulated price affect prices over the whole period for which the regulatory policy is in place. Any reset exercise should therefore focus on setting this initial level correctly.

40. Resetting the initial allowed price level accurately is particularly important in any re-initialization exercise because any error will be compounded over a significant period of time. The magnitude of the overall cost of making mistakes in this initial reassessment can be illustrated by a simple example.

41. Suppose that the regulated price in 2005 was equal to 100 and that it was in line with the competitive benchmark. Suppose further that the correction factor which would have tracked the competitive benchmark correctly is denoted by $x_c\%$. Over the 11 years from 2005-16, this means that the competitive benchmark would have moved from 100 to

$$P_c(2016) = \frac{100}{(1+\frac{x_c}{100})^{11}}$$

42. Now consider a resetting exercise which concludes, incorrectly, that the actual rate of change that should have been applied in order to track the competitive benchmark is x_r. According to this assessment, this regulated price in 2016 would be

$$P_r(2016) = \frac{100}{(1+\frac{x_r}{100})^{11}}$$

43. This regulated price is higher or lower than the true competitive level depending on whether x_r is smaller or larger than x_c. Suppose now that the new regulatory regime is successful in establishing the correction factor x_f, which will ensure that the change in the maximum price tracks the change in the competitive (cost compensatory) price over the next 10 years. In year t (with t = 0 at the time of the reset), the ratio between the regulated and true competitive prices is then equal to:

$$R(t) = \frac{(1+\frac{x_c}{100})^t}{(1+\frac{x_r}{100})^t}$$

At the end of the ten years, the true competitive price is then equal to

$$P_c(2026) = \frac{100}{(1+\frac{x_c}{100})^{12}(1+\frac{x_f}{100})^{10}}$$

while the maximum allowable, regulated price would be equal to

$$P_r(2026) = \frac{100}{(1+\frac{x_r}{100})^{12}(1+\frac{x_f}{100})^{10}}$$

Comparing the two formulas, it is clear that the regulated price increasingly diverges from the true competitive price each year, over the whole period of future regulation. The divergence between the regulated and competitive prices represents the loss, or windfall, that the regulated firm faces for each year after the reset if the reset was inaccurate. Table 1 shows this loss/windfall relative to the level of the true competitive price.

Table 1: Percent difference between regulated and competitive prices as a function of the reset rate (measured relative to the competitive price)

	$x_c = 1\%$	$x_c = 2\%$	$x_c = 3\%$	$x_c = 4\%$	$x_c = 5\%$
$x_r = 1\%$	0	12.50%	26.50%	42.10%	59.40%
$x_r = 2\%$	-11.20%	0	12.40%	26.20%	41.60%
$x_r = 3\%$	-21%	-11%	0	12.30%	26%
$x_r = 4\%$	-29.60%	-20.80%	-10.90%	0	12.20%
$x_r = 5\%$	-37.30%	-29.40%	-20.60%	-10.80%	0

Source: CRA

44. This table shows that relatively small mistakes in resetting the initial price for the price cap can result in sizeable discrepancies. For example, mistakenly estimating the rate used for the reset at 4% when the correct rate is 3% creates an erroneous price reduction loss of 10.9% for the regulated firm. This magnitude applies to any discrepancy of one percentage point. A two percentage point discrepancy leads to about a 20% error. Given that the regulation itself aims at ensuring that firms only get a competitive return, this means that the regulation would actually impose a considerable and unjustifiable economic loss on the regulated firm. As these losses cumulate over time until a further reset exercise might be conducted, the total amounts involved are likely to be large. The same point applies if the adjustment factor is set too low, in which case the regulated firm would enjoy a windfall gain.

45. As the previous table shows, small mistakes on the X-factors applied in order to “reset” the regulated price can lead to rather large discrepancies between that price and the true competitive price. If the FCC decides to adopt a reset, it is important for the Commission and the parties concerned to invest significant effort in getting this initial level right.

46. The most appropriate way to do this is to compute the X-factor that would accurately reflect the changes in input prices and total factor productivity since 2005 (or the alternative period from 2000), based on the U.S.-KLEMS input price and productivity data constructed by the Bureau of Labor Statistics. Using this X-factor and the observed changes in the GDPPI, one can generate the correct path of prices over this period and compare it to the actual prices that were set under the previous regulatory regime. This comparison yields the appropriate reset to prices, if one is to be adopted. In addition, the appropriate X-factor for price cap regulation going forward should be based on the same source of input price and total factor productivity data at the sector and economy-wide levels.

4.2. The X-Factor Approach for a Potential Reset

47. As we have seen, the basic methodologies for computing X factors are well-established. In this regard, there is a broad commonality of views between what appears to be the FCC's approach and the approaches taken in various responses to the consultation exercise, such as Christensen Associates[8] and Sappington and Zarakas. The main differences in the results obtained by different parties come from three different sources: the choice of data set, the choice of the period over which the X factor is computed and further refinements of the basic methodology.

8 Mark E. Meitzen, Ph.D. and Philip E. Schoech, Ph.D., "Assessment of the FCC's Proposed Options for the Special Access Price Cap X-Factor," Christensen Associates, as attached to Letter from Kyle J. Fiet, Sidley Austin LLP, WC Docket Nos. 16-143, et al., filed June 28, 2016.

4.3. The Choice of the Data Set for the Reset

4.3.1. KLEMS Approach to the Reset

The "KLEMS" approach suggested by the FCC is well-established and relies on easily available data. By contrast, approaches based on cost simulation models are not reliable in this context for a number of reasons:

- *They rely on estimates which can be very sensitive to changes in the underlying assumptions, notably the allocation of joint costs.*
- *Models like the CACM do not have any solid basis for estimating the rate of technological change.*
- *There must be internal consistency between estimates of TFP and the input price indices used to adjust the regulated price. One cannot simply "mix and match" changes in costs from a model like CACM and changes in TFP obtained outside of such a model.*

Sappington and Zarakas use data from the EU-KLEMS data base and conclude that regulated prices should be drastically reduced. This analysis is entirely unreliable, for two main reasons:

- *The authors err by using a measure of TFP based on value-added without properly rescaling it to account for the significant difference between value added and total output.*
- *The EU-KLEMS input price index increases much less sharply than the US-KLEMS input price index, leading to more drastic adjustments in the regulated price. However, the EU-KLEMS input price index includes only intermediate inputs, but excludes the prices of the two most important factors -- capital and labor. As such, it is economically inappropriate and should be rejected.*

48. The choice of data set has two dimensions. First, one must choose between the three "approaches" proposed by the FCC. The first approach relies on KLEMS data, the second uses the "Connect America Cost Model," and the third complements the CACM model with financial data obtained from TDS Telecom. Second, within the KLEMS approach, one must choose the sector which is most appropriate to represent the cost-conditions faced by suppliers of DS1 and DS3 services.

The KLEMS-Based Method is the Most Reliable and Consistent of the Three Proposed Approaches

49. If the Commission decided to reset rates, the most reliable and economically meaningful approach is to base the measurement of the X-factor for the reset, and the ongoing price cap implementation, on productivity and input price data from the U.S. Bureau of Labor Statistics. This is a tried-and-tested approach that is firmly grounded in economic logic, administratively efficient and easy to update, and with which the FCC has extensive experience. In this section we explain why we believe that both the CACM and the augmented CACM approaches are not suitable for calculating the productivity and input price adjustments required for the reset and ongoing price cap implementation.

50. In 2011 the Commission adopted CACM to provide *a forward-looking estimate* by census block of the costs of providing a voice and broadband-capable network. This model contains data on cost shares for ten cost categories and *estimates* of future prices for these ten inputs. CACM is a stylized, static forward-looking cost model, and is likely to be highly sensitive to how joint and common costs are used to provide BDS and other services. Moreover, while the forward-looking nature of the cost estimates it generates might at first appear to be a virtue in the price cap context, it is not. Quite the contrary, the uncertainty and sensitivity of the estimates to the underlying assumptions and modelling structure make it unsuitable for the purpose. In our view, models like the CACM offer the illusion of precision, but they are underpinned by a complicated simulation structure and set of assumptions that are never subject to rigorous empirical validation. While companies do use a variety of cost simulation models to help inform their corporate planning decisions, adopting such a “predictive” model to set the absolutely critical X-factor for a potential reset, and price caps going forward, would be very problematic in our view, for the reasons discussed below.

51. First, these cost simulation models vary across companies, making the choice of any single one for the price cap (such as CACM) difficult to justify. Second, it is likely that the results of this model would be sensitive to changes in the structure and assumptions of the model, Confirming whether the conclusions from such models are in fact robust would be administratively burdensome, controversial and in practice would require all affected parties (both consumers and service providers) to have access to the model and data to examine the robustness of the "predictions". Third, the ten cost categories used in the CACM model are not exhaustive: they cover labor, fiber, poles, conduit, drop, optical net terminal, fiber pedestals, splitters, electronics, and land/buildings. Fourth, the CACM is primarily a simulation model of the costs of an ILEC with a focus on residential services, not business data services. While the FCC has expressed the view that the cost shares and input price changes (and total factor productivity gains) are not likely to be different for residential and business data services, this remains undemonstrated and is disputable (especially given the different bandwidth and other requirements for residential and business users).

52. In addition, and very importantly, the CACM model claims to predict costs but it does not have any modelling basis for predicting the rate of total factor productivity growth – neither the rate of technological change nor estimates (as opposed to assuming) the degree of economies of scale, both of which affect TFP growth. Yet these are the two key elements that determine how unit costs evolve over time (apart from exogenous changes in input prices). In fact, in the empirical results presented by the FCC on the CACM in the Further Notice, it says simply that "Two measures, one high and one low, were used for changes in total factor productivity" (31 FCC Rcd at 4878 ¶ 410). These measures are taken instead from the Federal Reserve Board (San Francisco) and correspond to economy-wide TFP growth, not sector-specific TFP as is required.

53. None of this is grounded in real data and actual cost (or total factor productivity) experience. This makes the CACM approach highly unsuitable for the purposes of determining the critical elements for the reset and price cap. All of these critical drawbacks and limitations apply equally to the third approach considered by the FCC, augmenting the CACM with financial data from TDS (plus the mismatch between cost categories in the CACM and TDS, as mentioned in the FCC Notice, 31 FCC Rcd at 4879 ¶ 411).

