BT Leased Lines: Efficiency benchmarking

Critiquing the efficiency approach used by Ofcom

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Glossary

Term	Definition
AVE	Asset volume elasticity
BAU	Business-as-usual
BCMR	Business Connectivity Market Review
BT	BT Plc
CMA	Competition and Markets Authority
Comreg	The Commission for Communications Regulation in Ireland
CVE	Cost volume elasticity
DEA	Data envelope analysis
DFA	Deterministic frontier analysis
FAMR	Fixed access market review
FTI Consulting	FTI Consulting LLP
IP	Internet protocol
LECs	Local exchange carriers
LLCC	Leased Line Charge Control
MEA	Modern equivalent asset
PVEO	Price volume efficiency other calculation
SFA	Stochastic frontier analysis
SG&A	Sales, general and administration costs
TFP	Total factor productivity
TI	Traditional interface
TSO	Technology service and operations division
WBA	Wholesale broadband access

1. Executive Summary

1.1 On 12 June 2015, Ofcom published a consultation document related to its Business Connectivity Market Review of leased lines charge controls and dark fibre pricing. This contained a proposal for an efficiency factor of 4% to 7% per year for both TI and Ethernet services, with a base case estimate for each of those services of 5% per year.

1.2 The proposed base case efficiency factor is higher than previous efficiency factors of 1.5% per year for TI services and 4.5% per year for Ethernet services. We are surprised that Ofcom would consider that TI and Ethernet services should be subject to the same efficiency factor, given the services are at different points in their lifecycle, use different technologies and have different demand profiles. Further, if implemented, equal efficiency factors for both services would undermine dynamic efficiency and the appropriate migration path from TI to Ethernet.

1.3 It appears that Ofcom's primary justification for its efficiency factor proposals is its interpretation of a set of PVEOs provided by BT. The use of PVEOs may not be appropriate for regulatory price setting purposes. We have three primary concerns with Ofcom's use of PVEOs for estimating efficiency in charge controls:

- The robustness of the methodology used to calculate the efficiency term particularly with regards to incomplete data and mapping of individual cost reduction initiative to products alongside inconsistencies with other parameters in the charge control, such as AVEs and CVEs and MEA assumptions.
- PVEO analysis does not recognise the flattening off of efficiency gains for products over time as demand declines and technology becomes obsolete. Without appropriate adjustment this may create perverse management incentives if a firm that has worked hard to improve efficiency in the past may be penalised by a higher efficiency challenge in future periods
- Ofcom focuses on short-term cost orientation at the product level, rather than consideration of the longer-term optimal allocation of resources between products and the impact of this on innovation and migration from legacy platforms.

1.4 Ofcom supports its proposed efficiency factors with public announcements from BT on cost performance. However, these do not identify the source of the cost reductions such that they can be attributed to price, volume or efficiency impacts or, in general, attribute the cost savings to particular business units or products.

1.5 Ofcom also attempts to estimate BT's historical efficiency gains using regulatory accounting data. We concur with Ofcom's concerns around the practical limitations of this approach (in particular, there are a number of reasons why the regulatory accounts may not represent a 'business-as-usual' or 'steady' state) but also note that regulatory accounting information can only reliably estimate historical efficiency changes when assessing patterns over several years.

1.6 The limitations of relying solely on internal firm information are a key reason why regulatory authorities typically review external benchmarking analysis in addition. In this regard, Ofcom has omitted key sources of information and studies that it has previously relied upon to set the efficiency target in the LLCC and which consistently supported a TFP estimate of 0.5% to 3%. These analyses, for TI and Ethernet respectively, are summarised in Tables 1-1 and 1-2 below.

Table 1-1: Evidence on TI efficiency assumption used by Ofcom in LLCC 2013

	TI specific historical trend analysis	BT Wholesale internal efficiency targets	2012 Deloitte study	Statistical analysis (NERA, Deloitte)
Efficiency %	~1.5%	Not available	2.25%	~2%
Comment (from Ofcom)	Ofcom's analysis of BT Wholesale's historical TI data	Relates only to SG&A costs, which account for only a small proportion of total BT Wholesale costs	Benchmark against 5 other European operators	Benchmark against US LECs

Source: LLCC final statement, 2013, Figure A12.22. Ofcom noted that "other sources of information were considered. However for the reasons set out below we did not factor these into our final range".

Table 1-2: Evidence on Ethernet efficiency assumption used by Ofcom in LLCC 2013

	Openreach specific trend analysis	Openreach internal efficiency targets	2012 Deloitte study	Statistical analysis (Deloitte, NERA)	KPMG study
Efficiency %	~5%	Not available	2.25%	~2%	~2.3%-2.6%
Comment (from Ofcom)	Ofcom analysis of Openreach's historical cost data	Internal targets set for the subsequent 3 years	Benchmark against 5 other European operators	Benchmark against US LECs	Excludes fault rates and task times

Source: LLCC final statement, 2013, Figure A12.23.

1.7 Further, in a change of approach, Ofcom has not separated efficiency into catch-up and frontier shift components. This appears contrary to its position in the previous charge control where it said "*we do believe that the forecast for real unit cost savings to be used in the model should be capable of being decomposed into frontier shift and catch up in a way which is consistent with other data on the potential for improvements each of these types of efficiency*" This approach makes it difficult to benchmark Ofcom's efficiency factor to separate estimates of catch-up and frontier shift.

1.8 We note that in the previous charge control, Ofcom considered BT to be broadly efficient. Ofcom noted that "*The NERA, Deloitte and KPMG studies suggest that BT was relatively efficient and that the scope for catch-up gains in efficiency (as opposed to frontier shift gains) was limited*" If it is assumed that BT's relative inefficiency has not worsened then this implies the entire efficiency challenge is frontier shift which, in our view, is implausible when compared to reasonable TFP benchmarks (as discussed below). If, on the contrary, the efficiency challenge represents some catch-up efficiency, then this would imply that BT is currently significantly more inefficient than a hypothetical benchmark firm[1].

1.9 Ofcom has not considered other regulatory benchmarks, which suggest a far lower efficiency factor might be applicable. We have reviewed recent regulatory decisions and determinations in other UK regulated sectors, which confirm that an array of techniques is used to estimate efficiency factors. These often involve both econometric analyses and bottom-up analyses, and draw on a range of complementary analyses.

1.10 The need for a broad approach is endorsed by the CMA, which recently stated, for example, that "*no benchmarking analysis or cost assessment method will be perfect, and there will always be limitations in any approach[2]*".

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1 The proposed LLCC price control period is three years, but Ofcom's modelling is based on a 2013/14 base year and forecast forward for 5 years. If it is assumed that the efficiency factor has been set so that BT is as efficient as the benchmark at the end of five years, then, using a 'reasonable' frontier shift estimate of 2%, then BT's implied efficiency is between 10% (i.e., 4% less 2% multiplied by 5) and 25% (i.e. 7% less 2% multiplied by 5).

2 Bristol Water Price Determination, July 2015.

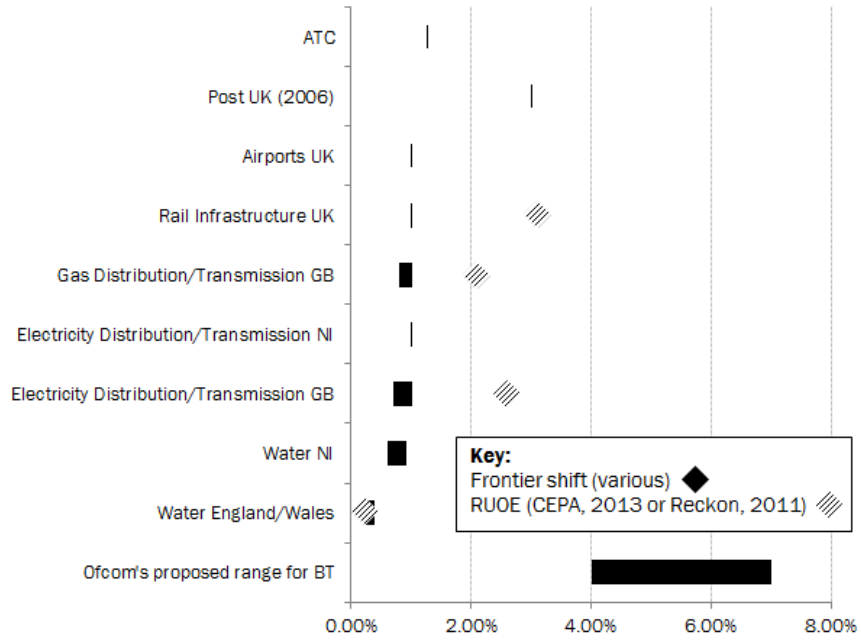
1.11 In sectors where there are fewer regulated companies, regulators are more likely to analyse efficiency trends in other sectors. For example, the ORR and CAA have both commissioned reports to assess various measures of efficiency across regulated industries over time:

- Reckon (2011) surveyed the productivity and unit cost change in UK regulated network industries and other UK sectors; and
- CEPA (2013) applied a range of top-down benchmarking techniques to assess the scope for efficiency gains at Heathrow, Gatwick and Stansted airports.

1.12 We have looked at these reports and performed a survey of more recent regulatory decisions to assess the range of frontier shift efficiency factors applied in UK regulatory contexts.

1.13 Regulatory benchmarks suggest a frontier shift range of 0-2% with central estimate of 1%[3]. Figure 1-1 below summarises the recent regulatory precedent in this area and for reference, we also show the range suggested by Ofcom.

Figure 1-1: Summary of recent frontier shift estimates



Note: continuing efficiency as applied to opex, capex or totex.

3 Whilst 'catch-up' efficiency is typically bespoke for each firm, and varies between sectors depending on the differentials in efficiency between firms, the concept of continuing or 'frontier shift' efficiency is more general and relates to the pace of productivity improvement in the industry as a whole

1.14 When cross-sectoral comparators are used to estimate frontier shifts, it is of course necessary to bear in mind the differences between contexts (such as the cost structure of the industry and the length of time for which the industry has been subject to competition).

1.15 Even with the above caveats in mind, it is clear that regulatory benchmarks suggest a frontier shift range significantly lower than that proposed by Ofcom. Given the maturity of the TI market and the limited scope for further development, we would suggest that BT's TI services are most comparable to electricity distribution or transmission which broadly results in a range of 1-2%.

1.16 Ethernet leased lines are a newer technology, although some time has elapsed since the previous LLCC. General measures of productivity and in particular, TFP, are more relevant.

1.17 TFP can be defined as "*the portion of output not explained by the amount of inputs used in production*"[4]. TFP may be calculated at the whole economy level or for particular sectors in the economy. TFP estimates are particularly useful for providing a cross-check on other analysis, although it must be considered whether BT can be expected to be more or less efficient than the benchmark.

1.18 We have reviewed some estimates of TFP from a range of sources:

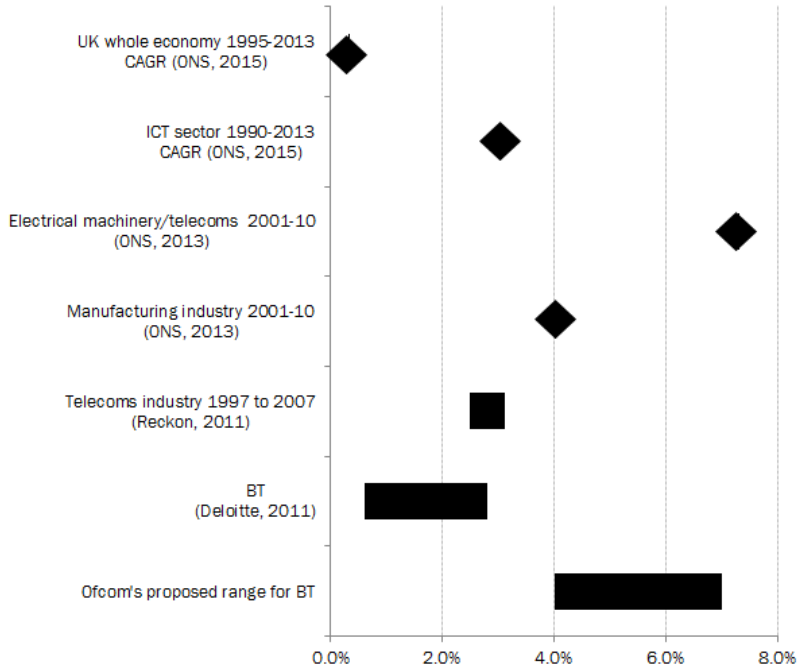
- TFP growth in the UK economy has been low in recent years: in the last ten years it has only been over 1% once (in 2006 where it was 1.5%).
- TFP growth varies between sectors. Telecoms TFP growth as a whole is higher (e.g. Reckon (2011) uses EU KLEMS data to estimate telecoms sector TFP growth over last business cycle (1997 to 2007) at 2.5%-3.1%[5]). This range relates to the entire telecoms sector, which comprises a variety of services including newer services such as 4G and next generation mobile as well as legacy services such as BT's TI services and copper landlines.

4 See, for example, *Total Factor Productivity*, Diego Comin, New York University and NBER, August 2006.

5 Reckon (2011).

1.19 Figure 1-2 below summarises the TFP estimates we have reviewed and for reference, we also show the range suggested by Ofcom.

Figure 1-2: Summary of TFP estimates



1.20 These TFP estimates can help inform a reasonable range for BT's Ethernet services. We would suggest one key benchmark is Reckon (2011) which analysed the telecoms industry over the whole business cycle using EU KLEMS data and assessed an upper estimate of annual TFP growth at 3.1%. If there is any scope for 'catch-up' in the efficiency of BT's Ethernet services, then the appropriate efficiency factor may be higher – but, on the basis of the evidence we have reviewed, we would consider that the efficiency factor from the previous control (of 4.5%) should be an upper limit, on the basis that it is unlikely that scope for efficiency gains can increase over time.

1.21 In summary, Ofcom's approach to efficiency analysis does not consider incentive effects, forecasting errors, Ofcom's previous analysis or regulatory benchmarks. Considering these other sources of evidence, we suggest an efficiency target in the range of 1% to 2% for TI and 2% to 4.5% for Ethernet may be appropriate. We note also that BT's own PVEO analysis suggests an upper limit of 5% may be appropriate

1.22 The evidence base is summarised below.

Table 1-3: Comparison of evidence

Source	TI Assumption	Ethernet Assumption	Comments
Unit cost trend analysis	1% to 2%	1% to 2%	Excludes one-off items and taking into account cost allocation changes
TFP analysis of telecoms sector	Less relevant	0.5% to 3.0%	Cluster of estimates around 2%
TFP analysis of ICT sector	Less relevant	2.0% to 4.0%	Higher rate of TFP growth not consistent with a market that has been in sharp decline and expected to continue to do so
BT's relative position	BT has made catch-up improvements over time, and is now close to the frontier	BT has made catch-up improvements over time, and is now close to the frontier	
Frontier shift assumptions made by other sector regulators	0.25% to 3.0%	Less relevant	Consensus of 1% frontier shift
Historic and forecast PVEO analysis	1% to 2% (BT)	3% to 5% (BT)	Ofcom calculated historic estimates of 4.5%-8.5% and future estimate estimates of 5%-10%
Assessed range based above evidence	**1% to 2%**	**2% to 4.5%**	

2. Introduction

2.1 This report has been prepared by FTI Consulting LLP ("FTI Consulting") for BT Plc ("BT") in connection with Ofcom's proposal for the efficiency factor to be applied in the leased line charge control ("LLCC") as set out in Ofcom's business connectivity market review ("BCMR") consultation published in June 2015.