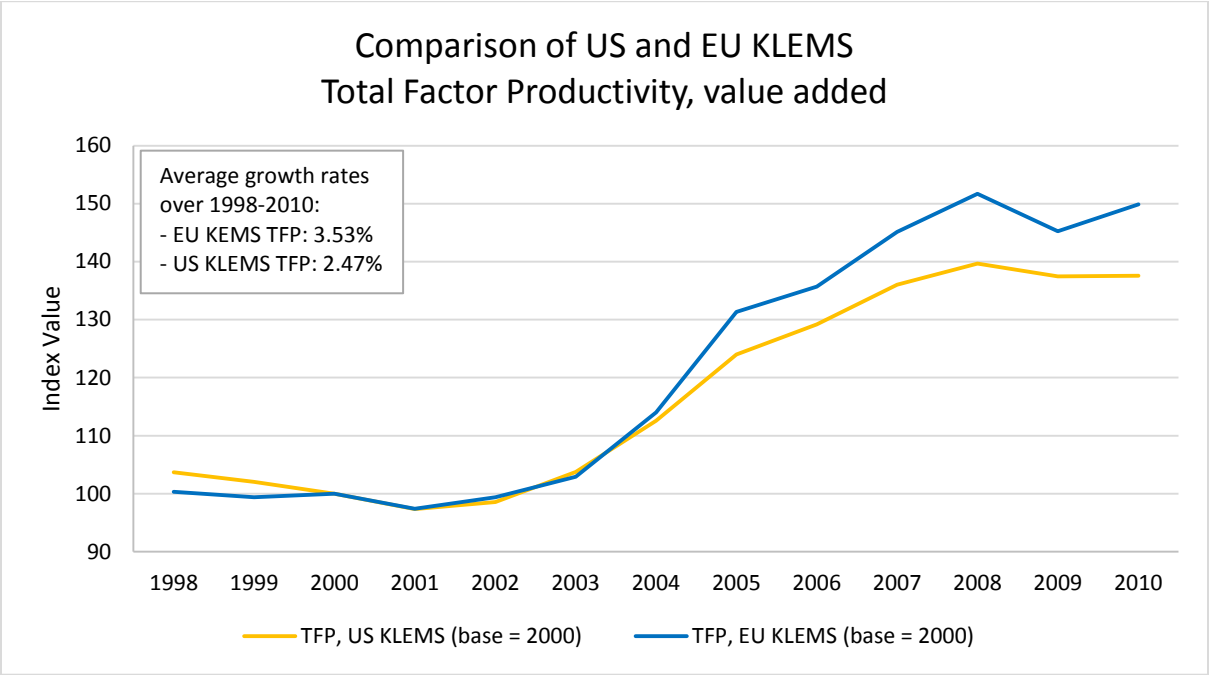
54. Finally, there is also a very important conceptual problem with the CACM approach. Any properly derived measure of total factor productivity, that is a critical element of the X-factor, is necessarily accompanied by a *corresponding* index of input prices. This is a well-known feature in the economic literature on productivity measurement. One cannot simply mix and match an input price index from one source and a productivity measure from another. They go hand in hand, and both derive from the underlying production function generating output. Mixing and matching makes the whole exercise internally inconsistent from an economic perspective. Yet this is exactly what using CACM would require, since that model does not generate estimates of the sector-specific TFP growth. Of course, one can compute such "mixed and matched" numbers, but they are not meaningful. Since the input price index from the CACM is not integrated with the computation of TFP growth, the approach suffers from this critical problem.

Using the EU KLEMS data is not appropriate

55. In a report submitted on behalf of Sprint, Sappington and Zarakas rely on KLEMS data. Like us, the authors choose KLEMS data rather than the two alternatives considered by the FCC because the KLEMS approach ensures that TFP is obtained in a consistent manner. However, Sappington and Zarakas argue that the US data available from the "EU-KLEMS" database is more suitable than the US or "World-KLEMS" versions. The stated reason for their choice is that the US data conflate information from the Telecommunication and Broadcasting industries, while the EU version isolates telecommunication services.

56. By relying on the EU-KLEMS data set, Sappington and Zarakas obtain a much larger adjustment factor in the indirect price cap approach (i.e., higher productivity adjustment and input price difference) and thus regulated prices which fall much more steeply than for the US data set. As shown in the following figure, this is because the productivity data which they use shows both higher productivity levels and – more importantly – faster increases in productivity than the US-KLEMS data used by the FCC as well as in our report.

Figure 1: Comparison of US and EU KLEMS



Source: The TFP series from EU KLEMS refers to the variable "TFPva_I: TFP (value added based) growth, index" for "Telecommunications" in the EUKLEMS database, March 2013 release, accessed via http://euklems.net/, last accessed: 13/07/2016. The TFP series from KLEMS refers to the variable "Multifactor productivity" in Table 1.2, for "Broadcasting and telecommunications (NAICS 515, 517)" from the Bureau of Labor Statistics (BLS), accessed via http://www.bls.gov/mfp/mprdload.htm, last accessed: 30/06/2016.

57. Sappington and Zarakas' use of these data would imply a very significant reduction in regulated prices to re-initialise the prices for the price cap, if a reset were to be adopted. However, we believe that the data used by Sappington and Zarakas is inappropriate, for four important reasons.

58. The first, and most important, reason is that the EU-KLEMS source that they use constructs TFP measures based on value-added, not gross output. This raises two issues. Firstly, it is well-known in the economic literature on productivity that one can obtain a meaningful measure of TFP based on value-added only under very restrictive assumptions on the shape of the underlying (gross output) production function, conditions which are typically found not to hold in a wide range of empirical studies including telecommunications.[9]

59. Secondly, even if these conditions were satisfied, the rate of growth in TFP obtained on a value-added basis will systematically be higher than the true rate of growth in TFP based on gross output. It is well known that the rate of growth in TFP based on value added (which is gross output minus intermediate inputs) is equal to the true rate of growth in TFP based on gross output multiplied by the ratio of gross output to value-added (e.g. Cobbold, 2003, cited in footnote 9). In short, the value added TFP growth that Sappington and Zarakas use overstates the true growth in TFP. This is not a big issue when one uses the TFP for the economy as a whole since, with the exception of imports, value added sums up to gross output at the aggregate level, but it is absolutely crucial to make the adjustment when looking at only one sector of the economy. Formally, this can be stated as:

$$True\ growth\ in\ TFP = (growth\ in\ VA - Based\ TFP)\frac{VA}{Gross\ Output}$$

60. Using the EU-KLEMS data, the ratio of value added to gross output for the telecommunications sector in the U.S. varied between 1.78 and 1.97 over the period 1998-2010, with an average of 1.89.[10] This means that Sappington and Zarakas' use of EU-KLEMS data leads them to overestimate the true TFP growth, based on gross output, by more than 80%. Little wonder that they find a large X-factor adjustment and a greater implied reduction in prices for the potential reset. *This approach is wrong and should be rejected by the Commission.*

9 For example, *see* E.W. Diewert, "'Hicks' Aggregation Theorem and the Existence of a Real Value-Added Function," in M. Fuss and D. McFadden, eds., *Production Economics: A Dual Approach to Theory and Applications* (Amsterdam: North Holland Publishers, 1980), pp. 17-51. For a good discussion of the theoretical issues and the extensive literature on empirical tests of the validity of value added functions (most of which show the required conditions do not hold, including in communications), *see* Trevor Cobbold, "A Comparison of Gross Output and Value-Added Methods of Productivity Estimation," Australian Government Productivity Commission, Research Memorandum GA511 (November 2003).

10 EU-KLEMS database, March 2013 release, accessed via http://euklems.net/, on 13/07/2016.

61. Thirdly, contrary to the claim of the authors, the data that appears under the "Telecommunications" heading in the EU-KLEMS data for the US does not isolate the telecommunication sector. Just like the US-KLEMS data, it aggregates Telecommunications and Broadcasting.[11] There is therefore no possible advantage in relying on the EU KLEMS data base. We should add that the user notes for the US part of the EU-KLEMS data base also mention that sector J – which includes telecommunications – "is the sectors (sic) for which time series estimates will be most inaccurate".[12]

62. Finally, the large changes in TFP on which the Sappington and Zarakas analysis relies simply do not pass a basic "sanity" test. We understand that, as economists, we are limited to using the data that is available. In particular, since we do not have sufficient information about TFP at a finer level than the "telecommunications" sector, we cannot directly apprehend any significant difference that there might be across the various technologies used in that sector. However, this should not be an excuse for completely ignoring the technological heterogeneity which is a feature of the real telecommunication sector. It seems beyond dispute that DS1 and DS3 are based on very mature "legacy" technologies, where recent investment has been limited and no significant technological breakthrough has been made for many years. Nor can any be reasonably expected in the future, given the increasing shift to Ethernet-based services.

63. It strikes us as extreme to assume that the change in TFP observed for the telecommunications sector as a whole, where key segments of growing importance, like wireless, have seen spectacular technical advances, would be representative of the evolution of TFP for legacy technologies such as TDM-based DS1 and DS3 services. This means that using a classification which bundles telecommunications and broadcasting together – as in the US KLEMS data – might actually give us a better reflection of the evolution of TFP for the actual services to be regulated, if technological progress in broadcasting has – as one might suspect – been somewhat slower than in telecommunications. At the very least, this "reality check" suggests that any adjustment factor based on TFP estimated for rather buoyant sectors must be an *upper bound* and should be discounted considerably before being applied to DS1 and DS3 services.[13]

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11 *See* http://www.euklems.net/data/nace2/USA_sources_12i.pdf .

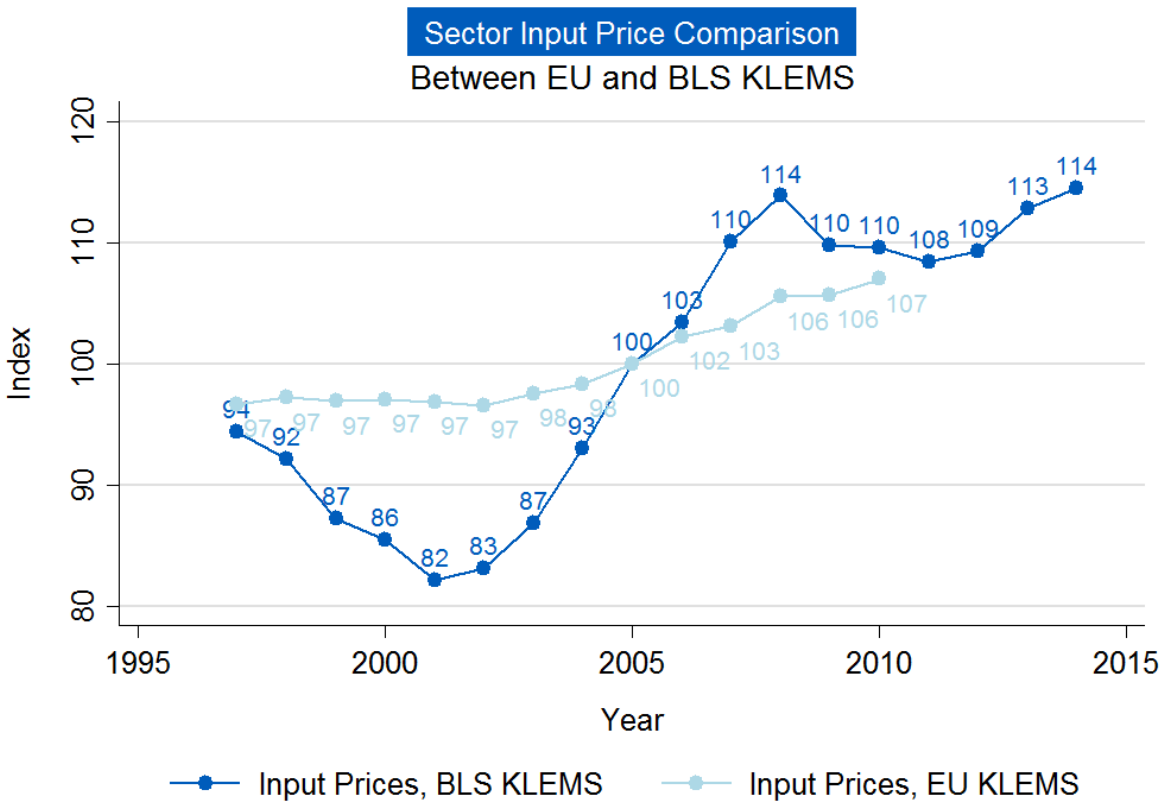
12 *Id*., page 3.