2.2 FTI Consulting's work has been led by Meloria Meschi and Schellion Horn. Both are Managing Directors in FTI Consulting's Economic and Financial Consulting practice based in London. Meloria specialises in econometrics, with a particular focus on efficiency estimates and is also a lecturer on this subject. Schellion specialises in the economics of regulated utilities.

2.3 We have been asked by BT to review Ofcom's approach to estimating the efficiency factor proposed for the LLCC, focusing on the impact that this approach may have on efficiency incentives and the achievement of dynamic incentives, and comparing Ofcom's approach to methodologies and estimates from other regulated industries, academic literature and other relevant sources. Specifically we have been asked to consider:

- the approaches to measuring efficiency proposed by Ofcom for the LLCC and the extent to which these are consistent with those used by other regulators and whether there are other approaches that Ofcom could have considered;
- the impact of Ofcom's calculation approach on dynamic efficiency incentives;
- the efficiency factors that have been estimated in these industries, considering catch-up and the time trend of efficiency gains;
- any other publically available information on efficiency factors; and
- the extent to which Ofcom's efficiency factor appears reasonable when compared against other relevant efficiency benchmarks.

2.4 In undertaking this work, we have considered the efficiency analysis undertaken by Ofcom for the purposes of the LLCC consultation and, amongst other things, analogous top-down studies undertaken for other regulators and the decisions reached by other regulators. Our review covers the methodologies applied, the dataset used and the conclusions reached.

Background

2.5 On 12 June 2015, Ofcom published a consultation document related to LLCCs and dark fibre pricing[6]. This set out details of the proposed LLCC including the efficiency factor.

2.6 In Ofcom's charge control structure, the efficiency factor is intended to be a measure of pure efficiency – essentially total factor productivity ("TFP"), which excludes input price, general inflation and volume effects which are captured separately in the charge control model. The efficiency factor is applied to both operating costs and capital expenditure.

2.7 In a change to the methodology used by Ofcom in previous LLCCs, which combined bottom-up and top-down efficiency estimations, Ofcom's proposed efficiency estimate for the current LLCC is based on a review of five types of information. However, it appears that most weight has been placed on information from BT's management accounts. Ofcom proposes a range of 4% to 7% with a base case estimate of 5% for both of BT's Ethernet and traditional interface ("TI") services. In our view, this range is related only loosely to the specific results of the underlying analysis. Ofcom has not benchmarked BT's efficiency against comparator companies, undertaken detailed bottom-up analysis, nor estimated separate catch-up and frontier shift efficiency components.

2.8 Ofcom's approach differs from the approach employed in previous LLCCs where it has considered both benchmarking information and BT's business plans when determining the appropriate efficiency factor. Another change in approach is that Ofcom no longer estimates catch-up and frontier shift (often referred to as 'continuing efficiency') separately. These changes appear to contribute to the increase in the efficiency from 1.5% (TI) and 4.5% (Ethernet) in previous LLCCs to the proposed base case estimate of 5% in this current charge control proposal.

Sources of information

2.9 We have relied upon publicly-available information published by Ofcom in the LLCC consultation and from other regulatory authorities in the UK and Europe as well as from academic sources and government agencies. We have also relied upon analysis provided to us by BT, for which we have not undertaken further work to check its robustness.

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6 Business Connectivity Market Review: Leased lines charge controls and dark fibre pricing, Ofcom, 12 June 2015.

Restrictions of the report

2.10 This report has been prepared solely for the benefit of BT for use in responding to Ofcom's LLCC consultation. We have agreed that BT may provide this report to Ofcom and that it may be published by Ofcom in the context of the BCMR.

2.11 FTI Consulting accepts no liability or duty of care to any person other than BT for the content of the report and disclaims all responsibility for the consequences of any person other than BT acting or refraining to act in reliance on the report or for any decisions made or not made which are based upon the report.

Limitations to the scope of our work

2.12 No representation or warranty of any kind (whether express or implied) is given by FTI Consulting to any person (except to BT under the relevant terms of our engagement) as to the accuracy or completeness of this report.

2.13 This report is based on information available to FTI Consulting at the time of writing of the report and does not take into account any new information which becomes known to us after the date of the report. We accept no responsibility for updating the report or informing any recipient of the report of any such new information.

Structure of this report

2.14 This report has four further sections:

- In Section 3, we review the methodology that Ofcom has used to estimate efficiency factors for the LLCC consultation.
- In Section 4, we review the impact of Ofcom's proposed methodology on dynamic efficiency incentives.
- In Section 5, we provide a summary of efficiency estimation techniques that are commonly used to estimate efficiency factors in regulatory contexts.
- In Section 6, we compare Ofcom's approach to those employed by other regulatory and competition authorities. We provide a set of benchmark efficiency factors from a range of contexts which we compare to Ofcom's current proposed efficiency factors.

2.15 In Appendix 1 we provide a bibliography of public information we have relied upon.

3. Ofcom's approach to estimated efficiency for leased lines

3.1 In this section, we review the approach used by Ofcom to estimate the efficiency factor for TI and Ethernet for use in the LLCC. This is based on a review of the information provided by Ofcom in the LLCC consultation and, in respect of analyses specific to BT, discussions with BT management. We demonstrate that the analysis undertaken by Ofcom is limited in scope and does not support an efficiency range of 4% to 7%.

Ofcom's proposed measure of efficiency

3.2 Within a charge control setting, the term "efficiency" is intended to refer to cost efficiency, sometimes referred to as productive efficiency. The efficiency factor (sometimes referred to as the 'X' factor) is intended to incentivise the firm to improve its cost efficiency. In order to be cost efficient, a firm must be both technically and allocatively efficient:

- technical efficiency requires producing the maximum level of output using a given set of inputs and technology; whereas
- allocative efficiency requires choosing the least costly combination of inputs to produce a given level of output.

3.3 Ofcom intends for its approach to capture both types of efficiency. The efficiency factor that Ofcom is estimating:

- is applied to cash payments – covering operating costs (excluding depreciation) plus capital expenditure;
- is independent of volume effects;
- is independent of input price changes, including inflation; and
- reflects a net reduction in cash costs (i.e. it reflects any additional costs incurred in delivering efficiencies).

3.4 Ofcom state that its measure of efficiency can therefore be thought of as a measure of the increase in BT's TFP over time. It is important to note the efficiency factor is in addition to unit cost changes that occur from volume effects through the use of asset volume elasticities ("AVEs") and cost volume elasticities "CVEs"), general price inflation and input price changes through the use of modern equivalent asset ("MEA") approaches. Therefore, it is only one part of the overall unit cost reduction that has been built into the LLCC.

3.5 Unlike in some previous Ofcom charge controls:

- the efficiency term has not been separated into catch-up efficiency (the change required to bring BT in line with an efficient operator) and frontier shift efficiency (the movement in efficiency over time expected by an efficient operator); and
- the same range and point estimate of efficiency is proposed for both TI and Ethernet. In previous charge controls, differential rates have been used.

Sources of evidence considered by Ofcom

3.6 Ofcom sets out that it has based its efficiency analysis on five types of information. These are:

- recent charge controls;
- movements in component costs in the regulatory accounts, using the cost forecasting formulae within the LLCC model;
- historical and forecast BT management accounting information that identifies cost transformation and efficiency targets for BT divisions;
- an independent benchmarking study provided to BT; and
- other public information about BT's cost performance such as public statements and brokers reports.

We provide a high level review of each of Ofcom's sources of information below.

Recent charge controls

3.7 In the March 2013 LLCC statement, Ofcom applied a 1.5% efficiency rate to the operating costs of TI services. This was largely based on estimates of BT Wholesale's efficiency derived from TI specific historical trend analysis, BT Wholesale internal efficiency targets and external benchmarking studies. These studies included top-down econometric analysis which built on the approach used by Ofcom in the previous LLCC statement which also confirmed a rate of 1.5%. In both of these consultations, evidence was put forward that BT did not have the potential for catch-up efficiency and that the efficiency time trend was approximately equal to the inflation rate.

3.8 Table 3-1 below summarises the evidence on TI efficiency used by Ofcom in its 2013 LLCC.

Table 3-1: Evidence on TI efficiency assumption used by Ofcom in LLCC 2013

	TI specific historical trend analysis	BT Wholesale internal efficiency targets	2012 Deloitte study	Statistical analysis (NERA, Deloitte)
Efficiency %	~1.5%	Not available	2.25%	~2%
Comment (from Ofcom)	Ofcom's analysis of BT Wholesale's historical TI data	Relates only to SG&A costs, which account for only a small proportion of total BT Wholesale costs	Benchmark against 5 other European operators	Benchmark against US local exchange carriers LECs

Source: LLCC final statement, 2013, Figure A12.22. Ofcom noted that "other sources of information were considered. However for the reasons set out below we did not factor these into our final range"

3.9 Ofcom summarised its use of a 1.5% efficiency factor target for TI operating costs as follows[7]:

> *"In light of the above considerations, we regard 1.5% as an appropriate efficiency figure for BT Wholesale's provision of TI services. We note that this may be considered a relatively low target for efficiency improvements compared to those used in other charge controls on BT. However, TI services are a mature and declining set of markets and we believe that the evidence does not justify making a stronger efficiency assumption. We consider that this reflects that there is still some scope for BT Wholesale to reduce operating inefficiency, but less than in other services due to the declining nature of the service. This level of efficiency is also consistent with our analysis of past efficiency savings by BT Wholesale."*

3.10 In the 2013 LLCC, Ofcom set an operating cost and new capital expenditure efficiency factor of 4.5% for Ethernet services. Similar to the BT Wholesale evidence reviewed for TI, this was based on Openreach specific trend analysis, Openreach internal efficiency targets and external benchmarking studies.

7 LLCC final statement, 2013, paragraph A12.96.

3.11 Table 3-2 below summarises the evidence on Ethernet efficiency used by Ofcom in its 2013 LLCC.

Table 3-2: Evidence on Ethernet efficiency assumption used by Ofcom in LLCC 2013

	Openreach specific trend analysis	Openreach internal efficiency targets	2012 Deloitte study	Statistical analysis (Deloitte, NERA)	KPMG study
Efficiency %	~5%	X	2.25%	~2%	~2.3%-2.6%
Comment (from Ofcom)	Ofcom analysis of Openreach's historical cost data	Internal targets set for the subsequent 3 years	Benchmark against 5 other European operators	Benchmark against US LECs	Excludes fault rates and task times

Source: LLCC final statement, 2013, Figure A12.23.

3.12 Ofcom that "*we do believe that the forecast for real unit cost savings to be used in the model should be capable of being decomposed into frontier shift and catch up in a way which is consistent with other data on the potential for improvements each of these types of efficiency*"[8].

3.13 By contrast, whilst the current LLCC consultation suggests catch-up efficiency is available on both TI and Ethernet products, it does not decompose the proposed efficiency factor into frontier shift and catch-up components. Ofcom also calculates the same efficiency range and point estimate for TI and Ethernet services. This is a significant change to the analysis in the previous LLCC, where Ofcom noted that separate efficiency assumptions were appropriate for TI and Ethernet, since they are based on different underlying technologies[9].

8 LLCC final statement 2013, paragraph A12.109.

9 LLCC final statement, 2013, paragraph A12.72.

3.14 Ofcom has not updated the external benchmarking studies which it relied upon in the previous LLCC for both TI and Ethernet. We would have expected Ofcom to continue to look at these types of studies given how significantly they have featured in the previous LLCCs, and in particular because:

- The AT Kearney report may indicate that BT has achieved some catch-up efficiency during this current leased line charge control and so using historical data as a basis for the forecasts could overstate the potential for future efficiency improvement.
- There is no a priori reason to suggest that BT's comparative efficiency position will have worsened and that there should now be a catch-up component when KPMG, Deloitte and NERA previously demonstrated there was limited catch-up available.
- There is no a priori reason to expect BT's efficiency potential during the next charge control to be higher than for the current charge control. This is particularly true of TI which has minimal opportunities for technology enhancement and further operating savings.
- There is no a priori reason to suggest that the efficiency rates of TI and Ethernet will converge, since they will continue to be based upon different technology.

3.15 Ofcom has applied the efficiency target to capital costs, as well as operating costs. However, in 2013 it noted that it would not be appropriate to do so due to asset price changes being captured separately in the CC model (as part of the MEA approach) and the forecast decline in TI volumes rendering it unlikely there will be new capex (and falling volumes being associated with asset disposals). Since these conditions still hold, applying the efficiency factor to capital costs does not appear justified[10].

[10] The extent to which the extension of the efficiency factor to new capex will impact TI costs will depend on a number of assumptions in the LLCC model – largely around the calculation of new capex, replacement capex and disposals and assumptions around asset price inflation. This analysis is outside the scope of this report.

3.16 Ofcom references the previous Fixed Access Market Review ("FAMR") which included an efficiency assumption of 5%, applied to operating costs and capital expenditure and was based largely on estimates of Openreach's efficiency. Our view on these estimates is that they have limited relevance for LLCC as the networks used are broadly different to those used by both TI and Ethernet services. Further, the analyses are more limited and make less use of a range of evidence than in the previous LLCC review.

3.17 Ofcom also references the 5% efficiency target in the July 2014 wholesale broadband access ("WBA") statement which was applied to operators costs only and was based largely on the efficiency of BT's Wholesale and Technology service and operations ("TSO") divisions, using historical BT Wholesale management information on cost reductions and potential efficiency improvements. We do not consider this figure a particularly relevant benchmark because:

- The efficiency improvements may not be applicable to legacy services such as TI or to Ethernet where BT Wholesale is less relevant.
- The potential efficiency improvements estimates are based on 'price' 'volume' 'efficiency' 'other' ("PVEO") analysis which may not be suitable for this analysis, particularly as historical efficiency improvements should not mean future is possible.

3.18 In conclusion, having reviewed Ofcom's recent LLCC, we consider that more weight should be placed on the methodology and efficiency estimations in the previous LLCC. Previous LLCCs made the distinction between Ethernet and TI products which, in our view, was and remains warranted. We would have expected Ofcom to update the benchmarking analysis since it was a key component of the previous LLCC efficiency analysis.