13 It may be challenging to measure TFP for this subset of services because of the need to allocate joint costs. That said, one must nonetheless account for the fact that the regulated services, DS1 and DS3, are legacy services which differ sharply from the rest of the telecommunications sector, both in terms of the decline in their demands as consumers migrated to more advanced technologies, and in the different scope for productivity gains for these legacy services as compared to other, more frontier technologies. Later in this report we show how one can make an informed adjustment to account for these differences in the measurement of the appropriate X-factor.

The Composition of the EU-KLEMS Input Price Index is not Clearly Defined

64. Another source of discrepancy between the results of the Sappington and Zarakas study and our calculations based on US-KLEMS data is their use of the EU-KLEMS input price index. For some reason, this index increases significantly less over their chosen period of analysis (1998-2010) than the BLS input price index for the "telecommunications and broadcasting sector" used in both our computations and the FCC's KLEMS-based approach. As seen in the following graph, the difference between the two series is quite substantial.

Figure 2: Comparison of sector input prices from EU-KLEMS and BLS KLEMS data



Source: CRA, with EU-KLEMS and BLS KLEMS data

65. The increase in input prices over the periods 2005 – 2014 and 2000 – 2014 is markedly different between the two series. Recall that the lower the rate of increase in input prices, the lower the regulated price under either the direct or indirect price cap formulations. Therefore, the fact that the EU-KLEMS series increases much more slowly than the US data used by the FCC, combined with their erroneous use of value added-based TFP data, helps explain why Sappington and Zarakas end up with much lower estimates for what the regulated price should be at the time of the reset.

66. In fact, the EU-KLEMS input price index excludes the prices for the primary inputs of capital and labor – which constitute over half of total telecommunications' costs.[14] This is a particular concern because, as explained above, the EU-KLEMS TFP data is based on value added. To be consistent with this approach, the appropriate input price index should be based on the set of inputs in the value added formulation – that is, it should be based only on the prices of labor and capital (and not include the intermediate inputs that are netted out of gross output to get value added). Effectively then, Sappington and Zarakas rely on a time series for input prices which is both illegitimate and inconsistent.

67. Irrespective of the actual composition of the EU-KLEMS index, we believe that the claim by Sappington and Zarakas of a large difference between the input price indexes for the telecommunications sector and the private business sector should be seen with a healthy dose of scepticism. One needs some reality check: what is the main source for this divergence? Are there specific inputs used heavily in telecommunications which have remained especially cheap over the time period (remember: the focus should be on labor and capital here)? Are these inputs important for the supply of TDM services? In the absence of a more detailed "story" explaining the peculiar behavior of the EU-KLEMS input price index, we believe that the FCC is better served by relying on the official data from the U.S. Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA).

14 *See* http://www.euklems.net/data/EUKLEMS_Growth_and_Productivity_Accounts_Part_I_Methodology.pdf (pp. 6-8) and (http://ec.europa.eu/economy_finance/publications/publication9467_en.pdf (p.8).

4.3.2. Choosing the Relevant Period for Assessing a Potential Reset

- The only period which is relevant for determining the proper rate of annual adjustment to regulated price and hence the extent of the required reset is the period for which regulation was felt to be unsatisfactory and hence in need of correction.
- It makes no sense to use only the information that would have been available at the beginning of the past regulatory period for computing any potential reset. All available, relevant information should be exploited.
- If the Commission wants to correct for the regulatory regime prevailing since 2005, where the annual rate of adjustment was set equal to the change in the GDPPI, then the adjustment rates should be computed on data from 2005.
- If the Commission also wants to correct for the regime since 2000, it should use data from 2000 onwards. There is even a case for extending the data back to 1997, since the productivity factor used during most of the period 1997-2003 was set far above the actual productivity performance.

68. In Table 7 of its Further Notice, the FCC computes the X-factors over three different periods: 1997-2013, which is the longest period for which the FCC has data; 1997-2003, which the period for which data would have been available in 2005; and 2005-2013. For purposes of a potential reset, the task is to change the current level of regulated price to reflect the difference between the cumulative effects of the annual adjustment since the chosen start date and a set of annual adjustments that would have reflected changes in input prices and productivity accurately. Any analysis based on the 2005-2013 period assumes that 2005 rates are an appropriate starting point. But any choice of a date range that begins after 1997 will be inherently conservative and errs on the side of inappropriately low rates. As discussed below, any methodology that begins at any date after 1997 will not fully correct for methodological errors during the 1997-2003 period, when the FCC generally applied a 6.5% X-factor that a court invalidated as empirically ungrounded and that we now know, from currently available data, was indeed excessive.

69. There is absolutely no reason to rely instead only on the data which "would have been available" in 2005. Doing this amounts to second guessing what the regulatory regime would have been, if the FCC had opted for a traditional price cap approach rather than for the GDPPI adjustment. Why does it make sense to try to rewrite history – and hence unavoidably misjudge the true evolution of "competitive prices", when one can take advantage of *ex post* knowledge as to what the determinants of competitive prices actually were? This would be equivalent to determining the position of a comet today not based on its known trajectory since 2005, but based on what astronomers' prediction of that trajectory would have been in 2005.

70. The FCC also estimates the adjustment rate over periods which are longer than the period for which regulated prices must be adjusted. We understand that using a longer period means more data points which can help "average out" whatever "noise" there is in the data. However, including data from outside the period for which an adjustment may be warranted also means that the adjustment rate is affected by technology and cost conditions which might be quite different from those that prevail during the period for which prices must be adjusted. In our view, estimating the adjustment factor from 2005 up to the most recent data available (likely to be 2015 or 2016 by the time the new regulation comes into place) gives us enough directly relevant observation points not to risk introducing less relevant information into the estimation procedure.[15] We conclude that, of the three estimates presented by the FCC, only the estimate corresponding to 2005-2013 is logically consistent. According to the FCC's own computations, this suggests a positive reset of 0.48%. (Our own attempt at replicating the FCC's analysis yielded a slightly different result, i.e. a negative reset of 0.63%).[16]

71. However, there is also a strong case for extending the analysis to a period before the start of the "GDPPI" adjustment era. From 1997 to 2003, the X-factors were very high – 6.5% through 2003 (with the exception of 3.0% for 2000) -- which far exceed the appropriate adjustments based on the BLS KLEMS data, as we show below. Thus the appropriate "reset" required before the new price cap is put in place should, in our view, also include some or all of this earlier period. We conducted the calculations for the period 2000-2014, and the results are presented in Tables 2 and 3. Again, because this period begins after the excessive 6.5% X-factor was adopted in 1997, it is conservative and errs on the side of too-low rates.

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15 Further, for reasons set out in the following paragraph, it would be inappropriate to use pre-2005 data to adjust the price cap only with regard to the post-2005 period and not adjust the price cap for the pre-2005 period given that the generally prevailing 6.5% X-factor was excessive.

16 See Appendix 2 for details of our computations.

Table 2: Reset needed to correct for ad hoc regulation over the 2000- 2014 period

Year	GDPPI, %	X-factor, % (CALLS Order)	Sector Input price growth, % (based on KLEMS data)	Sector TFP growth, % (based on KLEMS)	Price Cap adjustment, %, direct method (based on KLEMS)
2000	2.28	3	-2.04	-2	-0.04
2001	2.28	6.5	-3.91	-2.6	-1.31
2002	1.53	6.5	1.22	1.3	-0.08
2003	1.99	6.5	4.47	5.2	-0.73
2004	2.75	2.75	7.09	8.5	-1.41
2005	3.22	3.22	7.48	10.1	-2.62
2006	3.07	3.07	3.41	4.2	-0.79
2007	2.67	2.67	6.49	5.3	1.19
2008	1.93	1.93	3.39	2.7	0.69
2009	0.79	0.79	-3.54	-1.6	-1.94
2010	1.23	1.23	-0.21	0.1	-0.31
2011	2.06	2.06	-1.04	-0.9	-0.14
2012	1.84	1.84	0.76	-0.2	0.96
2013	1.63	1.63	3.28	3.3	-0.02
2014	1.64	1.64	1.45	1.70	-0.25

Source: The variable "X-factor, % (CALLS Order)" is set to 3% in 2000, 6.5% in 2001 to 2003, and equal to GDP-PI thereafter. The sector TFP data is taken from the variable "Multifactor productivity" in Table 1.2, and for the sector input prices a list of variables is used: "Price of Capital Services", "Price of Labor", Price of Energy", "Price of Materials" and "Price of Purchased Services" from Table 2.3 and "Capital Factor Shares", "Labor Factor Shares", Energy Factor Shares", "Materials Factor Shares" and "Purchased Services Factor Shares" from Table 5.1 for "Broadcasting and telecommunications (NAICS 515, 517)" from the Bureau of Labor Statistics (BLS), accessed via http://www.bls.gov/mfp/mprdload.htm, last accessed: 30/06/2016.

72. From Table 2 we see that, while during the 2000 – 2004 period the underlying economic factors of input prices and total factor productivity would have justified significant reductions in regulated prices, the adjustments that were actually made were more drastic than needed. Not surprisingly, when we look at the total cumulative adjustments from 2000 to 2014 implied by actual regulation (next to last column in Table 3), we get a number which is significantly more negative than if we compute the total cumulative adjustment that should have been applied had regulation been based on a formal price cap approach.

73. Thus if the FCC decides to adopt a reset to correct the distortions introduced throughout this period, the regulated price for the reset should quite unambiguously be increased. The actual cumulative reduction under the CALLS Order amounted to 12.7%, while the reduction called for by the actual productivity gains and input price changes is only 6.6%. These calculations indicate clearly that the reset of the initial price, if one is to be adopted, should be an increase of 7%,[17] before the new, more systematic price cap regime is introduced. Again, these are conservative estimates that do not account for the excessive X-factors applicable before 2000.

Table 3: Cumulative Adjustment Factors and Reset for 2000-2014 and 2005-2014

Period	GDPPI, CAGR	X-factor, CAGR (CALLS order)	Direct Price adjusted CAGR (based on KLEMS)	Cumulative adjustment (CALLS Order)	Cumulative adjustment (unadjusted direct approach)	Implied Reset
2005-2014	1.2%	1.2%	-0.05%	0.0%	-0.4%	-0.4%
2000-2014	2.0%	3.0%	-0.5%	-12.7%	-6.6%	+7.0%

Source: The input data for these calculations is taken from the previous table. The Cumulative adjustment (CALLS order) has been calculated as (1+GDPPI-XFACTOR)^14 - 1, the Cumulative adjustment (based on the unadjusted direct approach) has been calculated as (1+Direct P adj.)^14 - 1.

17 This is a rate by which the actual regulated price should be increased at the beginning of the new regulatory period. Define the price at the beginning of the period as P_o, the actual regulated price at the end of the period as P_R and the correct regulated price at the end of the period as P_1. We have $P_R = (1 - x_R)P_o$, where x_R is the proportion by which the initial price has been reduced over the period and $P_1 = (1 - x_1)$, where x_1 is the proportion by which the initial price should have been decreased over the whole period. This implies that $P_1 = \frac{1-x_1}{1-x_R} P_R$.

4.3.3. DS1 and DS3 services differ significantly from the rest of the Telecom (and Broadcasting) sectors

Utilizing long-established legacy technologies, DS1 and DS3 services are unlikely to have experienced the same productivity gains as the rest of the telecommunications, or even telecommunications + broadcasting, sector over the last decade. While the data for estimating this difference do not exist, one should bear in mind that, even under a conservative scenario where TFP for DS1 and DS3 only increased 25% less than for the sector as a whole, this differential would call for an additional positive reset of 4.0% for the 2005 – 2014 period and 10.5% for the 2000 – 2014 period.

74. Available data do not allow us to factor in likely differences in the rate of change in input prices and productivity for DS1 and DS3 services as compared to the sector(s) for which data is available. The fact that such discrepancies cannot be measured precisely does not mean that they should be ignored. It seems patently clear, for example, that old legacy technologies, such as TDM-based DS1 and DS3 services, cannot possibly have experienced the same rate of productivity increase as other parts of the sectors included in the data, such as wireless telecommunications or other data transfer technologies that rely more heavily on fiber.

75. Referring to Table 2 above, we see that, over the period 2005 to 2014, TFP growth averaged about 2.5% per year. If we assume that productivity growth in the supply of DS1 and DS3 was three quarters as high – which seems to us a generous assumption for a declining technology – the rate of adjustment for DS1 and DS3 should be reduced by 0.63% a year. This in turn yields a cumulative correction of about 13% over the period. This means that, *starting from any estimate of the reset obtained based on the BLS KLEMS data for the sector, one should increase the implied reset price by 6.3%.* So, for example, the FCC's own KLEMS-based estimate of a reset of -0.3% would become a positive reset of 6%.

4.3.4. Adjusting for economies of scale and the erosion of demand for DS1/DS3 services

- *Changes in TFP are only routinely assessed for the sector as a whole. This means that TFP captures the evolution of costs for a range of products, not just DS1 and DS3. In the presence of economies of scale, a secular decline in demand – as observed for DS1 and DS3 – leads to higher costs.*

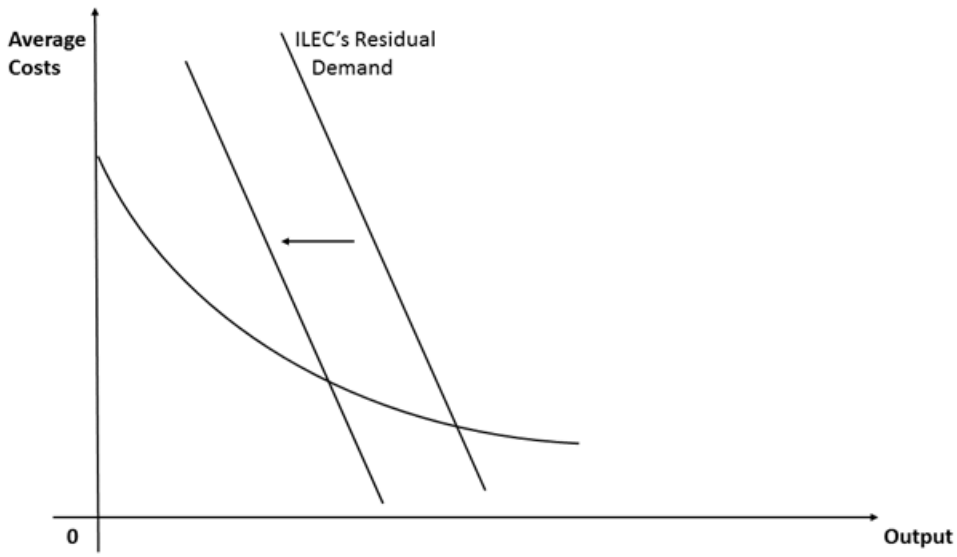
- *Since ILECs have experienced a sharper decline in demand and/or DS1 and DS3 services account for a larger than average share of their revenues, sector-wide data on TFP growth overestimates the actual productivity gains (cost declines) experienced by ILECs. This conclusion holds even if the demand for DS1 and DS3 services increased for some period, as long as these legacy services grew at a slower rate than the aggregate of all other services provided by the sector.*

- *We demonstrate that, for reasonable parameters, this "economies of scale" effect implies that regulated prices should be revised upwards by an additional 0.36% to 0.81% in any potential reset.*

76. The supply of DS1 and DS3 services involves significant fixed costs so that, for a given company, average costs are decreasing with the level of output. This is especially likely to be true for ILEC's since, at the current stage of the life-cycle of these services, basic network investments have been made, though significant maintenance costs for this network remain.

77. Over the recent past, ILEC's supplying DS1 and DS3 services have faced intensified competition from CLEC's offering identical services or close substitutes, such as Ethernet-based services, leading to significant erosion of their market shares and, in fact, reductions in their actual levels of output. In economic terms, we can think of ILEC's as facing a residual demand function (netting out competitors' output) that shifts to the left over time, moving the ILEC "up its average cost curve", as shown in the figure below.

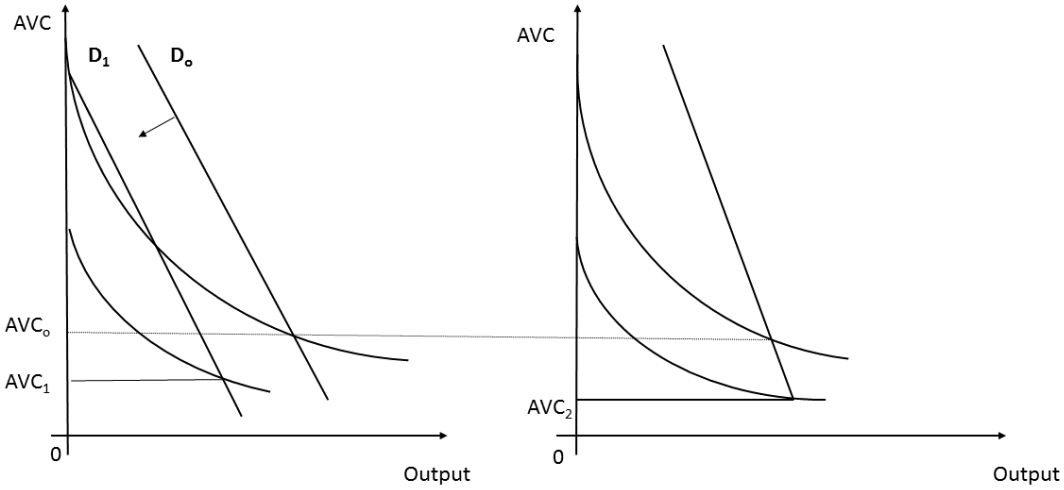
Figure 2: Decreasing Average Costs and Shifting Residual Demand



78. Such a shift would not be an issue if it were experienced by all products and close substitutes, or if the available estimates of TFP only reflected the evolving conditions for this narrowly defined set of products. However, in practice, neither of the two conditions is likely to be satisfied. On the first count, total demand for Ethernet services has been growing sharply, while DS1 and DS3 have been either growing much more slowly or declining. On the second count, we do not have information about changes in TFP for DS1/DS3 services or even for those services plus Ethernet. To the extent that other products with which DS1/DS3 are bundled for the purpose of measuring TFP have not experienced a contraction in (residual) demands, with the resulting movement up along the average cost curve, the TFP estimates used in our (and the FCC's) calculations would overestimate the change in TFP which is relevant to the price cap for DS1/DS3 services in "non-competitive" markets.

79. This is illustrated in the picture below where (for simplicity) we assume that DS1 and DS3 services experience the same downward shift in the average cost curve as the rest of the telecom industry (this is due to technological change), but the DS1/DS3 supplying ILEC's also face a residual demand that shifts to the left due to competition from new, superior technologies.

Figure 3: The Effect of Shrinking Residual Demand



80. We see that the resulting decrease in average costs is higher for the rest of the sector (right-hand graph) than for the company operating in a subsector where it faces decreasing demand for its product. Since the change in TFP for the sector will be a weighted average of the changes in the subsector and the change in the rest of the sector, it will overestimate the cost reduction experienced by the regulated firm. This overestimation will be more acute when the sectors or firms experiencing decreasing demand account for a smaller share of the total sector.

81. A simple numerical example helps illustrate that this overestimation of the actual unit cost reduction can potentially be significant, and in fact is likely to be so. We simplify by supposing that ILEC's and CLEC's sell both regulated TDM-based services (output 1) and other telecommunication services (output 2). As we derive in Appendix 3, the following relationship holds between the growth in TFP, the growth (or decline) in the two output levels of the company and the shift in the company's cost function (which represents technological change):

$$dTFP = (1-\varphi)\{r_1 dY_1 + r_2 dY_2\} - dC$$

where *dC* is the (percentage) downward shift in the total cost function which reflects the rate of technological change, dY_i is the rate of growth (or decline) in output i, r_i is the revenue share of output *i* and φ is the sum of the cost elasticities of the two outputs. Hence, economies of scale imply that φ is smaller than one (doubling all outputs would less than double total costs).