3.19 The departure from the separate estimates of catch-up and frontier efficiency makes Ofcom's approach less transparent and difficult to benchmark to previous LLCCs and charge controls from other contexts. It is not clear whether the base case efficiency factor proposed by Ofcom in this consultation includes solely frontier shift efficiency, or is a combination of frontier shift efficiency and catch-up efficiency:

- If it is the former (i.e. 5% = frontier shift only), we would note that a 5% frontier shift is higher than that assumed in previous LLCCs and is not supported by regulatory precedent (as discussed later in this report).
- If it is the latter (i.e. 5% = frontier shift + catch-up) then the inclusion of catch up is inconsistent with the finding of previous studies showing BT is efficient relative to other operators. It is inappropriate to include catch-up in the absence of any evidence that shows BT is inefficient.

3.20 Further, Ofcom notes that that it has re-run the 2013 LLCC model and that the inclusion of a 5% efficiency target produces an outcome closer to BT's actual historical performance. To the extent that BT has been achieving higher efficiency gains than its charge control efficiency factor in the past, this may indicate that it may well have closed any catch-up efficiency gap that may have existed or is likely to have done so by the start of the charge control period currently being consulted on. In other words, BT would have responded appropriately to the incentives provided by the regulatory charge control, and one of the major objectives of the charge control would have been achieved. However, this does not necessarily indicate that BT will continue to perform at this rate and in fact may suggest the opposite (all else being equal, higher historic efficiency gains may indicate that the potential for future efficiency gains will be lower).

Regulatory accounting information

3.21 Ofcom uses BT's regulatory accounts as a basis for assessing forward looking efficiency assumptions. We agree with Ofcom's concerns around the practical application of this approach.

3.22 Ofcom is assuming that (a) prior cost behaviours are a robust indicator of future cost behaviours, and (b) that the regulatory accounts are in a sufficiently steady state that, when adjusted for volume and price effects, a robust view of efficiency trends can be established. There are a number of reasons to suggest that the regulatory accounts do not represent a sufficiently steady state. These are as follows:

- The regulatory accounts seek to represent the behaviour of costs for a complex and evolving portfolio of networks and services over time. Even assuming cost allocation methodologies and data sources do not change over time, changes in service mix will cause variations in the distribution of costs between services.
- As part of business as usual ("BAU") continuous improvements, BT will review and refine cost allocation methods between reporting periods. Since movements in unit cost may be due to distributive change rather than underlying efficiency trends, these BAU changes will naturally reduce the meaningfulness of year to year unit cost analysis for efficiency estimation purposes.
- During the time period reviewed by Ofcom, there have been a high number of changes to methodologies that are used to allocation costs between services such as that observed changes in unit costs cannot be assumed to be driven by efficiency driven.

3.23 Notwithstanding the above, it is our view that if regulatory accounting information is used to demonstrate historical efficiency changes, this can only be achieved by looking at patterns over a number of years. This is because the data is too 'noisy' over a single set of year pairs, and in addition, most initiatives to increase efficiency have higher costs initially followed by savings in later years (e.g., redundancy programmes).

BT management accounting information

3.24 Consistent with previous charge controls, Ofcom has continued to undertake analysis based on historic and forecast management accounting data which aims to distinguish between 'price', 'volume' 'efficiency' and 'other' effects. This type of analysis is typically referred to as 'PVEO' analysis. In the current charge control, Ofcom has placed considerable weight on this analysis due to less focus on econometric analysis.

3.25 However, we have a number of concerns about this analysis, which we detail below.

3.26 First, the underlying BT data upon which the analysis is based is not product specific and requires the assumption of constant efficiency rates across products within a division. In particular:

- The data provided to Ofcom relates to the historical and forecast performance of BT's Openreach, Wholesale and TSO divisions. Ofcom assumes that the observed efficiency gains within each division are constant across all products which are supported by that division[11]. No further analysis has been undertaken to assess the drivers of efficiency and whether, based on how and where the efficiency gains are expected, certain products are likely to benefit disproportionately from these. In particular, it would be expected that BT would limit new investment in legacy products and focus on newer platforms.
- Ofcom uses the analysis to determine a single efficiency range which is applicable to both operating and capital expenditure. This assumes that the operating and capital mix is constant across products and/or there is an equal opportunity for operating and capital efficiencies across products. However, this is unlikely to be the case as the profile of new investment, replacement capex and maintenance changes over the lifecycle of the product. As assets age, there is typically a greater need for maintenance and refurbishment investment, which may lead to a "U" shaped asset cost profile over the life of the investment[12].

11 The different in efficiency gains between products is due to the weightings applied to TSO, BT Wholesale and Openreach.

12 An example of an ageing asset is the synchronous digital hierarchy (SDH) platform which is characterised by low levels of new investment.

3.27 Second, the analysis does not take into account the lifecycle of the product:

- TI is a legacy service with declining volumes and BT is unlikely to invest in new technology or cost improvement programmes which may improve efficiency as there is unlikely to be a net benefit from doing so. In particular, there is a very limited second-hand market for many of the legacy assets which further reduces the business case for new investment. Information provided by BT to Ofcom on its cost transformation plans indicates that only one low value item relates to leased lines specifically. This demonstrates that there are likely to be differing efficiency rates between products.
- It may be difficult to purchase more efficient equipment for legacy services as it is not being manufactured. It may therefore be inappropriate to assume that past levels of efficiency can continue for legacy products or that they will be as high as for other products.
- There is the potential for inconsistency in the LLCC model between the asset price inflation assumptions, treatment of replacement / new capex, disposals and an efficiency factor that is also applied to new capital costs. This is one reason why Ofcom has previously only applied the efficiency factor to the operating costs of TI. However, the mechanics of the LLCC model are outside the scope of this report.

3.28 Third, the PVEO analysis is incomplete:

- For Openreach, the PVEO analysis uses as an input all operating costs and capital expenditure costs. However for BT Wholesale and TSO only operating costs are included. Ofcom considers that this is appropriate because capex is low. This may be the case for TI products, although depending on how the efficiency factor is applied in the LLCC and the inter-relationship with other variables such as asset price inflation then the exclusion of capex in this calculation could be more meaningful.
- Analyses are not available for TSO for 2016/17 or 2017/18. Ofcom uses depreciation as a proxy for capex. However, depreciation covers both legacy and next-gen assets whereas capex is likely to be predominantly next-gen focused. Therefore one is not a proxy for the other. Consequently, unless the ratio of new capex to depreciation is constant across business units the analysis will be distorted.

3.29 Fourth, there are a number of inconsistencies between the PVEO approach and Ofcom's LLCC model.

- There is an inconsistency between the estimation of cost volume effects in the PVEO and the estimation of these in Ofcom's charge control model which involves the derivation of detailed AVEs and CVEs. For example we understand from BT that within the PVEO model, the "V" captures the impact on the direct costs of sales but not on overhead costs. This could imply that cost changes are being double-counted and considered in both the efficiency term derived from the PVEO analysis as well as in the AVEs and CVEs. In cases where volumes are falling then this is likely to lead to an overstatement of the efficiency rate.
- As Ofcom notes, it is consulting on a number of changes to cost allocation methodologies and on the exclusion of costs. Furthermore, the weightings assigned to TSO, Openreach and BT Wholesale will change over time as their costs are forecast to change at different rates. These impacts are not captured in the PVEO analysis.
- A further inconsistency exists between the inflation rates used in the LLCC model and that used in BT's PVEO analysis. Ofcom states that the impact is likely to be within the "*margin of accuracy*"[13]. There is further uncertainty over the treatment of inflation within transfer charges. Ofcom states that both these issues are likely to have led to an underestimation of efficiency gains. However this is not necessarily the case if prices have been falling. Regardless, these inconsistencies further highlight the limitations and accuracy of the PVEO approach.
- Ofcom proposes that the efficiency factor reflects the net cost reduction achievable. However, restructuring costs are removed from the cost stack and do not feature in the starting price[14]. Furthermore, Ofcom's LLCC model assumes there will be disposals on TI assets but the costs associated with making these disposals have not been specifically added by Ofcom and therefore may not be included in the PVEO analysis.
- The costs included in the PVEO analysis are not necessarily consistent with those that are included in the starting prices in the charge control. There are a number of regulatory adjustments that have been made which exclude certain types of costs from the regulatory accounts or reallocate costs to other markets. Therefore, efficiency gains from the PVEO analysis may be capturing changes to costs which have already been excluded from the starting prices.

13 LLCC consultation – Annexes, 12 June 2015, paragraph A8.204.

14 LLCC consultation – Annexes, 12 June 2015, paragraphs A7.53-A7.57.

3.30 Ofcom has not cross-checked the PVEO analysis with a bottom-up review of whether the efficiency gains are achievable. The PVEO analysis generates very similar efficiency rates for TI and Ethernet is inconsistent with the prior expectation that legacy TI should have a lower efficiency rate than Ethernet. This casts doubt on the appropriateness of the analysis for the LLCC.

3.31 To check for appropriateness, Ofcom could, for example analyse the individual programmes that are part of the PVEO analysis and seek to identify the assets / operating cost types that may be affected and, through FAC methodologies, identify which of these are allocated to TI and Ethernet products. Alternatively, Ofcom could, in common with some other regulatory authorities, undertake a more engineering based study to identify potential efficiency gains.

3.32 It is well understood that efficiency estimation is often limited by the availability and quality of information and that a degree of judgement maybe required. As such, the practical implementation issues associated with the PVEO analysis do not necessarily render it unworthy of consideration. However these issues should factor into the balance of evidence and, when also considered alongside the perverse incentives the use of PVEO may create, substantially reduce the weight that Ofcom places on this analysis and encourage Ofcom to explore a wider range of sources.

Independent benchmarking study

3.33 We understand from BT that they are surprised about the inclusion of the AT Kearney report in Ofcom's review, given the limitations that exist with the report in the context of a charge control process. This concurs with Ofcom's previous view of the report expressed in the June 2014 WBA statement: "*We consider the other* [AT Kearney] *benchmarking of limited use for helping to set an appropriate efficiency target for WBA services particularly in the light of BT's own caution about how to interpret it*." Ofcom has not explained why this report was considered of limited use in the WBA market review but is now being relied upon.

3.34 Ofcom has used the AT Kearney report as evidence of an efficiency gap[15]. However, it is not clear that an efficiency gap necessarily does exist on the basis of a review of previous analysis and Ofcom statements. In particular:

- BT disagrees with the interpretation of the AT Kearney report and has previously written to Ofcom to explain that the report does not contain sufficiently comparable analysis to be of use, that past gains are not a reliable guide to future gains and, in any case, demonstrates BT to be an efficient operator[16].
- Ofcom has not referred to other reports provided by BT to Ofcom previously (in 2008, 2009, 2010, 2012) or reports which Ofcom commissioned from NERA consultancy which demonstrate that BT (Wholesale or network operations) are efficient. These were considered by Ofcom in previous charge controls (for example, in the 2013 LLCC as demonstrated previously).

3.35 Finally, we note that Ofcom itself has previously stated that "*The NERA, Deloitte and KPMG studies suggest that BT was relatively efficient and that the scope for catch-up gains in efficiency (as opposed to frontier shift gains) was limited*".[17] If Ofcom's current efficiency factor proposal represents some catch-up efficiency, then this could imply that BT is currently 10%-25% more inefficient than a hypothetical benchmark firm, which has neither been argued nor evidenced by Ofcom. This is illustrated in Table 3-3 below.

Table 3-3: Implications of Ofgem's proposals for BT current inefficiency

Ofcom proposal	'Reasonable' frontier shift	Implied current inefficiency
4% (low end)	2%	(4% - 2%) x 5 = 10%
7% (high end)	2%	(7% - 2%) x 5 = 25%

Note: The proposed LLCC price control period is three years, but Ofcom's modelling is based on a 2013/14 base year and forecast forward for 5 years. This analysis assumed that the efficiency factor has been set so that BT is as efficient as the benchmark at the end of five years, and also, for the purposes of illustration, that a 'reasonable' frontier shift is 2% per year.

15 It should be noted that Ofcom does not define what the catch-up gap is in relation to.

16 Letter from BT to Ofcom on 30th January 2014.

17 LLCC final statement 2013, paragraph A12.108.

3.36 The likely slowdown in efficiency savings is also a view expressed by some analysts who have noted that the opportunities for BT to further reduce costs are becoming limited. For example, in October 2014 Morgan Stanley noted that *"…on the cost-cutting front, new wins are harder to come by"*[18]. As discussed elsewhere in this report, however, we consider that such statements generally provide limited insight in the context of a product-specific charge control.

3.37 We also have a general comment on the appropriateness of benchmarking studies and cost analysis that are based on whole divisions, as opposed to being product specific. The analysis is a technology static analysis based on a particular product – so for TI, it assumes that the existing legacy technology will be used to provide the product (the MEA might be the technology used to provide Ethernet, but the TI product is assumed to use legacy technology in the LLCC). Therefore, the achievable efficiency gains on this specific product are likely to be lower than the frontier shift analysis, or benchmarking, might imply – as the frontier shift will be driven by changes to and improvements in technology. For TI, there may be some efficiency savings available in some shared and overhead costs such as customer services but for the bulk of the direct costs, e.g. power and chilling, there are unlikely to be large efficiency savings. Therefore, the efficiency rate applied to TI may be expected to below the rate of change of the efficient frontier.

Public reports about BT cost performance

3.38 Analyst reports and BT press statements provide an indication that there are likely to be further cost reductions at BT. However, they do not provide information on the cause of these reductions – for example efficiencies, volume effects or input price effects and to which division, cost type or products these refer.

3.39 BT's financial performance in 2014/15 appeared to show large cost reductions. However, Ofcom has not undertaken an attribution of these to efficiency versus other factors or assessed the extent to which these were one-off efficiency gains versus gains that could be expected to continue in the future (likely due to frontier shifts).

3.40 Whilst confirming historical cost savings and highlighting potential future cost savings at BT Group or divisional level, these public reports provide very limited insight into efficiency rates and do not provide a measure of the future efficiency rate that BT may be expected to achieve on TI and Ethernet products.

[18] Morgan Stanley research note, 24 October 2014.

Conclusions

3.41 Ofcom have drawn on five types of information – recent charge controls, regulatory accounting information, BT management accounting information, an independent benchmarking study and public reports about BT cost performance. Ofcom has not considered external benchmarking analysis or TFP estimates which would allow it to refine and cross-check its estimates.

3.42 There are clear limitations in the analysis that has been undertaken by Ofcom. This is not necessarily surprising given the difficulties in obtaining reliable efficiency estimates and is a problem that is commonly encountered by regulatory authorities. It is for this reason that regulatory authorities typically review a large range of evidence to determine an appropriate efficiency factor.

3.43 However, for Ofcom's current LLCC proposals, when compared to the analysis undertaken in the previous LLCC, there has been a change in approach used by Ofcom in four key areas and a reduction in the range of evidence considered:

- the efficiency factor for TI and Ethernet has been set at the same level, being unreflective of differences in technology;
- the efficiency factor is no longer calculated in terms of catch-up and frontier shift separately;
- there has been an increased focus on the use of BT management forecasts and internal targets in setting the efficiency factor; and
- external benchmarking reports on Openreach and BT Wholesale, which have previously been relied upon, have not been updated nor included in the review of available benchmarks.