82. We can use this formula to compute the relevant change in TFP for both the sector (indexed by S) and the ILECs (indexed by i). To keep matters simple, we assume for this illustrative calculation that 1) the ILEC and the sector as a whole experience the same rate of growth for DS1 and DS3 services, and the same rate of growth for other telecommunication services, and 2) that the rate of technological change is the same for the ILECs and the sector as a whole. Thus the ILEC only differs from the sector because DS1/DS3 services represent a larger share of its total business than for CLECs. In this simple case, the discrepancy between TFP growth for the (telecommunications) sector and TFP growth for the ILECs is:

$$DISCREPANCY \equiv TFP^S - dTFP^I = (1-\varphi)(r_1^S - r_i^I) * [dY_1 - dY_2]$$

83. Notice that our assumptions in this calculation -- that the sector and the ILECs experience the same rate of change in each of their two output categories (but different between the services), and the same rate of technological change for ILECs and their rivals -- we are almost surely being highly conservative. This is so since ILECs have suffered greater contraction in their TDM services (specifically, DS1 and DS3) than CLECs and other rivals, and ILECs are more focused (in terms of their revenues) on legacy services that likely have less efficiency gains than technological frontier services.

84. We illustrate the likely impact of this adjustment by using confidential data supplied by CenturyLink. Unfortunately, because of a number of major acquisitions, we only have consistent data from 2011 to 2015. For this period, we have $r_1^I = 0.123$ (in 2011), and the cumulative change of revenues of $dY_1 = -27.7\%$ and $\mathrm{d}Y_2 = +2.42\%$. We understand from CenturyLink that the share of the revenues accounted for by DS1 and DS3 services at the sector level is unlikely to be larger than 5%. Accordingly, we consider $\theta \equiv r_1^I - r_1^S$ to be at least equal to 0.07. We can now calculate the discrepancy between the sectoral change in TFP and the change in TFP that should be applied when regulating the ILEC (DS1/DS3 services) for various values of the elasticity of scale (consistent with the economics literature on economies of scale in telecommunications) and various values of θ.[18]

18 For a good survey of this literature, *see* Ferenc Kiss and Bernard Lefebvre, "Econometric Models of Telecommunications Firms: A Survey," *Revue Economique* (1987), vol. 38, number 2, pp. 307-374.

85. The results are presented in Table 4. The entries in each cell present the difference between TFP growth for the sector as a whole and the correct TFP growth for the ILEC (labelled DISCREPANCY in the equation above). Thus positive entries indicated that sector-level measures of TFP growth will overstate the true measure for the ILEC. The table shows that over the 2011 to 2015 period, the regulated price obtained from an X-factor computed on the basis of sector-wide KLEMS data would lead to a reset that is too stringent by between 0.36% and 0.81%.

Table 4: Difference between TFP growth for the sector and the ILEC, calibrated on CenturyLink data

		Total Cost Elasticity	
	$\boldsymbol{\varphi = 0.7}$	$\boldsymbol{\varphi = 0.75}$	$\boldsymbol{\varphi = 0.8}$
$\boldsymbol{\theta = 0.06}$	0.54%	0.45%	0.36%
$\boldsymbol{\theta = 0.07}$	0.63%	0.53%	0.42%
$\boldsymbol{\theta = 0.08}$	0.72%	0.6%	0.48%
$\boldsymbol{\theta = 0.09}$	0.81%	0.68%	0.54%

Source: Calculated by CRA

86. Of course, if the period from 2005 to 2011, or from 2000 to 2011, were also characterised by a smaller expansion (or greater decline) for the relevant TDM services than for the sector as a whole, then using the traditional X-factor methodology to "reset" the regulatory price before embarking on the new price cap regime would lead to an even greater underestimation of the correct regulated price. Indeed, if we obtained similar results for the rest of the 2000-2014 period, omitting this scale-related adjustment would lead to resetting prices between 1.2% and 2.6% too low. In summary, this is *one more good reason for making sure that one does not err on the low side in any potential reset of the regulated price based on conventional methods and the best KLEMS data.*

4.3.5. Controlling for cyclical fluctuations in capacity utilization

87. Total factor productivity is widely acknowledged to be pro-cyclical – it increases in boom periods and declines in recessions.[19] When using past data to compute an adjustment factor for future use, when the shape and duration of future economic fluctuations are unknown, it is important to ensure that this X-factor is correct, on average, over the business cycle. This means that, it is important to use an X-factor from which the effect of changes in capacity utilization over the business cycle have been removed. We make an explicit adjustment to the computations of the X-factors in each of years over the relevant 2005-2014 period. Formally, the "capacity utilization adjusted" growth in TFP for year t is:

$$\Delta TFP_t^{adj} = \Delta TFP_t - \mu_t$$

where μ_t is the rate of change in capacity utilization. This formulation implicitly assumes that the change in capacity utilization affects all factors of production in a similar manner. Alternatively, one can assume that fluctuations in capacity utilization affect only capital (i.e., that capital is quasi-fixed and labor is fully flexible). In this case, the adjusted TFP is

$$\Delta TFP_t^{adj} = \Delta TFP_t - s_k\mu_t$$

where s_k is the share of capital in total costs.

88. The tables below show both the unadjusted and capacity utilization-adjusted yearly growth in TFP for a number of periods. The unadjusted change is in the second column. The third column assumes that all inputs are affected by utilization rates (the first formulation above), while the fourth column assumes that utilization only matters for capital (the second formulation above). For the rate of utilization, we use the aggregate utilization series published by the U.S. Federal Reserve Board.[20]

19 *See* for example D. Comin, August 2006, "Total Factor Productivity", http://www.people.hbs.edu/dcomin/def.pdf.

20 U.S. Federal Reserve, Industrial Production and Capacity Utilization – statistical release G.17 (419), July 15, 2016. Available online at https://www.federalreserve.gov/releases/g17/Current/g17.pdf, last accessed on July 31, 2016.

Table 5: Annual Rate of Change in TFP without and with an Adjustment for cyclical movements in Capacity Utilization

Period	% change in TFP, unadjusted	% change in TFP, adjusted/all factors	% change in TFP, adjusted/capital only
2005 – 2014	1.60%	1.50%	1.60%
2000 – 2014	2.60%	2.60%	2.60%

Source: The TFP series from KLEMS refers to the variable "Multifactor productivity" in Table 1.2, for "Broadcasting and telecommunications (NAICS 515, 517)" from the Bureau of Labor Statistics (BLS), accessed via http://www.bls.gov/mfp/mprdload.htm, last accessed: 30/06/2016. From the same source, the variable "Capital Factor Shares" is taken, see Table 5.1. The utilization rate for the economy is calculated from the variable "dutil: Utilization of capital and labor" from the FED database, precise citation: John G. Fernald, "A Quarterly, Utilization-Adjusted Series on Total Factor Productivity" FRBSF Working Paper 2012-19 (updated March 2014).

89. Not surprisingly, the adjustments do not make much of a difference if one considers a sufficiently long period of time (since the number of years with high and low capacity utilization tend to average out as the period becomes longer), but it matters more when shorter periods are considered. Nonetheless, the overall conclusion is that the direct adjustment for *cyclical fluctuations* in capacity utilization—as opposed to the more consequential long-term declines in demand for DS1 and DS3 services in particular—do not have a large effect on the computed X-factor.

90. The next table shows the annual rate of adjustment required in order to reset the regulated price at the proper competitive level if we use the changes in TFP in the previous table.

Table 6: Cumulative % Adjustment Required to "Reset" the Regulated Price

Period	Direct Approach, unadjusted	Direct Approach, adjusted for all factors	Direct Approach, adjusted, capital only
2005 – 2014	-0.4%	0.1%	-0.3%
2000 – 2014	+7%	+6.1%	+6.8%

Source: This table uses data described in detail in earlier tables. As an overview, the following variables are used here: the TFP variable for NAICS classifications 515 and 517 from the BLS KLEMS data and the input price based on tables 2.3 and 5.1 from the same source. For adjustments, utilization rates of the economy (data from the FED) and the capital share from KLEMS for the NAICS sectors 515 and 517 are used.

91. Since the reason for potentially resetting the regulated price is to account for the lack of cost-based adjustments since 2005, tracking the adjustment factor adjusted for cyclical fluctuations in capacity utilization over the period 2005-2014 (or later as data becomes available) makes the most sense. The computations presented above indicate a cumulative reset of between -0.4% and +0.1%, if the Commission chooses to adopt a reset. Using the longer period 2000-2014, which we would recommend, indicates a cumulative reset between +6.1% and +7% if any reset is adopted.

4.3.6. Direct Versus Indirect Approach

● *The "indirect approach" to computing the X-factor uses changes in the economy wide TFP and cost of inputs as points of references. Otherwise, just like the direct approach, it adjusts the regulated price to reflect changes in TFP and input prices over time.*

● *Relying on the indirect approach we obtain rates of reset for the regulated prices which are marginally higher than with the direct method: +1% instead of -0.4% for 2005 – 2014, and +10.9% instead of +6.1% for 2000 – 2014.*

92. All of the computations we have provided so far were based on the “direct” approach, described at the beginning of this report. For completeness – and as an additional robustness test -- we now report the results of computations based on the “indirect” approach. Since we do not have a measure of capacity utilization which is specific to the telecommunications sector, capacity utilization does not enter this calculation: we would be subtracting the same rate of change in aggregate capacity utilization from both the change in aggregate TFP and the change in sectoral TFP. Since only the difference between the rate of change in aggregate and sectoral TFP matters for the indirect approach, the utilization adjustment nets out.

Table 7 shows the annual changes in regulated prices implied by the indirect approach for various periods of time. Table 8 shows how the required cumulative adjustments compared to the actual regulated price evolves from 2005 to 2014. We see that the implied “reset” (cumulative change) over the ten year period is very small, indicating that current regulated prices should actually be increased by 1%. For the period 2000-2014, which we recommend, the potential reset should be a much larger 10.9% (this is because the very large, arbitrary productivity factors used in the 2000-2004 period greatly exceeded the appropriate adjustments based on hard productivity data).

Table 7: Indirect Approach, Annual percentage change in regulated prices

Period	Annual price cap change
2005 – 2014	0.10%
2000 – 2014	-0.20%

Source: In addition to variables described earlier, the following variables are used here: for the aggregate TFP, the variable "dtfp: Business sector TFP" is used, from the FED database, precise citation: John G. Fernald, "A Quarterly, Utilization-Adjusted Series on Total Factor Productivity" FRBSF Working Paper 2012-19 (updated March 2014), and the variable "Input Price" in Table 4.2 in the XG tab (Excluding Government Enterprises), from the Bureau of Labor Statistics (BLS), accessed via http://www.bls.gov/mfp/mprdload.htm, last accessed: 30/06/2016.

Table 8: Indirect Approach: Cumulative Reset of the Regulated Price

Period	Cumulative reset
2005 – 2014	1%
2000 -2014	10.9%

Source: As per the previous table. Note that the data herein refers to the unadjusted data.

4.4. The need to differentiate any potential reset across markets

- *Evidence from the economics literature shows that there are economies of density. Therefore, if regulation aims to align prices more closely to costs, any potential reset price should be differentiated according to the business density of the local area.*
- *We show how this can be achieved using a simple methodology. Moreover, this differentiation can be set up so as to be "revenue neutral" overall.*
- *Once the initial prices have been differentiated, a single annual adjustment factor can be applied in the price cap across all markets.*

93. Whatever methodology the FCC decides to adopt to determine a potential reset, it will almost certainly be the case that unit costs tend to be higher in markets where business density is lower. This should not be surprising since network industries are typically characterised by sizeable economies of density.[21] As a result, the cost of providing DS1 and DS3 services should be expected to be higher in, for example, rural areas than in urban ones.

94. In order to get an idea of the magnitude of the corrections needed to reflect differences in business density across "markets", we need information on the magnitude of economies of density and on the variations in business density across the USA. For the elasticity of cost with respect to density in this illustrative calculation, we will assume a value of -0.02, which is a very conservative estimate – i.e., it is at the low end of the range of estimates for network industries in the economics literature. This value means that a 10% increase in (business) density leads a 0.2% reduction in unit costs. For business density, we use U.S. Census data on the number of establishments per county and Wikipedia's area per county to compute business density. While this information relates to counties rather than census tracts, it should still provide a good sense of the magnitudes involved.

21 *See* for example Caves, D.W., L. R. Christensen and M.W. Tretheway, 1984, "Economies of Density Versus Economies of Scale: Why Trunk and Local Service Airline Costs Differ", *Rand Journal of Economics,* 15:4, pp. 471–489 or M.J. Roberts, 1986, "Economies of Density and Size in the Production and Delivery of Electric Power", *Land Economics*, 62:4, pp. 378–387.

95. Looking at Colorado alone, business establishment density per square mile ranges from less than 0.33 (Clear Creek County) to more than 145 (Denver). Taking somewhat less extreme examples, compare the density of 145 for Denver with 16 for Boulder and 2 for Arapahoe County. Using the economies of density elasticity of -0.02, this would imply that the competitive price in Boulder should be 3.2% higher than in Denver and that the competitive price in Arapahoe County should be 3.1% higher than in Boulder.[22] If economies of density are stronger, these effects would be larger. Clearly, we would find even greater discrepancies – and hence an even more acute need to differentiate the resetting of the regulated price across markets -- if we looked across counties throughout the whole of the USA.

96. The key message is that imposing a single "reset" regulated price across all non-competitive markets cannot even come close to mimicking the workings of competitive markets, which calls for aligning prices to costs. Introducing a differential (or "de-averaged") reset that reflects the wide variations in business density is warranted in order to achieve the FCC's stated objective of using regulation to mimic competition effectively.

97. Resetting the price at a different level for each census tract (or other geographic units) would be a monumental task. Moreover, the proliferation of regulated prices would also impose a serious administrative burden on the regulated companies (which we argue should be both the ILEC's and other BDS providers of DS1 and DS3 operating in "non-competitive" markets). There is, however, a relatively simple solution to address this important challenge. One would start by determining an "average" level at which prices in non-competitive markets would be reset, using the KLEMS-based TFP approach we discussed earlier. One would then classify all census tracts into a few categories based on their business establishment density (and possibly a small number of other criteria the FCC feels are warranted). For example, one could have a group with densities exceeding 100, another with densities between 20 and 100, a third group with densities between 5 and 20, and a fourth group with densities below 5.

22 In these computations and the ones that follow, we multiply the elasticity of -0.02 times the percentage difference in density between the two local markets, evaluated at the average of the two densities.

98. The (average) reset price obtained using the TFP methodology described earlier would be applied to those markets within a specified reference group (for this illustrative calculation, we use the 5-20 density category as the reference group). The initial regulated prices in markets belonging to different groups can then be adjusted. For example, consider the reset price for markets in the 20-100 density category. Using the midpoints of the reference group and this category (12.5 and 60, respectively), this difference represents a 130% increase in density with respect to the average of the two midpoints. Using the density elasticity of -0.02, this translates into a reset price that is 2.6% *lower* for markets in this high density group as compared to the reference group. Conversely, if we consider a local market with density less than five, the comparison is between the midpoints for the reference group (12.5) and the low density category (2.5). This translates into a reset price for the low density market that is 2.7% *higher* than for the reference group.

99. Of course, since the de-averaging procedure results in some reset rates being lower than others (specifically, lower in the higher density, "non-competitive" areas as compared to the lower density markets), this may change the total revenue gain or loss associated with the reset. This can be avoided easily by appropriate choice of the density categories and by weighting the resets by the relative demands in each category. This will ensure that the differentiated reset generates the same overall revenue impact as the original (averaged) reset. Ensuring this "revenue neutrality" feature of the differentiated reset is an important aspect of our recommendation.

100. This approach provides a simple methodology which is consistent with the competitive logic that underpins the price cap. While this may be compatible with existing FCC rules allowing for zonal pricing flexibility, our approach goes further in actually ensuring that the regulated price in each (group of) geographic markets more closely reflects the actual costs.

101. *The important point here is that, if the Commission decides to adopt a reset, the re-initialised price for the price cap should reflect the key differences across markets that affect costs (as reflected in prices observed in competitive markets).* Once the prices have been reset (initialized) at their appropriate levels for markets with different business densities, ongoing price cap regulation would then proceed exactly as it would in the absence of such distinction. While we know that lower density is associated with higher unit cost, there is no compelling reason to believe that density systematically affects how fast these costs *change* over time. Thus the same X-factor can be applied across all density-based categories. Once the initial differential reset is made, the only additional complication brought about by this differential reset is that the FCC would need to check periodically whether given areas still belong to the same density category. As such densities change slowly, this should not be much of an additional burden.

4.5. Summary of Our Empirical Findings for a Potential Price Cap Reset

102. The two tables below summarize our findings for a potential price cap reset, if the Commission decides to adopt one. The first table is based on the 2005-2014 period, while the second is for the extended period 2000-2014. Each table begins with a number of alternatives estimates for the "base" rate of adjustment: the direct and indirect methods applied to US-KLEMS data and the direct method adjusted for capacity utilization. We then include *additional* adjustments that should also be considered. Notice that, for the scale effect, we only consider the adjustment required for the period 2011 – 2015, for which we have appropriate data.

103. For each period, we also settle on two summary numbers. The first one is the baseline estimate that applies the U.S.-KLEMS data to the direct method and adjusts for capacity utilization. This measure excludes the adjustments for economies of scale and for the difference between potential productivity growth in DS1/DS3 services as compared to the sector as a whole. The second effect adds the adjustment for ILEC scale effects and the adjustment that would be required to account for a rate of TFP growth that is 25% slower for DS1/DS3 than for the sector as a whole.

Table 10: Cumulative Reset of Regulated Price Implied by the X-Factor Approach, Allowing for Different Adjustments (2005 – 2014)

(1) FCC KLEMS 2005 – 2013	**-0.63%**
(2) KLEMS, Direct Method, 2005 – 2014	**-0.4%**
(3) KLEMS, Indirect Method, 2005 – 2014	**+1.0%**
(4) Adding Economies of Scale Effect Additional Reset	**+0.36% to +0.81%**
(5) KLEMS, Direct Method, Capacity Adjusted	**-0.3% to +0.1%**
(6) Allowing for 25% Lower TFP Growth for DS1/DS3. Additional Reset	**+4%**
(7) Possible Range = (2) to (3) + max(5) + (6)	**-0.4% to +5.81%**
(8) Baseline Estimate excluding economies of scale and lower TFP growth for DS1/DS3 = midpoint (5)	**-0.1%**
(9) Our "Best" Estimate including economies of scale and lower TFP growth for DS1/DS3 = midpoint (4) + midpoint (5)+ (6)	**+4.4%**

Table 11: Cumulative Reset of Regulated Price Implied by the X-Factor Approach, Allowing for Different Adjustments (2000 – 2014)

(1)	**KLEMS, Direct Method, 2000 – 2014**	**+7%**
(2)	**KLEMS, Indirect Method, 2000 – 2014**	**+10.9%**
(3)	**Adding Economies of Scale Effect Additional Reset**	**+0.36% to +0.81%**
(4)	**KLEMS, Direct Method, Capacity Utilization Adjusted**	**+6.1% to 6.8%**
(5)	**Allowing for 25% Lower TFP Growth for DS1/DS3. Additional Reset**	**+ 10.5%**
(6)	**Possible Range = Lowest (3) to (2) + max(4) + (5)**	**+6.1% to +18.51%**
(7)	**Baseline Estimate excluding economies of scale and lower TFP growth for DS1/DS3 = midpoint (4)**	**+6.45%**
(8)	**Our "Best" Estimate including economies of scale and lower TFP growth for DS1/DS3 = midpoint (3) + midpoint (4)+ (5)**	**+17.5%**

5. ONGOING PRICE CAP REGULATION

104. We now turn to the issue of how a price cap regime should be administered in the future. We consider that the "future" begins at the end of 2014. What matters of course is the methodology, which can readily be adapted to whatever the first year of a new regulation regime turns out to be.

105. The key point from the economic perspective is that there should be consistency between the approach used to determine the future rates of adjustment of regulated price and the way in which the initial price is reset. From this perspective, the computation of an X-factor based on the KLEMS methodology is most attractive. In the previous section, we also discussed the merits of using the price level in competitive markets as a benchmark for setting regulated prices. While we believe that this alternative approach can be quite useful in providing a "check" on the results obtained through the adjustment factor approach, getting access to the required information on a yearly basis would be quite onerous both for the FCC and the companies involved.

106. While the methodology involved is the same as that described in the section about the potential “reset”, we would like to make two additional points. First, because technology does not typically evolve at a steady pace, the estimates of changes in TFP and input prices used to determine the adjustment factor should not be based on too long a period. While more data is usually better, more recent data is likely to paint a more accurate picture of the future cost conditions faced by the firms. The second point is that, just as for resetting the initial regulated prices, one needs to take into account variations in capacity utilization when computing the adjustment factors. In the previous section we saw that controlling for capacity utilization did not make much of a difference when long periods were used, but could make an appreciable difference if the adjustment factor is computed over a shorter period. Given the desirability of basing forward-looking adjustment rates on recent data, the need for a capacity utilization adjustment is stronger for ongoing regulation than for the initial resetting exercise.

107. Of course, our other suggestions for the resetting of the initial price still applies to the determination of the ongoing regulated price. In particular some allowance should be made for the fact that available TFP data are likely to overestimate the rate of TFP growth actually experienced by the older, legacy technologies that will be regulated.

108. We conclude that the new regulatory regime should be based on the computation of the X-factor using the KLEMS data and either the “direct” or the “indirect” method described at the beginning of this report. Because we only have the necessary data for making the capacity utilisation adjustment for the “direct” approach, the results reported in this section are based on that methodology. As we have seen, the direct and indirect methods are just two variants of the basic idea that price adjustments should depend on changes in TFP and changes in output prices and they tend to produce similar results. Our reliance on the direct approach should not therefore be seen as a rejection of the validity of the indirect approach.