3.44 Ofcom has not explained the rationale behind its change in approach or why its proposed approach is more appropriate than that used in the previous LLCCs. The Competition and Markets Authority ("CMA") stated in Bristol Water that *"Consistency with previous regulatory decisions is a relevant consideration and any significant changes should be satisfactorily explained and well justified."*

3.45 Below, we summarise Ofcom's evidence on efficiency and note the areas that have not been considered and adjustments that might be appropriate. We would highlight that Ofcom has omitted previous regulatory decisions from its list of evidence despite setting this out as one of the areas to be considered (A8.149). This would support an efficiency factor for TI and Ethernet below Ofcom's proposed range.

Table 3-4: Ofcom's Evidence on Ethernet and TI efficiency analysis

Evidence in Ofcom's table	Period	TI efficiency per year	Ethernet efficiency per year	FTI Comment
Review of previous charge control decisions	Historic but includes frontier shift which can be used for forecasting	1.5% (TI LLCC)	4.5% (Ethernet LLCC)	Benchmarking studies provided in previous LLCC likely to still remain valid as they provide the frontier shift, which would not be expected to vary significantly over time. This would support a figure of 1.5% for TI and 4.5% for Ethernet.
		5% WBA 5% FAMR	5% WBA 5% FAMR	As explained above, WBA and FAMR efficiency rates are less relevant for TI and Ethernet due to the methodologies employed.
Review of regulatory accounting information	Historical	2.0% - 3.0%	8.0% - 10.5%	Ofcom highlight (and we concur) there are some practical issues with this approach. BT has provided alternative analysis that addresses some of these issues.
BT management accounting information (PVEOs)	Historical	4.5% - 8.5%	5.0% - 7.5%	Does not provide forward looking view. Calculation concerns have been provided previously, including inconsistency of E term with efficiency factor in LLCC model. BT has provided alternative analysis that addresses some of these issues, resulting in a significantly lower range of 1-2% for TI and 3-5% for Ethernet.

Evidence in Ofcom's table	Period	TI efficiency per year	Ethernet efficiency per year	FTI Comment
BT management accounting information (PVEOs)	Forecast	5% - 10%	5% - 10%	Incomplete, assumption based and "E" is inconsistent with Ofcom LLCC model – likely to overstate efficiency. BT has provided alternative analysis that addresses some of these issues, resulting in a significantly lower range of 1-2% for TI and 3-5% for Ethernet.
AT Kearney report	Historical	Redacted	Redacted	Demonstrates efficiency has been achieved historically. Potentially demonstrates any efficiency gap has closed. No insight on future rates.
BT broker reports and BT statements	Forecast	Cost transformation remains key to BT strategy, but efficiencies are likely to become more difficult to achieve over time		Indicates efficiency gains are likely to fall
BT Financial performance	Current	5%	5%	Not attributed to any particular product
BT annual report	Current	Cost reductions and improvements in 2014/15		Provides limited insight on forward looking rates

Source: FTI summarised from Ofcom, LLCC 2015.

3.46 In regulatory practice, it is common for a final efficiency range to relate somewhat loosely to the specific individual results of a range of analyses, especially when there are a variety of calculation bases and ranges.

3.47 However, the only justification for a 4% to 7% efficiency factor range for TI is from historical PVEO analysis. The forward looking PVEO analysis is significantly below Ofcom's proposed figure – and we consider both of these figures are likely to over-estimate efficiency gains due to falling TI volumes. There are a number of practical problems with using PVEO analysis in the context of a charge control, and, notwithstanding these, it is our view that if regulatory accounting information is used to demonstrate historical efficiency changes, this can only be achieved by looking at patterns over a number of years (which Ofcom has not done).

3.48 The other evidence that Ofcom has put forward also does not support Ofcom's proposed efficiency factor:

- Ofcom's proposed central estimate of the efficiency factor appears inconsistent with its previous LLCCs, which suggested efficiency factors of 1.5% and 4.5% for TI and Ethernet respectively. Ofcom has not articulated (and we consider there is no a priori rationale) why BT's efficiency rate during the next charge control should be higher, nor why the rates of TI and Ethernet should converge given the technologies are at very different maturities. The CMA stated in Bristol Water that "*Consistency with previous regulatory decisions is a relevant consideration and any significant changes should be satisfactorily explained and well justified".*
- Previous LLCCs have stated that TI capital costs should not be subject to the efficiency factor due to declining volumes associated with asset disposals and lower propensity for new capital formation. Ofcom has not articulated (and we consider there is no a priori rationale) why it now considers that TI capital costs should be subject to the same efficiency factor.
- Ofcom appears to place some weight on previous FAMR and WBA statements which are based themselves on limited analysis and are far less relevant to BT's Ethernet and (particularly) TI services.
- Ofcom appears to place weight on an AT Kearney report which it had previously dismissed as being of limited use. Ofcom has not articulated (and we consider there is no a priori rationale) why the findings in this report are more useful or reliable than previously.
- Ofcom has referred to public reports about BT cost performance which in our view provide very limited insights into future efficiency gains: the public reports are not specific about the drivers of potential cost reductions (of which efficiency is only one of many possibilities) or which division, cost type or products are referred to.

3.49 Ofcom's reliance on management information to set the efficiency target may be flawed and is at odds with other regulatory authorities who tend to take a more rounded view of efficiency analysis and also include efficiency benchmarking as part of their analysis.

3.50 Taking into account the evidence presented by Ofcom, including a review of the benchmarking reports and other analysis relied on by Ofcom in previous charge controls, a rate below 2% would appear more appropriate for TI based on the above analysis. However, given the implied savings only relate to opex, even a rate of 2% could be considered high.

3.51 The efficiency rate of 4% to 7% on Ethernet services also appears to be based on the historical and forward looking PVEO analysis. However, as noted previously, we have concerns over the robustness of this methodology and the impact on incentives of basing efficiency factors primarily on internal analysis. As such, these estimates are not suitable for this analysis, particularly when combined with reports that state that efficiency rates may be lower in the future. Taking into account the benchmarking studies that were considered as part of the previous charge control reviews, this evidence points to an appropriate rate being at the bottom end of the range put forward by Ofcom.

3.52 In the following chapter we discuss the negative impact on management incentives and dynamic efficiency that may occur from an over-reliance on BT's management information by Ofcom to set efficiency targets.

4. Relationship between the use of BT's information and incentive regulation

4.1 In this section, we present theoretical considerations on the impact of the regulated firm's incentives of using internal, management information to derive the efficiency factor. We then discuss the consequential impact of this on dynamic efficiency and consumer welfare.

Incentive regulation

4.2 Regulation can be considered as a response to two information problems:

- the problem of monitoring performance, and
- the problem of specifying performance targets.

4.3 Incentive regulation can partly overcome information problems. Sappington[19] provided ten guidelines for incentive regulation, which include prioritising regulatory goals and designing incentive regulation to achieve these goals.

4.4 In network industries, infrastructure investments are fundamental for providing services of adequate quantity and quality. While incentivising infrastructure investment and migration from an old to a new technology is a regulatory goal, regulatory access pricing can reduce a regulated firms' incentives to invest.

4.5 Efficiency targets affect prices, and this in turn affects the speed of migration from an old technology to a new one. There are three types of efficiency:

- technical efficiency, which means producing the maximum achievable output with the inputs available, for a given technology;
- economic (productive) efficiency, which means producing the optimal level of output at the minimum cost, for a given technology; and
- dynamic efficiency, which means introducing new technology to either reduce a firm's costs over time, or to achieve innovation that increases the efficiency of an economic system. This is the case of infrastructure investment and migration to new technologies.

19 Sappington, David E. M. 1994. "Designing Incentive Regulation," Review of Industrial Organization, 9, 245-272.

4.6 Achieving dynamic efficiency requires taking a longer term view of investment and moving away from the concept of setting prices equal to cost for every year of the charge control. It requires setting access prices (and therefore efficiency targets) that provide the right incentives to invest in, and migrate to, new technologies and processes.

4.7 Dynamic efficiency is fundamental for a country's competitiveness and growth. There can be a conflict between dynamic and static efficiency and one overarching aim of regulation is to ensure the balance between the two is appropriate.

Access pricing and incentives to migrate and invest

4.8 We consider that migrating from an old to a new technology (for example, from copper to fibre) does not happen at once: it is a slow process and the two technologies co-exist for a period of time. During this time, migration and investment incentives are influenced by access prices.

4.9 Bourreau et al.[20] show that:

> *"When the access price of the legacy network is low, the prices for the services which rely on this network are low, hence, in order to encourage customers to switch from the old network to the new network, operators should also offer low prices. This effect, which we refer to as the business migration effect, reduces the profitability of the new technology infrastructure, and hence the incentive to invest in it. … Our results highlight that regulators must not treat the decisions regarding the two access prices independently."*

4.10 The issue of migration and investment between new and old technologies has been debated in the literature. Three particularly significant papers are:

- Plum (2011)[21] which argues that a low access price for the legacy (copper) network would have a negative impact on the new network because it incentivises customers not to leave the old network, with obvious consequences for the business case for the new network;

[20] Borreau M., Cambini C., Dogan P. 2012. "Access Pricing, Competition, and Incentives to Migrate from 'Old' to 'New' Technology," International Journal of Industrial Economics, 30, 713-723.

[21] Plum, 2011. "Costing Methodology and the Transition to Next Generation Access," Report for ETNO.

- Plum (2015)[22] which argues that only in one of the two services (new or old) should access be regulated. In the case of UK leased lines, this should be the new (Ethernet) service, which is already regulated; and
- WIK (2011)[23] argues that low access prices for the legacy network (copper) provide the right incentives (i) for new entrants to investment in new (fibre) networks; and (ii) for dismissing the old network when the new one is in place.

4.11 We also note that the EU[24] has also recognised that regulatory policies during the migration period from old to new networks can have a fundamental impact on the incentives to invest in the new network, but does not comment on the links between access pricing in the two networks.

4.12 In summary, efficiency targets, through access prices, have a strong role in incentivising management to adopt a behaviour leading to dynamic efficiency and incentives for customers to make the optimal technology choice. The methodology used to set such efficiency incentives is therefore fundamental. In the next sections, we discuss how the methodology used by Ofcom, centred on BT's PVEO, results in distorted incentives.

Management incentives versus the incentive properties of a competitive market

4.13 A key part of the price setting regime with inbuilt incentives is that the efficiency factor reflects the scope for achievable improvements in cost efficiency over the period of the charge control. There are two components to this:

- an *internal* component, with all units of the regulated firm aiming to achieve the efficiency of its best performing units;
- an *external* component, with the regulated firm as a whole achieving best performance with respect to an achievable (external) benchmark.

4.14 Thus, the efficiency factor is not only based on a firm's past performance, but also on the performance of other firms in the industry. As a result, this type of regulation is intended to closely replicate the incentive properties of a competitive market.

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22 Plum, 2015. "Leaving a Legacy: Enabling Efficient Network Transition," Report for BT.

23 WIK Consult, 2011. "Wholesale Pricing, NGA Take-Up and Competition," Report for ECTA. Note this study provides a different (though not widely accepted) view that lower legacy prices is positive for migration which contradicts the Bourreau and Plum studies. At the time of publication, this study was generally not accepted by BEREC (see BEREC Opinion on Commission draft Recommendation on non-discrimination and costing methodologies).

24 EU Recommendation C(2010)6223 on "Regulated Access to NGA," September 2010.

4.15 In a competitive market, a firm will seek to lower absolute costs, but also to lower costs relative to its competitors. Where a firm has costs below that of its rivals, it is likely to gain market share, and increase profits.

4.16 Where over reliance is placed on management forecasts of a single regulated firm then the view of the industry is likely to be biased towards the regulated firm rather than the competitive market.

4.17 The situation is even more complex in the case of competing technologies, such as a new technology versus an old, outdated technology. In such a case, where the new technology is qualitatively superior and there are welfare gains to be made from migration to the new technology, migration and investment decisions are heavily influenced by the incentives put in place by regulatory interventions.

4.18 The use of the incumbent's management information to determine the efficiency factor for the charge control can, in this case, create perverse incentives. In BT's case, if Ethernet prices are set too low, this creates a negative incentive to migrate to, and invest in, the new technology. If this were the case, there would be a misalignment between short run, static, efficiency and long run, dynamic efficiency, with the lower access price for the old technology favouring short-run efficiency at the expense of dynamic efficiency.

Incentives to outperform the charge control

4.19 The use of an efficiency factor is intended to incentivise the firm to improve its efficiency over the period of the charge control, since it is potentially able to make supernormal profits it is able to do so. Lewis and Garmon (1997) define incentive regulation as "*the use of rewards and penalties to induce the utility to achieve desired goals where the utility is afforded some discretion of the manner of achieving goals*".

4.20 To incentivise short-term efficiency, prices must be set so that the regulated firm benefits from cost reduction which represents an outperformance over and above the forecast reduction.

4.21 However, in the absence of perfect foresight, prices and costs will inevitably diverge (either up or down), leading to pressure to reset prices in line with costs, thereby undermining the incentive to reduce costs in the long term (Mumssen and Williamson, 1999). To the extent that utilities anticipate that a substantial share of their efficiency gains (and associated cost reduction) will be passed on to customers, the incentive to make such savings is diminished. This suggests Ofcom should be conservative in its approach to setting its efficiency targets.

Providing opportunities for outperformance

4.22 One of the original premises of RPI-X regulation is that it encourages companies to outperform against their efficiency targets. The efficiency target is therefore not typically set at simply the highest possible reasonable level, but the regulator will exercise judgment on where to place the efficiency factor depending on the circumstances.

4.23 Firms require a reasonable assurance of cost recovery and will only invest if sunk costs can be recouped via retained cost savings and / or additional revenue allowances. This requires regulators to determine how much reward is needed to induce the operator to improve its performance and assess whether this additional efficiency gain is worth the cost of an additional reward.

4.24 For example Ofwat said: "*We have included only half of the scope for continuing efficiency…and just over half of the scope for catch-up… The balance represents the potential for outperformance for the companies…*"[25]

4.25 LECG analysis performed in 2005 found that across industries and regulated sectors, the average annual efficiency target has been some 2.5% whereas actual unit costs reductions were between 4.0 and 4.8%[26].

4.26 It is assumed that a firm's management forecasts are likely to be ambitious and err towards upside forecasts[27] – since they provide targets to stretch and motivate managers. They are therefore more likely to over-estimate than under-estimate the performance that might be achieved by the firm during the period.

4.27 Where the efficiency target is set on management forecasts that are already 'stretch' forecasts then the potential to outperform the efficiency target through cost reductions is reduced.

Time profile of over performance

4.28 Where the efficiency target is set on management forecasts for each year, then the opportunity for the firm to benefit from higher returns for more than one year is reduced. This is because the efficiency target is set following the expected profile of efficiency savings.

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25 Ofwat Final Determinations, 2004.

26 Future Efficient Costs of Royal Mail's Regulated Mail Activities, LECG, 2005.

27 This is particularly the case in a single, isolated process. For a repeating process, the firm may adjust its management forecasts downwards. Although there will be competing factors of needing to meet market expectations versus achieving a lower efficiency factor in the charge control.

4.29 This is an issue that has recently been considered by the Germany economics ministry in the context of an evaluation report on the incentive regulation framework that applies to energy network operators. The report considered network operators' investment behaviour, how this has evolved over time, and further measures needed to avoid barriers to investment.

4.30 The key finding is that incentive regulation has performed well, helping reduce cost while facilitating significant investment and security of supply. As a result, fundamental reform to the system is not needed. However, the report gives some recommendations for improving the system, including allowing companies to benefit from cost and efficiency savings through higher returns for more than one regulatory period[28].

Ensuring appropriate risk and gain share mechanisms

4.31 Additionally, management plans are based on the investment and programmes that the firm plans to undertake, given a set of forecasts about demand, return on capital employed etc., and on the benefits that it expects to derive as a result. However, it is possible that the demand or commercial rationale for undertaking these changes may not materialise – for example, insufficient demand may arise due to a global downturn, or integration problems may arise. [29]

4.32 However, the charge control does not factor in the downside risk of the efficiency gains not being achieved. This risk sits fully with the firm, even though it may be an appropriate and efficient decision to not implement a programme where the costs outweigh the benefits. Therefore, customers of the regulated product benefit if the programme is successfully implemented since the efficiency gains are factored into the charge control, where as it is the regulated firm who bears the risk should the efficiency gains not be achieved. The charge control should consider this risk sharing issue more fully and ensure that there is an appropriate level of risk sharing.[30]

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28 BNetzA Report on incentive regulation.

29 For example, NHS productivity was expected to improve as a result of an IT system which linked hospitals and GPs. However, after integration issues and huge cost overrun the project was abandoned as the efficiency benefits were deemed to be less than the escalating costs.

30 For example, it is worth considering the drive in the NHS towards outcome based commissioning. These contracts between commissioners (GPs) and hospital Trusts aim to incorporate a degree of risk sharing. Whilst they are based on regulated prices, they seek to incentivise both GPs and Trusts to increase their level of efficiency with the gains (and losses) being shared between the two parties. For example, see FTI Consulting report on outcomes-based contracting for diabetes care.

4.33 BT's management forecasts may contain optimism bias (since this is presumably expected by the market). Therefore, there is greater probability of BT under-performing against this target than over-performing. So there is more likelihood of BT underperforming than outperforming the charge control – which is contrary to the concept of incentive regulation, as noted by Ofwat amongst others. This also implies that BT takes on the underperformance risk associated with its cost reduction and efficiency programmes but is unlikely to share in the benefit. This does not accord with a risk / gain share approach.

Management incentives in a repeated process

4.34 Since a charge control is a repeated process, management will become aware that management forecasts are being used for regulatory efficiency purposes and may act accordingly. There may be a distorting of management incentives to set challenging operational targets. Two examples are:

- It is possible to see a position being reached where management look to influence the forecasts by lowering the level of efficiency that is contained within the plan. However, whilst this could lead to a lower efficiency factor set in the charge control, it will also weaken incentives on the firm's staff to reduce costs – particularly if bonuses are related to the management plan. Over time, this will potentially lead to less efficiency gains than may otherwise have incurred if staff had been incentivised on higher measures.
- Management may focus cost saving efforts towards non regulated products or those areas of the business which make a smaller contribution to the regulated product. This could result in a 'two speed' business with non-regulated areas being subject to greater technical advancement and progress than those which are not. This is because the regulated firm becomes aware that there may be a greater possibility of keeping outperformance benefits for a longer time. Even if the unregulated industry is competitive then the firm will benefit during the period which the market takes to reach the new equilibrium – where as if the efficiency is shown in the management forecasts of a regulated product then it may be removed immediately.

4.35 In effect, the use of management information may reduce the incentives properties of the charge control – since the firm is incentivised to inflate their asset base through over investment or inefficient resource allocation since it knows that these forecasts will be used as an input into the charge control. It was for these reasons that there was a move from rate of return regulation to incentive based regulation in the UK (initially by Stephen Littlechild[31]). The use of management efficiency targets which are potentially subject to influence in a repeated process appears to reduce the incentive properties of the charge control and could reward the firm for inefficient behaviour.

Past efficiency gains may not be good indicator of future efficiency gains

4.36 These forecasts are based on what happened in the past – what efficiency levels were obtained, the speed of migration between products, the previous regulatory environment etc. Even when updates have been made, they are unlikely to have captured all the changes that will occur (for example, a change in Ofcom's policy position for the relative pricing of TI versus Ethernet) and certainly embody a degree of risk.

4.37 Historically based efficiency improvements may not be a good predictor of future efficiency improvements, particularly if they relate to closing the efficiency gap rather than the frontier shift. Once the gap has been closed, those efficiencies are unlikely to be repeated. Therefore, efficiency gains are likely to slow over time if the historical efficiency rate has been higher than the frontier shift rate.

4.38 Management may not be able to continually achieve historical levels of efficiency. This has been noted by other regulators and is one reason why efficiency factors tend to decrease over time from their immediate post privatisation levels. Analysts also recognise this in valuations. However, this is not always reflected in management plans.

Circularities between management forecasts and regulatory policy

4.39 Management forecasts will reflect known events at the time of development, and are therefore unlikely to fully reflect changes to the regulatory environment. Once a particular charge control has been set, then it is likely that management will revise the forecasts and as a result the implied efficiency adjustment may well be altered.

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31 See, for example, the Centre for the study of Regulated Industries (CRI)'s retrospective on the origins of RPI-X regulation.

4.40 For example, in the current LLCC consultation, Ofcom has changed the relative pricing structure of TI versus Ethernet. Previously Ethernet was subject to higher annual reductions in price than TI (which was subject to an RPI plus cap in the last LLCC). The management forecasts were presumably made on the presumption that there would be continued migration from legacy to next gen products, supported by the regulatory environment. However, the change in the regulatory environment implies a likely slowdown in the migration and a need to continue to maintain dual platforms for longer. This may well reduce the level of efficiency gains that can be achieved. This has not been captured within the management forecasts – and likely will not be until Ofcom concludes on this issue in the LLCC. Therefore there is circularity between management forecasts and charge controls.

Review of Ofcom's use of internal data on dynamic efficiency

4.41 Ofcom places significant weight on PVEO analysis from BT's management forecasts and, to a lesser extent, on BT's regulatory accounts. In the previous chapter, we set out some particular concerns with regards to the techniques being employed to forecast efficiency from this data and the consistency of these techniques with the LLCC. However there is also a broader question of whether, even if these techniques were technically correct, the efficiency approach would lead to dynamic efficiency.

BT is operating in an uncertain environment, particularly how and when customers will migrate from TI to Ethernet

4.42 BT currently supplies a broad portfolio of access services across both Ethernet and TI leased lines, the latter which use legacy equipment which, in some cases, is no longer manufactured or supported. The structure of pricing across BT's leased line portfolio is important as BT manages significant migrations between services alongside meeting the increased overall level of demand.

4.43 However, the operating environment is uncertain as are consumer preferences and the migration path. The ongoing pace of migration between services, particularly how and when the remaining TI customers may choose to migrate to Ethernet services, but also the scale of overall migration and connection activity that will need to be undertaken is not yet clear. This has for ongoing support of TI services based on legacy technologies and on Ethernet services.

4.44 Ofcom's approach to efficiency estimation does not consider the interrelationship between BT's investment programmes in different services. We consider this is wrong, for two reasons:

- As a matter of principle, it would be dynamically inefficient of BT to invest as much in cost reduction programmes for legacy products as non-legacy products, leading to negative implications for the economy as a whole.

- On a more practical level, we would expect that there are more limited opportunities for efficiency gains as these are likely to be limited to opex reduction programmes that are now likely to be occurring in any case[32].

Imposing a symmetric efficiency challenge for both Ethernet and TI services will distort both demand and supply and reduce dynamic efficiency

4.45 It is recognised that both price and non-price signals may be used to facilitate dynamic efficiency, in this case through encouraging the migration of customers from legacy TI services onto the Ethernet platform. If the efficiency target is inappropriately set, leading to inappropriate prices then there will likely be a wider market distortion and reduced dynamic efficiency.

4.46 The use of PVEO analysis has resulted in an efficiency target which is higher than had weight not been placed on this analysis. This reduces charged control prices for both TI and Ethernet products below that which otherwise would have been calculated.

4.47 In the previous LLCC, Ofcom advocated a position of ensuring prices are set at efficient levels, allowing for efficient cost recovery and giving the flexibility for efficient migration where appropriate[33]. Ofcom also noted in this consultation that a *"retail level safeguard cap was appropriate and that it should allow changes in these costs to be reflected in retail prices in order to encourage efficient migration to newer services"*.

4.48 The treatment of efficiency the current LLCC consultation is only one aspect of a presumed Ofcom policy shift away from the pricing of TI versus Ethernet to incentivise migration to Ethernet to one of "protecting" those customers who have remained on TI. This can be observed in the decline in TI prices that is being proposed following a period in which TI prices were permitted to increase.

Table 4-1: Comparison of LLCC

Product	Basket level charge control in LLCC 2013	Basket level charge control in LLCC 2016
Ethernet	RPI – 11.5%	Starting adjustment: -9% CPI – 13.75%
TI	RPI + 2.25%	Starting adjustment -7.75% CPI – 12.25%

32 However whilst the timeframe for migration remains uncertain, BT will need to continue to undertake sufficient maintenance investment in TI to ensure that it can meet both demand and quality requirements.

33 Para 4.8 of Ofcom LLCC 2012 Consultation

Note, we present a single control for each of Ethernet and TI, but recognise there are a number of products and sub-caps beneath this.

4.49 However, this change in policy position reduces customers' incentives to migrate to Ethernet products. This results in:

- relatively high prices for remaining customer on the TI platform as the cost of the platform is divided amongst a smaller customer base;
- BT being required to run two platforms for longer, incurring dual running costs;
- BT continuing to maintain and invest in a legacy platform which has the scope to offer far lower efficiency gains than the alternative Ethernet platform where the potential for frontier shift efficiency gains is likely to be higher;
- a reduced signalling to users of the TI platform that it is reaching its end of life; and
- the absence of incremental economies of scale which would be available to leased line users if TI volumes were migrated to the Ethernet platform.

4.50 The symmetric efficiency target being applied to both TI and Ethernet products will slow down migration towards Ethernet products. This will result in BT running dual platforms for longer - continuing to maintain and invest in a legacy platform which has the scope to offer far lower efficiency gains than the alternative Ethernet platform where the potential for future efficiency gains is likely to be higher. This is dynamically inefficient and leads to average costs above those that would occur otherwise.

4.51 Furthermore this approach reduces signalling to users of the TI platform that it is reaching its end of life, prompting customers to remain on a legacy platform which offers far lower benefits than the more technologically advanced Ethernet platform.

4.52 The result of having efficiency targets which are too high and also symmetric will be to reduce dynamic efficiency incentives. Take-up of new technology which will both reduce BT's costs and therefore regulated prices over time and enable innovation that increases the efficiency of an economic system will be hindered by Ofcom's proposed approach. Achieving dynamic efficiency requires setting access prices (and therefore efficiency targets) that provide the right incentives to invest in, and migrate to, a new technology. It requires taking a multi-period view as opposed to focusing on cost and price alignment for each individual period.

4.53 In summary, the approach to assessing efficiency that has been proposed by Ofcom may not result in the appropriate allocation of resources and may dampen dynamic efficiency incentives. Therefore, it is important that Ofcom cross-checks its management analysis against other efficiency benchmarks. This is considered in the next chapter.

Conclusions

4.54 By setting an inappropriate efficiency target, Ofcom is potentially undermining incentives for dynamic efficiency. By placing its focus on short term price-cost alignment, Ofcom is in effect looking backwards towards rate of return regulation and the deficiencies of this approach. Rate of return regulation was replaced with incentive based regulation (RPI-X) to place greater incentives on the regulated firm to allocate resources efficiencies and to drive dynamic efficiency. It was recognised that consumers would also benefit from this as most closely mimics what would occur in a competitive market.

4.55 This has been recognised by other regulatory authorities and it has been found that regulated firms often outperform the efficiency targets within the charge control. However, this is not perceived as a problem as prices are moving in the right direction and, in any case, the reductions in unit costs are then factored into the starting prices in the next charge control. So, the consumer benefits from lower prices in the next charge control whilst the regulated firm is incentivised to work hard to outperform the target as it will be able to keep any additional profit – albeit for a short period of time.

4.56 It is recognised that both price and non-price signals may be used to facilitate dynamic efficiency, in this case through encouraging the migration of customers from legacy TI services onto the Ethernet platform. If the efficiency target is inappropriately set, leading to inappropriate prices then there will likely be a wider market distortion and reduced dynamic efficiency.

4.57 The symmetric efficiency target being applied to both TI and Ethernet products will slow down migration towards Ethernet products. This will result in BT running dual platforms for longer - continuing to maintain and invest in a legacy platform which has the scope to offer far lower efficiency gains than the alternative Ethernet platform where the "frontier shift" efficiency is likely to be higher. Furthermore it reduces signalling to users of the TI platform that it is reaching its end of life, prompting customers to remain on a legacy platform which offers far lower benefits than the more technologically advanced Ethernet platform.

4.58 The result of having efficiency targets which are too high and also symmetric will be to reduce dynamic efficiency incentives. Take-up of new technology which will both reduce BT's costs and therefore regulated prices over time and enable innovation that increases the efficiency of an economic system will be hindered by Ofcom's proposed approach. Achieving dynamic efficiency requires setting access prices (and therefore efficiency targets) that provide the right incentives to invest in, and migrate to, a new technology. Dynamic efficiency is fundamental for a country's competitiveness and growth.

5. Approaches to efficiency estimation

5.1 In this chapter we set out other approaches to efficiency estimation that could have been considered by Ofcom as part of the LLCC. These are mostly drawn from the academic literature. For each approach, we discuss the advantages and disadvantages and comment on the applicability of the approach to the LLCC, noting that in practice, data limitations often constrain the options that are available for a particular efficiency estimation exercise.

Catch-up versus continuing efficiency

5.2 There is usually a distinction between assessing comparative efficiency (which is used to calculate the catch-up efficiency) and the frontier shift (which provides the efficiency time trend, sometimes referred to as 'continuing efficiency'). Comparative efficiency refers to BT's efficiency relative to the sample or the efficiency frontier and is used to calculate the level of catch-up required for BT to be at the comparative level set by Ofcom. Frontier shift efficiency is the time trend of efficiency or the rate of change of the efficiency frontier over time.

Product specific versus firm level efficiency

5.3 Efficiency analysis may be product specific, usually assuming a constant technology type or it may be conducted at the operating division or firm level. Product specific efficiency is likely to be less than for firm level efficiency since it does not capture efficiencies that can be achieved from changing technology – for example by moving from legacy to internet protocol ("IP") network, which would lead to a shift in product volumes from TI to Ethernet.