109. While there are good reasons to look back to data before 2005 in resetting the X-factor—because, as explained, the X-factor prior to 2005 was generally set at 6.5% and not based on any valid productivity studies — the X-factor used for *on-going* regulation should be based on more recent data. The following table shows the annual changes in input prices, TFP and capacity utilization over the period from 2011 to 2014. The last column gives us the rate of adjustment implied by the direct approach. More precisely, the adjustment implied by the direct approach is equal to the change in input price minus the change in TFP plus the change in capacity utilisation.

Table 12: Ongoing Regulation: Direct method Adjusted for Cyclical Changes in Capacity Utilization, 2011 to 2014.

Year	% change in input prices	% change in TFP	% change in capacity utilization	Direct Method Adjustment
2011	-1.04	-0.90	1.13	0.99
2012	0.76	-0.20	0.09	1.05
2013	3.28	3.30	0.17	0.15
2014	1.45	1.70	0.05	-0.20
Average Annual Rate	1.1%	0.96%	0.36%	0.50

110. The compounded annual adjustment implied by the direct approach is an increase of 0.50%. Given that the average annual growth rate of GDDPI over this period was equal to 1.56%, this is equivalent to the FCC using an X-factor in its formulation equal to 1.56% - 0.50% = 1.06%. Of course, this computation should be updated to rely on the most recent years for which data is available when the new regulation actually starts.

111. We emphasize too that this estimate is conservative and prices should in fact be allowed to increases by more than 0.5% per annum because this estimate does not recognize the important considerations of 1) the impact of economies of scale and the erosion of DS1/DS3 markets which constitute a larger revenue share for ILEC's than CLEC's, and 2) the likelihood that these legacy services enjoy less scope for ongoing productivity improvements than other services in the telecommunications sector.

To address the first issue -- economies of scale and the erosion of DS1/DS3 markets -- we repeat our calibration exercise from Section 4.3.5 but, since ongoing regulation should be based on recent data, we only consider the last three years for which data is available, i.e. 2013 – 2015. Table 13 gives us the adjustment to the *annual* factor that is required to compensate for this distortion. We see that, once such adjustments are considered, prices should be allowed to increase by between 0.6% and 0.83% annually. Again, this is equivalent to the FCC adopting an X-factor in its formulation of between 0.73% and 0.96%.

Table 13: Difference between TFP growth for the sector and the ILEC, calibrated on CenturyLink data, annual rate 2013 – 2015.

		Total Cost Elasticity	
	$\boldsymbol{\varphi = 0.7}$	$\boldsymbol{\varphi = 0.75}$	$\boldsymbol{\varphi = 0.8}$
$\boldsymbol{\theta = 0.06}$	0.15%	0.13%	0.1%
$\boldsymbol{\theta = 0.07}$	0.18%	0.15%	0.12%
$\boldsymbol{\theta = 0.8}$	0.2%	0.17%	0.14%
$\boldsymbol{\theta = 0.9}$	0.33%	0.19%	0.15%

Source: Calculated by CRA

112. To address the second issue – legacy services experiencing less technological improvement -- we would suggest that the X factor for on-going regulation be decreased by some fraction of the absolute value of the change in sectoral TFP – we think a 25% reduction (i.e. legacy services having only 75% of the efficiency gains as technologically frontier services). While this is an imperfect solution to a real issue, we believe it is better than ignoring the issue altogether. If we take the period 2011-2014 (for which TFP growth was actually quite low at +0.97% annually) this would imply allowing prices to increase by an additional 0.24% annually, i.e., at an annual rate between 0.84% and 1.07% per year. Again, using the average annual increase in the GDPPI from 2011-2014 of 1.56%, this corresponds to an X-factor in the FCC formulation of between 0.72% and 0.49%.

113. There is another important issue: Which companies in non-competitive markets should be regulated? From an economic point of view, it seems clear that, once a *local market* has been identified as "non-competitive," the regulation should apply to *all firms* selling the relevant services in this market. If a local market's characteristics justify it being designated as non-competitive, these characteristics are bound to affect the behavior of all firms operating in the market, both the ILEC and the CLECs or other rivals. There is no reason to believe that some firms would be behaving "more competitively" than others in non-competitive, local markets. Hence the application of the regulation in a given market should not discriminate across participants. The designation "non-competitive" is a description of the market, not the company, and the regulation should apply symmetrically to all providers in a given market.

5.1. Risk Sharing and the Consumer Dividend

- *There is no sound economic rationale for the imposition of an ad hoc "consumer dividend".*
- *On the other hand, both sides need to be protected against the risk that the X factors – however carefully set – might not accurately capture changes in actual cost conditions.*
- *This might be addressed by combining planned periodic reviews with the use a few indicators (such as prices in competitive markets) on a more frequent basis.*

5.1.1. There is no economic rationale for imposing a "consumer dividend"

114. The FCC proposes that the type of ongoing adjustments of the regulated price should be complemented by a so-called "consumer dividend." In other words, the regulated price would be reduced annually by some additional percentage. This would be a mistake, for two important reasons. Firstly, we are not aware of any economic methodology to help determine what a sensible "consumer dividend" would be. This means that such a dividend can only be determined in completely *ad hoc* manner and thus invites rent-seeking lobbying by both companies and consumer groups. This is not the type of behavior that regulation should seek to foster.

115. Secondly – and more importantly – there are in fact no good economic reasons for introducing such a dividend. If the rate of annual adjustment of regulated prices has been set carefully, according to the methodologies discussed above, imposing an additional systematic annual reduction to regulated prices simply amounts to disavowing the results of one's own computations. If there were any reason to have an additional annual reduction, then this should have been reflected in the calculations of the adjustment following proper economics-based methodologies in the first place.

116. One should also keep in mind that, in an industry undergoing sustained technological change, policy-makers often find it desirable to ensure that the introduction of new technologies is not impeded by "adoption inertia". Introducing an arbitrary "consumer dividend" runs the risk, indeed likelihood, of setting the regulated price too low, and this would simply slow the shift of consumers from the old legacy technologies to the newer ones, undermining one of the FCC's long run objectives.

5.1.2. However, there is a need for some "risk sharing"/safeguard mechanism

117. While an additional *ad hoc* compensation which only benefits one of the parties makes little sense, there *is* clearly a need to protect both sides against the risk that the annual rate of adjustment – however carefully chosen *ex ante* – proves to be inappropriate. In our view, the simplest and most effective way to provide such "insurance" to both sides is to combine pre-specified periodic reviews. This could possibly be supplemented with a mechanism which allows a party to trigger an earlier review, if it can credibly demonstrate with hard evidence that the regulated prices have gotten significantly out of line with the competitive level that they are designed to track. However, such an option introduces the risk of pure rent-seeking interventions by either consumers or firms, and imposes greater administrative burden on the FCC and other parties. For these reasons, we do not recommend such a supplemental mechanism.

118. The ultimate backstop against the possibility of a growing wedge between regulated prices and the appropriate competitive (cost compensatory) levels is periodic in-depth reviews in order to check whether additional "reset" is warranted, similar to the methodology used to reset prices before the new price cap regime is ushered in. As in the current case, such reviews would benefit from combining an historical reassessment of changes in TFP and input prices, and possibly checking this approach against prices that prevail in markets deemed to be competitive. Indeed, even if one were sure that the annual adjustment rates remain appropriate, some form of (more limited) periodic review would be required anyway to re-evaluate the assignment of local markets between the "competitive" and "non-competitive" categories.

119. While the Commission might consider periodic reviews, it is important to bear in mind that they are very costly both to the FCC and other involved parties. They are also disruptive since, unavoidably, they tend to create considerable uncertainty and invite unproductive rent-seeking activities. Furthermore, unless the historical data used for resetting prices are completely independent of the regulated companies' own productivity gains, frequent reviews would seriously damage their incentives to invest in cost-cutting and other productivity improvements, since the companies would then expect that part of their productivity gains will lead to lower prices in the relatively near future. Thus, if the Commission decides to adopt periodic reviews, it is important that they be infrequent, perhaps once every five years. But it would be important to keep in mind in such reviews that the likely scope for productivity gains in the legacy services that are subject to regulation is much smaller than in the rest of the telecommunications sector that increasingly focuses on the technological frontier. Thus any increases in sector level TFP would almost surely overstate the changes in TFP for DS1 and DS3.

120. The Commission might also consider a mechanism allowing it to check, less formally but more frequently, whether the regulation remains on track. One way to do this would be for the FCC to monitor the evolution of regulated prices in a simple and economical manner by collecting – perhaps every other year – a sample of prices in competitive markets and comparing the evolution of these competitive prices to the evolution of regulated prices. The purpose of this exercise would simply be to determine whether there is a need for an in-depth review, *not* to make any adjustment based on this incomplete information.

6. CONCLUSIONS

121. We have focused on two aspects of the FCC's consultation document: 1) the potential "resetting" of regulated prices for DS1 and DS3 services to realign them with the levels that would prevail in a reasonably competitive market, and 2) the design of a price cap regime for future, ongoing regulation.

122. We outlined the underlying logic of the price cap approach to regulation. This approach relies on two main principles. The first principle is that it attempts to track the behavior of competitive prices. This is done in two steps: first, by setting the initial price at a competitive level and, second, by tying the evolution of this price to changes in the determinants of costs, namely changes in input prices and total factor productivity. The second principle is that, in order to preserve the regulated firms' incentives to invest in cost reduction, the measures of costs used to track the competitive price should not be under the direct influence of the regulated firm, but should accurately reflect the change in their own cost conditions. We then explain that the capped level of prices can be calculated by either one of two established methodologies: the "direct" and "indirect" approach. Although presented in a rather ad hoc manner, the FCC's own methodology is equivalent to the "direct" approach.

123. A potential need for "resetting" arises because of the lack of systematic price-cap regulation since 2005 when it was decided to freeze the nominal price, which is equivalent to setting the annual adjustment equal to the change in GDPPI. Since such an approach can only closely approximate the evolution of competitive prices by coincidence, a reassessment is indeed needed. However, the purpose of such an exercise is quite narrow: it is simply to compare the evolution of GDPPI to the evolution of the relevant input prices and total factor productivity over the period for which a proper price-cap regulation was lacking, 2005-2014. However, it also is reasonable, and in our view preferable, to use the longer period 2000-2014, since the productivity factors used during 2000-04 were not based on any hard evidence of productivity performance, as we do here.

124. For the period 2005-14, and taking into account a capacity utilization adjustment, our conservative estimate is that a potential reset should involve a *0.1% decrease* in regulated prices. If one makes allowance for scale effects and the fact that DS1/DS3 services are likely to have experienced lower productivity gains than the telecommunication sector overall, then our best estimate is that there should be a reset upwards by 4.4%.