Top down versus bottom-up efficiency analysis

5.4 There are two main types of efficiency analysis:

- **Bottom-up methodologies**: Studies of the capital and opex costs being incurred by the firm and the drivers of these costs. Expert opinion, benchmarking, engineering studies and other working methods are used to identify those areas of the business where specific cost savings may be possible.
- **Top-down methodologies**: Cost benchmarking exercises, typically using statistical analysis or linear programming, that measure the relative efficiency against a sample of comparator companies or divisions within a firm. Efficiency maybe expressed as being relative to other companies or to an efficient frontier.

5.5 In practice, the two approaches are usually viewed to be complimentary with bottom-up analysis, which may be more specific to a particular group of costs or product providing a cross-check on top-down estimates which tend to be estimated at the divisional or firm level.

Top down efficiency estimation

5.6 There are four main approaches that can be considered for efficiency estimation. These are described below.

Performance ratios

5.7 *Performance ratios* are ratios such as unit costs. Whilst simple to calculate and requiring less data than many other approaches, these ratios do not take into account multiple cost drivers, non-controllable cost drivers (outside of management control) and volume effects.

Productivity models

5.8 *Productivity models*, e.g. total factor productivity (TFP) are based upon standard growth theory. These are typically econometric models, based upon growth functions, which analyse the change in productivity of the network. Simpler measures can be calculated using indexation based on the rate of change of input and output indexes.

5.9 These models seek to estimate underlying productivity change, independent of inflationary effects. Simpler methods require less information to be collated but the efficiency level is more likely to include non-efficiency factors.

5.10 These models do not account for movements of the firm towards or away from the frontier. However, given the frontier is defined by the average of firms in any year, these movements may be expected to average out over time. These models provide information on the rate of change of productivity levels over time, but do not provide information on the comparative efficiency of a particular firm. Therefore, it is most useful for assessing ongoing efficiency as opposed to catch-up efficiency.

5.11 *Partial productivity models*, which take into account only a subset of inputs, are commonly used by regulators to assess efficiency changes. These measures are calculated by deflating nominal operating expenditure to its real value and then dividing by the appropriate measure of output, or cost driver. Since volume effects can lead to output increasing by more than costs without necessarily implying higher efficiency, these measures are usually adjusted for volume effects.

5.12 Real unit operating expenditure (RUOE) is a partial productivity measure that includes both productivity improvements and input price inflation (relative to the measure of inflation used to deflate the nominal cost trends). The RUOE time trend also includes both catch-up efficiency and continuing efficiency.

Parametric frontier models

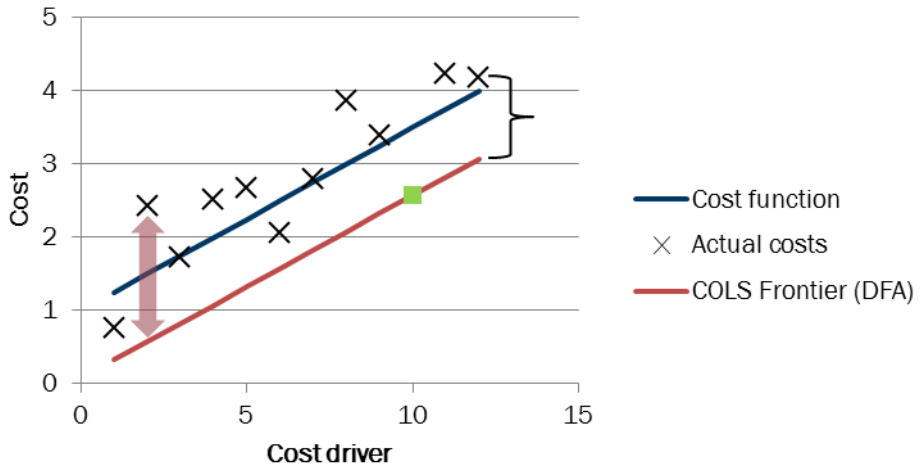
5.13 *Parametric frontiers* are estimated using econometric techniques, namely, regression. Regression analysis is used to estimate economic relationships and to test economic theories. It can be used to assess the mathematical relationship between explanatory variables (asset characteristics, the cost of labour and materials, topology, etc.) and the variable of interest.

5.14 There are two stages in constructing a parametric frontier:

- First, regression analysis is used to estimate a cost function. The estimated coefficients measure the numerical impact of each driver on costs. Regression analysis requires the imposition of a particular functional form for the cost function. The cost function must also be compatible with economic theory and industry factors, and consistent with the data.
- Second, the cost function is developed into a frontier. The frontier can be determined using deterministic frontier analysis ("DFA"), or stochastic frontier analysis ("SFA"). Efficiency is measured relative to this frontier.

5.15 *DFA* involves applying a technical transformation to the estimated cost functions. The most common DFA technique is known as corrected ordinary least squares (COLS). Conceptually, COLS measures inefficiency as the part of the cost incurred by a unit, which *cannot* be explained by the level of output, input prices, or cost drivers. Graphically, this amounts to defining the frontier by 'shifting the cost function' down until all but one unit lies above it, and then measuring each unit's efficiency relative to this frontier. [34] This is illustrated in Figure 5-1 below.

Figure 5-1: Illustration of DFA analysis



Note: The one unit operating on the frontier (shown in green) is assumed to be 100% efficient, while the others are not. The vertical distance between each unit and the frontier, reflects its inefficiency.

5.16 The principal advantage of DFA/COLS is that it takes account of differences in the levels of output, input prices, and cost shifters, before measuring inefficiency. This avoids mischaracterising units as inefficient, simply because they need to do more maintenance work, or face higher input prices, or have other unavoidable characteristics that increase their costs.

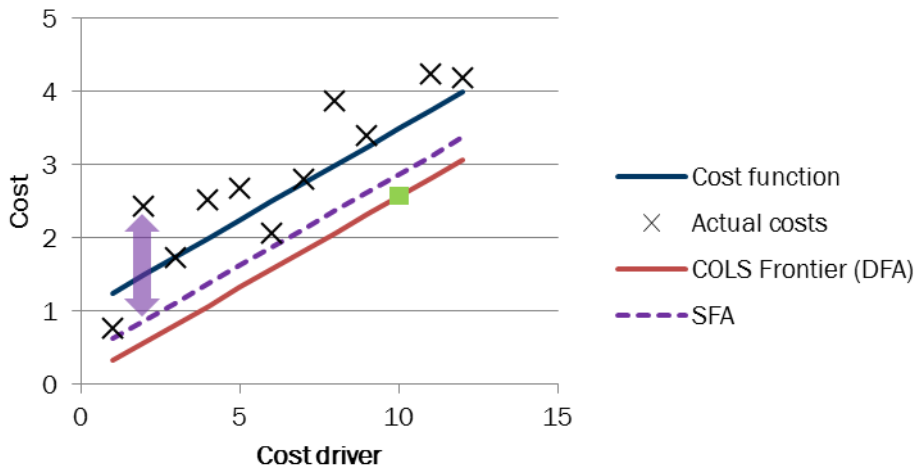
[34] Specifically, an efficiency score is constructed from the residuals of the regression. An efficiency score of 0.8 is equivalent to an inefficiency score of 0.2. They both indicate that actual costs should be reduced by 20% to attain the efficient frontier.

5.17 The principal disadvantage of DFA is that it attributes the *entire* difference between a unit's observed cost, and the frontier, to inefficiency[35]. DFA does not distinguish between chance events and other errors, and genuine inefficiency and therefore tends to overstate the level of inefficiency. One can allow for this by adjusting the COLS model's efficiency estimates. Graphically, this amounts to translating the COLS frontier vertically upwards, so as not to attribute the entire residual to inefficiency.

5.18 SFA is an alternative method to DFA that allows explicit estimation of the relative importance of error and efficiency. SFA allows an efficient frontier to be created that controls for any random errors in the data. SFA has previously been used by Ofcom to estimate BT's efficiency.

5.19 Graphically, SFA results in a frontier that is higher than the COLS and efficiency scores that are therefore lower than under DFA. This is shown in Figure 5-2 below.

Figure 5-2: Illustration of SFA analysis



Note: The vertical distance between each unit and the stochastic frontier reflects its inefficiency.

35 This difference is represented by the red arrow in Figure 5-1.

5.20 The principal advantage of SFA is that it can be used to distinguish between chance events and genuine inefficiency. SFA has a number of disadvantages:

- It requires assumptions on the distributional form of the inefficiency component. The most popular distributional forms used in this setting are the half-normal distribution, the truncated normal distribution, and the exponential distribution. Alternative assumptions could lead to different conclusions about the scope for efficiency changes. It is important, therefore, to assess which distribution best fits the data. If the data does not allow one to choose which form is appropriate (and we note that there is no statistical test to choose between the exponential distribution and the other two), one would need to carry out sensitivity analysis to estimate the degree of uncertainty created by this problem.
- In general, one cannot assume that the decomposition of the error term is correct. Even if there are no errors in efficiency measurements, some inefficiency may be wrongly regarded as "noise". That is, in separating the effect of random occurrences on costs from the effect of inefficiency, some inefficiency might be wrongly classified as random occurrences. This would tend to underestimate the level of economic inefficiency.
- Where there are outliers that appear unusually efficient, perhaps because of measurement error, the residual can be mistakenly attributed to random disturbances. This problem can be particularly serious in small samples.
- When data is available for one time period only, SFA cannot be used to estimate the degree of inefficiency of individual units. This is because these individual estimates are biased when single-period data are used, only their average is correct. However, SFA could still be used to inform the assessment of what proportion of the COLS residuals may actually be sensibly attributable to inefficiency *on average*. This problem does not arise when multi-period data is available for each firm.

5.21 SFA may be applied to estimate the efficient frontier based on inter-firm data, e.g. from BT and the US Local Exchange Carriers ("LECs"), or intra-firm data, e.g. from BT's exchange areas or operating units, provided information is available at that level.

5.22 There is a large body of literature on the potential errors associated with parametric models and the methods for overcoming these issues. We do not seek to summarise these here. However, when specified correctly, these types of models are typically viewed as producing the most robust estimates of efficiency and it is for this reason they tend to feature in a regulators tool kit.

Non-parametric models

5.23 Non-parametric methods establish an efficient frontier relating outputs to inputs without recourse to econometric estimation. Data Envelopment Analysis ("DEA"), which uses linear programming to determine the efficient frontier, is the most widely used approach in this category.

5.24 Each observation is benchmarked against the most efficient unit(s) in the sample. The most efficient unit (or units) is a real firm or unit, rather than a theoretical construct, as in SFA. DEA uses linear programming to generate all the possible input-output combinations, and then compares each firm to the best corresponding combination. Under DEA, a firm is classified as efficient if no other firm, or linear combination of companies, can produce more output(s) using less of any input. This means that the efficiency frontier is constructed from the 'envelope' of these linear combinations of inputs – hence the name of the technique.

5.25 The advantages of DEA include:

- it produces efficiency scores without the need to impose a particular functional form on the cost function; and
- it can be used with small data samples.

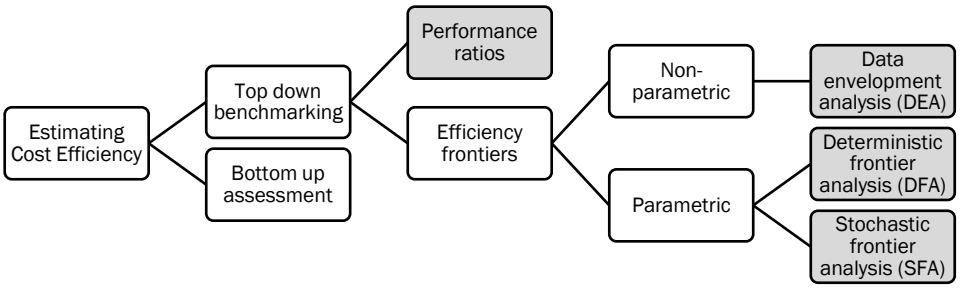
5.26 The disadvantages of DEA include:

- it cannot be used to quantify the impact of the various drivers of cost;
- it does not allow us to ascertain which drivers are significant: the selection of drivers that enter DEA is therefore subjective;
- efficiency estimates are sensitive to the choice of variables input into the model, and to whether one assumes there are economies of scale; and
- efficiency estimates are biased upwards in small samples, especially for extreme observations.

Summary of cost benchmarking methods

5.27 There is a wide range of cost benchmarking methodologies which may be used to estimate the efficiency of a firm. These vary in terms of simplicity, robustness and the ability to calculate catch-up efficiency separately from on-going efficiency. A selection of these methodologies is shown in Figure 5-3 below.

Figure 5-3: Cost benchmarking methods



5.28 In practice, the choice of which efficiency models to use depends on a number of factors:

- The extent to which it is possible to identify costs, cost drivers, input prices and output measures as well as the underlying cost function for parametric approaches.
- Availability of cross sectional data. For example, is it possible to obtain a sufficient number of data points on comparator companies or on divisions or operational units within a firm in order to reach the required number of degrees of freedom? Can information be obtained across both financial and non-financial variables?
- Availability of time series data. In order to calculate the time path of efficiency, time series data is required. Do sufficient data records exist, and on a consistent basis, to be able to construct a panel?
- Data quality and robustness. This will often depend upon the source of the data. Where data is being compared across companies, different measurement techniques may be used. For example, different accounting treatments or product definitions.

Conclusions

5.29 Whilst there are a large number of techniques for estimating efficiency that could be considered by regulatory authorities, including Ofcom, in practice the choice of techniques is likely to be limited by a number of factors and, in particular, the availability of a sufficient quantity of good quality data.

5.30 It is therefore not to be expected that Ofcom would undertake all types of analysis. However, whilst Ofcom purport to rely on a range of information sources, in our view Ofcom's analysis omits other widely-used techniques to estimate efficiency that could have been used for the LLCC. In particular, Ofcom does not appear to have applied a full range of top-down methodologies to estimate efficiency nor have they applied bottom-up techniques which could be used to cross-check conclusions emerging from top-down analyses.

6. Efficiency estimation by regulatory authorities

6.1 This section sets out the efficiency estimation methodologies that have been used by other economic regulators and previously by Ofcom and also provides efficiency benchmarks. Through this analysis, we demonstrate that Ofcom's approach to efficiency estimation in the current LLCC is more limited in scope than many other regulators as it does not consider measures of efficiency in other sectors or analysis undertaken by undertaken by regulators.

Ofcom's previous approaches to efficiency estimation in LLCC

6.2 In the two previous LLCCs, Ofcom considered a broader range of efficiency methodologies, using both bottom-up and top-down techniques.

Benchmarking analysis: Stochastic frontier analysis and productivity models

6.3 BT provided Ofcom with a series of report which used stochastic frontier analysis (SFA) to assess BT's cost efficiency relative to other operators[36]. The function was specified to include both operational and capital costs and consisted of a panel of data allowing for the time trend of efficiency (frontier shift) to be captured as well as BT's relative level of efficiency compared to the sample and the efficient frontier.

6.4 In earlier studies, BT was compared to the US LECs which replicated the approach which Ofcom had previously used[37]. However, when this data became unavailable, the sample group was instead formed of a selection of European incumbents and a selection of other incumbent operators where data was available. BT supplemented the SFA analysis with TFP analysis, calculated using both indexation and by using econometric techniques.