125. For the period 2000-14, which is the one we would recommend for any potential reset, our conservative estimate is that the reset should involve a *6.45% increase* in regulated prices. If we take into consideration other important factors (e.g. competitive erosion of market share in the context of economies of scale, and the fact that DS1/DS3 are legacy technologies with likely lower TFP growth than other parts of the telecommunications sector), our best estimate is that the reset should involve a *17.5% increase* in regulated prices.

126. We conclude that if the FCC decides to adopt a reset, the initialized regulated prices should be differentiated across broad categories of markets, grouped according to this business density. The evidence indicates that business density is a critically important determinant of unit cost and thus such differentiation is compatible, indeed required, if the price cap is to achieve the stated objective of tracking prices in competitive markets. We explain how this can be easily implemented, and offer simple examples to assess the likely magnitude of the differences in capped prices across these categories of markets. After that, for ongoing price cap regulation, a single X-factor based on productivity evidence should be adopted.

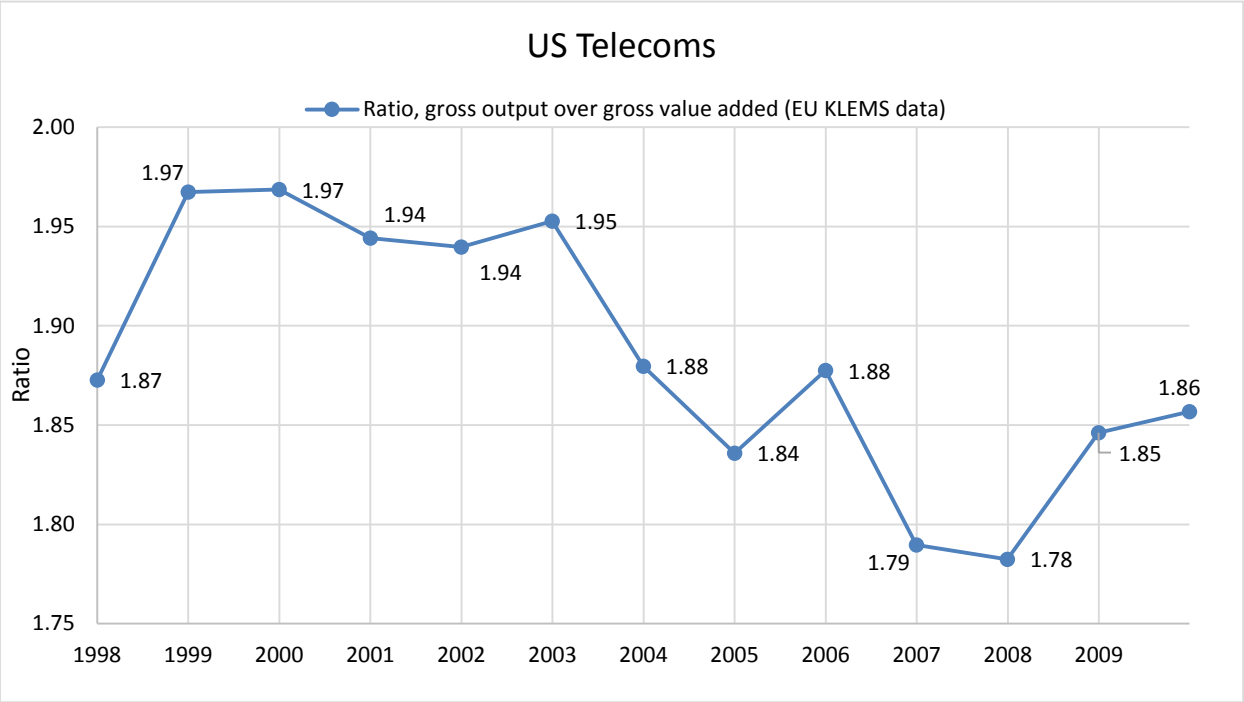
127. We believe that the rate of the productivity adjustment factor to be used in the ongoing price cap regime is best obtained by applying the KLEMS-based “direct” or “indirect” approaches to data that relate to a period recent enough to capture current productivity trends accurately. Because this relatively short reference period cannot guarantee that differences in utilization rates are “smoothed” out, the adjustment rate should be adapted to take into account the rates of utilisation over the estimation period. Based on the hard productivity evidence from the last few years and taking into account scale effects, we recommend that, going-forward regulated prices should be allowed to increase by between 0.6% and 0.83%. This implies an X-factor in the FCC formulation of the price cap of between 0.73% and 0.96%. This should be taken as the minimum upward adjustment because it does not recognize the likelihood that DS1/DS3, which are legacy services that almost surely have less scope for ongoing productivity improvements than other services in the telecommunications sector. If this “productivity potential gap” is accounted for, we believe that the annual increase in regulated prices should be between 0.84% and 1.07%.

128. We agree with the Commission that there is a legitimate concern about the possibility that the productivity adjustment factor chosen initially might fail to track competitive prices accurately as circumstances change. To mitigate this risk – which *both* service providers *and* consumers of the *regulated* services face -- we suggest adopting pre-specified in-depth reviews every five years, possibly together with more sporadic checks based on the prices charged in the markets that the FCC deems to be competitive. It would be economically unwarranted and unwise to address this two-sided risk by introducing a one-sided “consumer dividend” (or a dividend for service providers, for that matter).

7. APPENDICES

7.1. Appendix 1: Gross Output to Value added Ratio

Gross Output to Value Added Ratios, US Telecoms (from EU-KLEMS)



Source: The gross output and gross value added series from EU KLEMS refer to the variables "GO: Gross output at current basic prices (in millions of US Dollars)" and "VA: Gross value added at current basic prices (in millions of US Dollars)" respectively, both for "Telecommunications" in the EUKLEMS database, March 2013 release, accessed via http://euklems.net/, last accessed: 13/07/2016

7.2. Appendix 2: Resetting Computations with KLEMS

129. The FCC's Tariff Investigation Order[23] report outlines how the productivity-based X-factors and the price cap adjustments were computed; in Appendix C the FCC provides formulae and sources for the data used in its calculations. While the explanations given for the calculation steps are at times not intuitive, nor fully detailed, we successfully replicated both the report's KLEMS methodology and results.

23 U.S. Federal Communications Commission. *Tariff Investigation Order and Further Notice of Proposed Rulemaking*, *Business Data Services in an Internet Protocol Environment*, WC Docket No. 16-143, 31 FCC Rcd at 4876-80, ¶¶ 404-415, 4966-71 (Appendix C); Available at: https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-54A1.pdf. Accessed: July 30, 2016.

130. The economy-wide inflation measure used in our calculations is the Gross Domestic Price Index (GDPPI) taken from the Bureau of Economic Analysis[24]. The X-factor formula used by the FCC (see paragraph 405 in the Tariff Investigation Order) is:

X-Factor = % Δ GDP-PI – % Δ Industry Input Price Index + % Δ Industry TFP

131. Taking the same approach as method 1[25] of the FCC report, we use KLEMS data[26] from the Bureau of Labor Statistics (BLS) for input prices (table 2.2) and total factor productivity (table 1.2) figures for NAICS sectors 515 and 517 combined (Broadcasting and Telecommunications). Additionally, the KLEMS dataset provides price indices for capital, labor, energy, non-energy materials, and service intermediary inputs separately. KLEMS input price data by all five factors was available from the year 1997 onwards, and all KLEMS data was available up to the year 2014 at the time of this report's writing.[27]

132. In line with the FCC's calculations, to produce an input price index for the sector we combined the five separate price indices of table 2.2 into a single input-price index, using as weights the Factor Shares (factor costs divided by the Value of Production, table 5.1) of each input, also available in KLEMS.

133. We then computed a compound annual growth rate over the desired year ranges[28] to each of the GDPPI; the Industry Input Price index; and the Industry Total factor Productivity. For each year range, the difference of the GDP Price Index minus the X-factor for the respective year ranges was compounded over eight years to provide possible price cap indices adjustments for the 2005-2013 period (see results in the table "X Factors and Adjustment Rates for Resetting").

7.3. Appendix 3: TFP, Economies of Scale, and Erosion of DS1/DS3 Markets

Using two outputs, multifactor productivity is defined by BDS as follows:

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24 U.S. Dept. of Commerce Bureau of Economic Analysis, National Income and Product Accounts, Table 1.1.4. (Price Indexes for Gross Domestic Product).

25 *See* note 23, *supra*.

26 [(Last Year Index Value / First Year Index Value) ^ (1 / Number of Years between First and Last) – 1] x 100.

27 Data as of July 12, 2016.

28 [(Last Year Index Value / First Year Index Value) ^ (1 / Number of Years between First and Last) – 1] x 100.

$$dTFP = r_1 dY_1 + r_2 dY_2 - \sum s_j dX_j$$

Where d denotes a rate of growth, $r_i = p_i Y_i / R$ is the revenue share of output i and $s_j = w_j X_j / C$ is the cost share of input j. In this, we interpret Y_1 as TDM services and Y_2 as other services.

The cost function is given as $C(Y_1, Y_2, w, t)$, where *w* is a vector of input prices. Hence:

$$dC = v_1 dY_1 + v_2 dY_2 \sum s_j dw_j + \frac{\frac{\partial C}{\partial t}}{C}$$

Where

$$v_i = MC_i \frac{Y_i}{C} = \epsilon_i$$

Is the elasticity of costs with respect to output I and MC is marginal cost, and $\frac{\frac{\partial C}{\partial t}}{C}$ is the time shift in the cost function. By definition, $C = \sum w_j X_j$, so log differentiation gives us:

$$dC = \sum s_j dw_j + \sum s_j dX_j$$

Setting our two expressions for *dC* equal to each other and solving for the shift in the cost function:

$$\frac{\frac{\partial C}{\partial t}}{C} = \sum s_j dX_j - \epsilon_1 dY_1 - \epsilon_2 dY_2$$

Substituting this into our expression for dTFP, we get:

$$dTFP = (r_1 - \epsilon_1) dY_1 + (r_2 - \epsilon_2) dY_2 - \frac{\frac{\partial C}{\partial t}}{C}$$

Which means that the measured growth in TFP captures the shift in the cost function and changes in the levels of output if $r_i - \epsilon_i \neq 0$.

Denote the cost elasticity as $\varphi \equiv \epsilon_1 + \epsilon_2$ so that increasing returns to scale imply $\varphi < 1$. To simplify further, we assume for this calculation that $\epsilon_1 = \epsilon_2 \equiv e$ and that the firm prices at average cost and thus earns a normal rate of return, so $R = C$.[29]Using these equations, after some further manipulations we obtain:

29 The assumption that $\epsilon_1 = \epsilon_2$ is conservative since legacy services are likely to have a lower cost elasticity. Since demand for legacy services has declined and the ILECs' revenue share in those services is higher than for CLECs, this will lead us to understate the actual impact of economies of scale on ILECs relative to the rest of the sector.

$$dTFP = (1-\varphi)\{r_1 dY_1 + r_2 dY_2\} - \frac{\frac{\partial C}{\partial t}}{C}$$