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36 BT has provided various reports to Ofcom on the efficiency of BT's regulated operations using SFA conducted by Deloitte. These were provided in 2008, 2009, 2010, 2012 and 2013. The most recent is Analysis of the Efficiency of BT's Regulated Options, Deloitte, September 2013.

37 NERA's analysis of the efficiency of BT's network operations, NERA, 2008.

6.5 The most recent SFA report was provided by BT to Ofcom in 2013 and neither party has made further updates to this. In the LLCC charge control, Ofcom placed greater weight on this analysis then it did in the WBA charge control where it had concerns over aspects of the modelling technique and the input data. However, the analysis was considered alongside other benchmarking evidence and the resulting efficiency factor in the charge control was very close to the results of the analysis – being set at 1.5% for TI.

Historical trend analysis

6.6 This represented analysis, based on management information, of the efficiency gains that were achieved and the components / operating cost types that were driving the gains. Ofcom calculated the average real unit cost change for components, holding volumes constant.

Management forecasts

6.7 Ofcom's previous analysis was limited to a review of sales, general and administrative ("SG&A") costs. These approaches allowed Ofcom to assess the catch-up component separately from the frontier shift component.

Efficiency rates used in the charge control

6.8 In the previous charge control, Ofcom set an efficiency rate of 1.5% for TI and 4.5% for Ethernet.

- This was mostly attributed to frontier shift as the analysis provided to Ofcom between 2009 and 2013 indicated BT was the most efficient operator within the sample group and that the cost frontier was moving at a rate of between 0% and 2.5% per year. In the most recent paper, the time trend was found to be constant in nominal terms[38]. Assuming that BT's relative inefficiency has not changed (so no catch-up is required) and the cost function remains constant – this implies that the appropriate efficiency factor would be equal to the rate of inflation.
- Some weight was also placed on Ofcom's bottom-up analysis and a review of Openreach and Wholesale specific cost trends which produced a range of 0% to 5%.

[38] BT has provided various reports to Ofcom on the efficiency of BT's regulated operations using SFA conducted by Deloitte. These were provided in 2008, 2009, 2010, 2012 and 2013.

Efficiency estimation approaches used by other UK regulatory and competition authorities

6.9 The application of an incentive-based charge control requires the measurement of efficiency. As such, the UK regulatory authorities all undertake a review of the efficiency factor as part of their regular charge control processes. In addition, the CMA and the Competition Appeals Tribunal have also reviewed efficiency estimations and undertaken their own analysis as part of regulatory appeals and this provides another set of approaches against which Ofcom's approach can be compared.

6.10 Charge control models are typically seeking to achieve the same outcome – that is to set a cost based cap on prices whilst incentivising a firm to improve its efficiency. However, whilst this objective is largely consistent, the design of charge control models differs between regulatory authorities and over time. This makes the comparison of efficiency estimates between regulators more difficult, as it must be ensured that there is a like for like comparison – for example that input price, volume effects and inflation are not included within the efficiency term.

Recent regulatory precedent

6.11 Table 6-1 below provides a summary of the efficiency estimation approaches that have recently been used by other economic regulators and the CMA in the UK.

Table 6-1: Summary of selected typical efficiency estimation approaches

Charge control	Principal approaches
WATER England/Wales Ofwat PR14 2015-2020	DFA; Panel COLS & Random Effects Translog for both water and wastewater.
WATER Northern Ireland UR PC15 2016-2021	COLS; catch-up analysis based on English comparators
ELECTRICITY DIST GB Ofgem RIIO-ED1 2010-2015	DFA, performance ratios COLS, pooled, with 3 years of historical data on 14 DNOs, and benchmarking against the upper quartile
ELECTRICITY TRANS GB Ofgem RIIO-ET1 2010-2015	Bottom-up analysis
ELEC DIST & TRANS Northern Ireland UR RP5 (**CC Determination**) 2012-17	Econometric analysis Review of business plans of close comparators (GB DNOs)

Charge control	Principal approaches
GAS DIST GB Ofgem RIIO-GD1 2013-2021	DFA of overall costs and disaggregated costs; Log-log model using OLS and panel time fixed effects approach; requirement to close 75% of efficiency gap
RAIL INFRASTRUCTURE UK ORR PR13 2014-2019	DFA and SFA of total maintenance and renewal costs with panel data; top-down benchmarking COLS, Random effects (with the random effects measuring efficiency), time-varying SFA
RAIL INFRASTRUCTURE London PPP Arbiter 2010-2017	TFP estimates from industries performing similar activities, and recent regulatory precedent
AIRPORTS UK CAA Q6 2014 -2021	TFP, bottom-up analysis for catch-up efficiency.
POST UK Postcomm 2006-2010	DEA, SFA, DFA (comparison of sorting offices) Bottom-up analysis (business plan review)

Sources:

Ofwat PR14 Final Determinations

Utility Regulator's PC15 Determination

RIIO-T1/GD1: Real price effects and ongoing efficiency appendix, Ofgem, December 2012

NIE CC Price Determination UR5

ORR PR13 Determination

PPP Arbiter Final Cost Directions, March 2010

CAA Q6 Price Control Review

Postcomm 2005 review

6.12 As Table 6-1 above shows, regulators in the UK typically apply a variety of techniques to estimate the efficiency factor. In the majority of cases there is a combination of top-down and bottom-up techniques applied. We note, more generally, that:

- In industries where they are a number of regional operating companies, such as energy and water, regulators use this information to undertake frontier analysis with a panel data set that allows for the estimation of both catch-up efficiency and continuing efficiency. Typically, this analysis includes consideration of both operational and capital costs and is usually undertaken at the regulated business level – following the definition of the business used in the regulated accounts.
- In industries where there are fewer companies, parametric analysis continues to be employed. However, this has typically focused on using information from the firm being regulated and constructing a data set with information on operating units of that firm. This is the case for the analysis undertaken by Postcomm for Royal Mail.
- In sectors where there are fewer regulated companies, regulators are more likely to analyse efficiency trends in other sectors. For example, ORR[39] and CAA[40] have both commissioned reports to analyse the real unit operating efficiency (RUOE) across regulated industries over time.
- Simple benchmarking techniques are not widely employed by regulators. We note that it is possible to purchase datasets with simple benchmarks of overhead functions, for example. However we have not found evidence of regulators using these.
- Where possible, regulators (and competition authorities) place significant weight on comparators within the industry. This is especially relevant in the case of industries in the UK with devolved regulatory oversight (e.g. NI Utility Regulator can look to GB regulatory decisions). However, there is also precedent for cross-sector efficiency reviews.

39 Productivity and unit cost change in UK regulated network industries and other UK sectors: initial analysis for Network Rail's periodic review, a report for the ORR, Reckon, 2011.

40 Scope for efficiency gains at Heathrow, Gatwick and Stansted airports, CEPA, April 2013.

- As we explain below, the CMA/CC typically assess the full range of evidence presented to it when making its regulatory determinations, as well as introducing new analyses where relevant and proportionate. The CMA/CC does not have a single 'preferred' approach to assessing efficiency and instead sees virtue in relying on a variety of approaches. The CC also has recently recognised that "*no benchmarking analysis or cost assessment method will be perfect, and there will always be limitations in any approach"*[41].

6.13 Another important pattern we would highlight is in most cases the two components of efficiency – catch-up and continuing efficiency – are quantified separately. This increases the transparency of the estimation and allows for meaningful comparisons to be made to other sectors and between companies. Whilst 'catch-up' efficiency is typically bespoke for each firm, and varies between sectors depending on the differentials in efficiency between firms, the concept of continuing efficiency is more general and relates to the pace of productivity improvement in the industry as a whole.

CC review – Bristol Water

6.14 Ofwat's PR09 price review set charges for the period 2010 to 2015 for the water industry. Bristol Water plc disputed the determination and the matter was referred to the (as was) Competition Commission for its determination[42]. In making its determination the CC assessed and tested the full range of evidence presented to it. In respect of continuing efficiency the CC stated: "*We started by looking at recent trends in productivity growth (as measured by the year-on-year change in output per hour) using the ONS electricity, gas and water supply index. We compared these trends with productivity growth in manufacturing industries and the overall economy*". The CC also examined the 'frontier' of the water industry over time as well as EU KLEMS TFP data.

41 Bristol Water Plc Price Determination, CMA, July 2015.

42 Ofcom Price Review 2009.

6.15 The CC's determination[43] explains that:

- With respect to efficiency, capex and opex were considered separately in PR09.
- CC agreed with Ofwat that industry capex efficiency should be set at 0.4% per year. Ofwat's determination of this figure (set out in PR09) is based on the median of adjusted expenditure forecasts collected using a 'cost base comparative tool'.
- CC agreed that 'base' opex efficiency should be set at 0.25% per year for continuing (frontier) improvement. Ofwat's determination of continuing efficiency was (on Ofwat's own admission) not a mechanistic process and relied on several types of evidence including advice from consultants, firms' own business plans and general productivity trends (the latest available information on forecast changes in input prices, particularly labour). Bristol Water argued that the reasoning for the 0.25% figure was not transparent and therefore inconsistent with regulatory good practice. The CC examined productivity trends in certain classes of industry and other reports and said "*in our provisional findings we assumed a productivity improvement of 0.9 per cent a year over PR09*". This, combined with the effect of industry-specific cost inflation factors[44], resulted in the CC calculating an efficiency challenge of 0.5%, adjusted downward to 0.25% (equal to Ofwat's figure) on the basis of various other subjective qualitative factors (such as the need for a conservative approach in light of uncertainty).
- Ofwat's determination of catch-up efficiency was based on assuming a firm will close 60% of the assessed efficiency gap to the frontier performance by 2014-15 with equal improvement steps in each year. This results in firm-specific challenges. Bristol Water argued in particular that Ofwat had not sufficiently adjusted for Bristol Water's firm-specific factors and there were statistical problems with the econometric modelling more generally. Ultimately the CC was satisfied that Ofwat's approach was reasonable. Ofwat's methodology resulted in a 'headline' figure of 0.92% per year for relative (catch-up) efficiency but there was a range of 0% to 2.9% depending on the firm.

43 See Determination on a reference under section 12(3)(a) of the Water Industry Act 1991, Competition Commission, August 2010.

44 Costs are set by reference to the RPI index. The methodology used accepts that the industry's inflation exposure is not equivalent to RPI. The necessary adjustment (estimated at 0.4% by the CC) is netted off from the efficiency challenge.

CC review – NIE

6.16 The Northern Ireland Authority for Utility Regulation (the Utility Regulator (UR)) issued its RP5 charge control determination for Northern Ireland Electricity Limited (NIE) in 2012. NIE referred this to the CC. In making its determination, the CC assessed and tested the full range of evidence presented to it as well as other regulatory precedent. In respect of continuing efficiency, the CC placed considerable weight on submissions by GB DNOs as the CC considered them particularly relevant comparators.

6.17 The CC determined[45] productivity improvements at 1% per year for each of opex and capex. This was based on a number of factors including:

- recent regulatory decisions, which indicated a range of productivity assumptions of between 0.7 and 1.2 per cent for capex and between 0.53 and 1.0 per cent for opex;
- EU KLEMS data, overall, we considered that the aggregate EU KLEMS data could support a range of estimates of productivity of between 0.5 and 1.5 per cent. Depending on time period, exact metrics etc. BUT the CC considered for opex that measures of labour productivity may be better than TFP as NIE's opex costs are largely labour costs; and
- RIIO-ED1 business plan submissions for GB DNOs. Most of the GB DNO business plans contained an assumption that overall cost efficiency could be improved at 1 per cent a year.

45 Northern Ireland Electricity Limited price determination, Competition Commission, March 2014.

CEPA

6.18 In 2011, CEPA for CAA assessed the scope for efficiency gains at Heathrow, Gatwick and Stansted airports[46]. CEPA selected the following methodologies in this assessment:

- **Labour productivity**. In the case of the airports studied, one example metric is passengers per man-year. CAA note that labour productivity metrics cannot be viewed in isolation because of capital substitution effects.
- **RUOE trends**. This 'partial' productivity measure which does not reflect all inputs. RUOE measures typically capture both frontier and catch-up efficiency and input price inflation. CEPA notes that RUOE measures, in particular, are sensitive to volume effects and this potentially needs to be adjusted for when comparing between sectors. CEPA do this by estimating cost elasticities.
- **Total Factor Productivity**. CEPA note that "*if the sample of firms is both: (i) large; and (ii) random, it seems reasonable to expect that the efficiency improvement should be largely driven by frontier shift*". CEPA use EU KLEMS data.
- **LEMS cost measure**. The LEMS measure is based on an analysis of labour (L), energy (E), materials (M) and services (S). This unit cost measure broadly captures costs excluding capital costs.
- **Output price indices**. The use of output price indices is based on the premise that they will reflect the changes in the price of inputs and the change in TFP.

6.19 CEPA ultimately used all these measures, but the key productivity metric for analysis was the number of passengers per man-year.

46 Scope for efficiency gains at Heathrow, Gatwick and Stansted airports, CEPA, April 2013.

Reckon (2011)

6.20 In 2011, Reckon for ORR assessed productivity and unit cost changes across UK regulated networks. This focused on two measures:

- **RUOE**. Recon drew attention to the fact that results are sensitive to the output measure chosen for each industry.
- **TFP composite benchmarks**. Reckon noted that the TFP composite benchmarks are based on estimates of what is known as "value added" total factor productivity growth. The concept of "value added" has a role in macroeconomic studies but seems less useful in making projections above the costs of specific companies. Estimates of total factor productivity growth on a "gross output" basis are more common in microeconomic studies, especially ones that concern the productivity improvements achieved by specific companies.

6.21 Reckon drew attention to some concerns with TFP and potential measurement errors (they consider, for example, that EU KLEMS outputs are subject to measurement error). Reckon stated: "*Rather than collating estimates of productivity growth, ORR could focus on estimates of changes over time, relative to the RPI, in measures of unit costs and in output price indices. Such estimates should capture the combined effects of historical productivity growth and changes, relative to the RPI, in input prices*".

Approaches used by other telecommunication regulatory authorities

Whilst the US LEC dataset was available, this was commonly used by telecommunication regulatory authorities to estimate relative efficiency of incumbent telecoms operators. For example, this approach was used in Ireland, Netherlands, New Zealand and Australia amongst others. However, once this dataset ceased to be available, this necessitated alternative approaches to be considered. Our review has suggested that a range of approaches are now considered – including both bottom-up and benchmarking analysis.

Australia – Telstra

6.22 The ACCC is currently in the process of reviewing the markets for a number of fixed line services and the wholesale ADSL service as part of its final access determination.

6.23 Telstra asked NERA to assess Telstra's opex efficiency "*relative to an appropriate international benchmark*"[47]. NERA refer to previous studies which have shown BT to be efficient[48]. The principal comparison is unit costs across four services[49].

47 The Comparative Efficiency of Telstra, NERA, April 2015.

6.24 NERA considered the Australia telecoms market to have broadly similar conditions to that of the UK; the main difference being in the density and dispersion of population. NERA noted the limitations of benchmarking (e.g. cost allocation issues) and in particular, declined from drawing conclusions on relative efficiency at service level. However, NERA did not that it considered Telstra to have a very similar efficiency level to BT, based on unit cost analysis.

6.25 We note that in Australia, for the charge control period 2006 to 2014, basic line rental services to businesses was subject to a price growth cap of CPI. In other words, there was no efficiency target applied[50].

Ireland – Comreg

6.26 The Commission for Communications Regulation in Ireland ("Comreg") consulted on Wholesale Broadband Access in July 2010[51]. It stated that its "*preliminary common assumption*" was a general efficiency factor of 3% per year.

New Zealand – Commerce Commission

6.27 In July 2015, New Zealand's Commerce Commission published a draft determination on Chorus' unbundled copper local loop service[52]. The Commerce Commission stated:

> *In relation to labour-related opex, our further draft decision is also to not allow for an additional adjustment for productive efficiency gains for opex related labour at this stage. The reason is that there is no convincing evidence to show what the adjustment for productivity efficiency should be, and we note that productivity efficiency gains could be greater or smaller than the productive efficiency gains already included in the LCI for all industries.*

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48 A paper NERA cite (Analysis of the Efficiency of BT's Regulated Options, Deloitte, September 2013) used proprietary information gathered from a set of operators in Europe and outside to benchmark BT's efficiency.

49 Unconditioned local loop service (ULLB1-3), Wholesale line rental (WLR), Fixed originating access service & Fixed terminating access service (PSTN) and Wholesale service (WADSL). Volume measured in either lines, minutes or rentals.

50 Report on Telstra's retail price controls, May 2014.

51 Wholesale Broadband Access: Consultation and draft decision on the appropriate price control, Comreg, July 2010.

52 Further draft pricing review determination for Chorus' unbundled copper local loop service, Commerce Commission, July 2015.

6.28 Some respondents to the consultation had submitted that efficiency and productivity gains in New Zealand should be possible over a five year period – and had proposed a figure of 5% per year. However, the Commerce Commission argued that the use of the relevant labour cost index in this context reflected some degree of productive efficiency gains and it was not able to determine with any degree of confidence there should be an additional adjustment.

Netherlands – ACM

6.29 The ACM (competition authority) has now taken over from OPTA as the regulator of the telecommunications sector. ACM is currently consulting on the market review of leased lines. This is expected to be influenced by the outcome of the European Commission review into wholesale local access provided at a fixed location in the Netherlands – phase II of which commenced in April 2015.

6.30 As part of the previous leased line charge control (2012), OPTA developed a model to calculate the value of the efficiency factor. There is limited documentation on the setting of the efficiency factor within the charge control – although there is note that efficient costs were based on analysis of KPN network which indicates a bottom-up style approach may have been used. However, the market review and subsequent charge control was subject to an appeal and therefore the final value was, in part, driven by the dispute proceedings as opposed to purely by the model itself.

6.31 For the WLA market, ACM proposed a mixture of safeguard caps and cost-orientated charge controls on the various products. Where a charge control was proposed, it was on the basis of a DCF model using cost estimates from KPN and allowing KPN to make its rate of return. There is no discussion of an efficiency factor being imposed on KPN in these charge controls. The safeguard cap is set based on KPN's embedded direct costs, increasing by CPI each year. There is no efficiency adjustment[53]. However, it should be noted that the appropriateness of these remedies are currently under review by the European Commission[54].

53 Commission Decision concerning Case NL/2013/1439: Implementation of the FttH ODF access tariff regulation in the Netherlands.

54 Wholesale local access provided at a fixed location in the Netherlands Opening of Phase II investigation pursuant to Article 7 of Directive 2002/21/EC1 as amended by Directive 2009/140/EC.

Spain – CMT

6.32 The Spanish regulator, the CMT (Comisión del Mercado de las Telecomunicaciones), published the results of its market review of the wholesale markets for terminating and trunk segments leased lines on 11 April 2013. In light of the results of its review of relevant markets, the CMT decided to impose a set of regulatory remedies in these markets, documented by the Commission in its Decision concerning cases ES/2013/1425 and ES/2013/1426.

6.33 Telefonica was found to be dominant in some, but not all, of these markets. For terminating segments of leased lines, price regulation was imposed. This was cost orientation for traditional leased lines and retail minus for Ethernet leased lines[55]. Cost orientation was assessed based on a LRIC model that was developed for CMT. There is no explicit discussion of an efficiency adjustment in the model.

Survey of recent regulatory determinations on efficiency factors

6.34 As noted above, whilst estimates of 'catch-up' efficiency are typically bespoke for each firm, and vary between sectors depending on the differentials in efficiency between firms, the concept of frontier shift is more general and relates to the pace of productivity improvement in the industry as a whole.

6.35 In this subsection, we set out some benchmarks relating to frontier shift findings in the context of UK regulation.

Recent UK regulatory precedents

6.36 Table 6-2 below sets out the (annual) frontier shift factors used in recent regulatory decisions and determinations.

Table 6-2: Summary of selected determinations

Charge control	Frontier shift
WATER, England/Wales Ofwat PR14, 2015-2020	Opex: 0.25% - 0.38%
WATER, England/Wales Ofwat PR09*, 2010-2015	Capex: 0.4% Opex: 0.25%
WATER, Northern Ireland UR PC15, 2016-2021	Opex: 0.9% Capex: 0.6%
ELECTRICITY DIST, GB Ofgem RIIO-ED1, 2010-2015	Opex: 1.00%

55 *Resolución por la que se aprueba la revisión de precios de la oferta de referencia de líneas alquiladas de Telefónica de España, S.A.U. y se acuerda su notificación a la Comisión Europea y al Organismo de Reguladores Europeos de Comunicaciones Electrónicas (ORECE) (AEM 2013/237)*.

Charge control	Frontier shift
ELEC DIST & TRANS, Northern Ireland UR RP5, 2012-17	Opex: 1.0% Capex: 1.0%
ELECTRICITY TRANS, GB Ofgem RIIO-ET1, 2010-2015	Opex: 1.00% Capex/Repex: 0.7%
GAS DIST, GB Ofgem RIIO-GD1, 2013-2021	Opex 1.0% Totex 0.8%
GAS TRANS, GB Ofgem RIIO-T1, 2013-2021	Opex: 1.0%
RAIL INFRASTRUCTURE, UK ORR PR13, 2014-2019	Opex: 1.0%
RAIL INFRASTRUCTURE, London PPP Arbiter, 2010-2017	Opex: 1.0%
AIRPORTS, UK CAA Q6, 2014 -2021	Opex: 1.0%
Post, UK Postcomm 2006, 2006-2010	Opex: 3.00%

Note: Controls with (*) were subject to CC determination. This table summarises the CC determination in those cases.

6.37 As noted previously, there is significant precedent for cross-sector reviews to inform charge controls. A number of regulators commissioned reports which analysed cost performance efficiency rates across sectors. These analyses were considered in the setting of some of the efficiency factors quoted above. Below we present some of the key findings from those surveys.

CEPA (2013)

6.38 In 2013 CEPA for CAA estimated that there has been an average real unit operating expenditure efficiency gain of 1.96% per year across its sample of regulated industries, taking into account volume effects. Table 6-3 below summarises CEPA's findings.

Table 6-3: Average RUOE efficiency, % per annum

Comparator	Period	Average RUOE efficiency (% p.a.)
Water – England and Wales	1992/3 - 2010/11	1.30%
Water – Scotland	2002/03 - 2010/11	2.10%
Sewerage – England and Wales	1992/3 - 2010/11	0.20%
Sewerage – Scotland	2002/03 - 2009/10	5.30%
Rail	2002/03 - 2009/10	3.10%
Electricity Transmission	1992/3 - 2010/11	4.90%

Comparator	Period	Average RUOE efficiency (% p.a.)
Electricity distribution	1992/3 - 2009/10	2.50%
Gas Transmission	2002/03 - 2009/10	2.90%
Gas distribution	2006/07 - 2009/10	2.10%
Airports - UK designated	1997/98 - 2011/12	-1.20%
Airports - UK other	2000/01 - 2011/12	0.30%
Airports - non-UK	2000/01 - 2011/12	0.00%
Range		-1.2% to 5.3%
Average		**1.96%**

Source data: CEPA for CAA, 2013.

6.39 CEPA also surveyed frontier shift targets across a range of sectors. Table 6-4 below summarises CEPA's findings.

Table 6-4: Frontier shift estimates

Regulator	Cost type	Frontier shift target (% p.a.)
Airports, GB: CAA, 2008-13	Opex	1%
Airports, Ireland CAA, 2010-14	Totex	2.5% (both)
NATS, GB CAA, 2011-15	Opex	1.25%
Rail, GB ORR, 2008-13	Opex	1.00%
Elec dist., GB Ofgem, 2010-15	Opex	1.0%
Gas dist., GB Ofgem, 2013-21	Opex	1.0%
Elec transmission, GB Ofgem, 2013-21	Opex	1.0%
Water/wastewater, Eng./Wales Ofwat, 2010-15	Opex	0.25%-0.38%
Telecoms, GB Ofcom, 2009-14	Opex	2%

Source data: CEPA for CAA, 2013.

Reckon (2011)

6.40 Reckon also assessed RUOE growth rates across a range of sectors. Table 6-5 below summarises Reckon's findings.

Table 6-5: Summary of growth rates in RUOE (average annual percentage change)

Sector	Oxera (2008)	Reckon (2011)	Weighted average over period
GB electricity distribution	-4.0%	4.0%	-2.7%
National grid electricity distribution	-4.9%	2.5%	-3.6%
England and Wales water	-1.8%	0.2%	-1.4%
England and Wales sewerage	-1.7%	-1.2%	-1.6%
Scottish Water	-8.8%	3.3%	-1.9%
Scottish Sewerage	-14.3%	1.3%	-5.4%
Average	**-5.9%**	**1.7%**	**-2.8%**

Source: Reckon (2011)

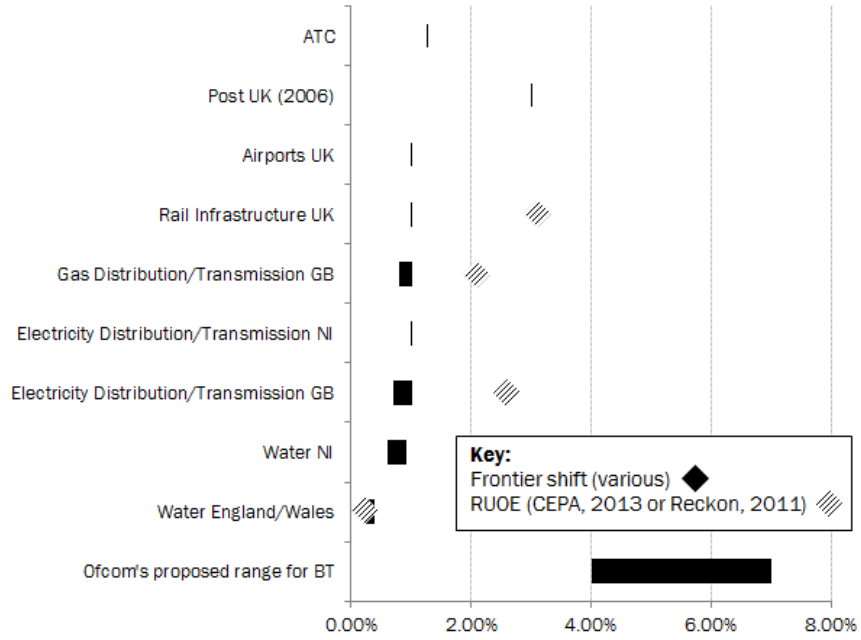
6.41 These are measure of cost change, rather than productivity change, and may capture other factors aside from efficiency including input price changes.

Summary

6.42 Figure 6-1 below summarises the sample of relatively recent determinations of continuing efficiency discussed in this report. The figure also includes industry estimates of RUOE from both CEPA (2013) and Reckon (2011). For reference, we also show the range suggested by Ofcom[56].

56 On assumption that range relates primarily to frontier shift.

Figure 6-1: Summary of recent determinations



Note: continuing efficiency as applied to opex, capex or totex.

6.43 Figure 6-1 shows that the general magnitude of continuing efficiency is in the range of 0 to 2%. This is consistent with, for example, CEPA's survey which found a range of 0.25% to 2.00%, as well as the more general observation of low productivity growth in UK economy over last couple of decades.

6.44 Figure 6-1 also includes estimates of RUOE for selected sectors. As explained in Section 4, RUOE is a productivity measure that reflects both catch-up efficiency and continuing efficiency and would therefore be expected to be higher than frontier shift efficiency alone (as demonstrated above). We would also note that in cases where regulators have set out catch-up and frontier shift separately, typically (although not in every single case) the catch-up component is larger than the frontier component.

6.45 We have explained above the regulators and authorities tend to look at a range of evidential sources to determine efficiency. When cross-sectoral comparators are used to estimate frontier shifts, it is of course necessary to bear in mind the differences between contexts. Some examples of the most important factors are:

- The **cost structure** of the industry. One may expect a bias towards improving operating efficiency over capital efficiency over the period. Typically, capital and operational costs have been treated differently in the charge control. Companies have clear profit incentives to reduce opex. However, the profits from reducing capex are likely to be more limited since this would lead to a reduction in the regulatory asset base and therefore the return on capital employed that can be made in subsequent charge controls. Therefore, reductions in opex may have been made by undertaking strategies which placed an emphasis on capital rather than operating expenditure and so the efficiency analysis, when undertaken only for opex, could be reflecting this changing mix. This contributed to Ofwat moving towards menu based regulation on a TOTEX basis.
- The **length of time for which the industry has been subject to competition** (or charge control mimicking some aspects of competition). Other regulators have noted that efficiency gains may be expected to slow down over time. There is a natural limit of any organisation to handle change and to continue to reduce unit costs. Eventually morale and quality of service, for example, will be impacted and net impact of continuing change programmes will be reduced. This has been recognised by Postcomm, who considered safety, quality and efficiency in parallel. These argue for efficiency factors to be set more cautiously. Secondly, rates are likely to be higher in the immediate post privatisation period as there is more 'low hanging fruit' (by contrast, in its current BMCR Ofcom has increased the efficiency ask relative to previous LLCCs for both Ethernet and TI services).
- **The sustainability of the efficiency savings**. Assessed levels of operating efficiency might not be sustainable in the long-term. Ofgem noted this in 2009 as part of its RPI-X@20 review[57]; RUOE had decreased by approximately 5.5% across the electricity distribution network since privatisation, but in more recent years Ofgem had observed changes and at the most recent charge control review allowed RPI+0 or RPI+X prices.

[57] Regulating energy networks for the future: RPI-X @ 20 review recommendation consultation, Ofgem, 2010.

- **Changes in quality over time.** As showed in a report on the scope for Network Rail's efficiency gains by (LECG, 2008)[58], the highest efficiency gains are associated with static or declining measures of quality and service reliability, and in a similar vein highest quality improvements are associated with lower efficiency gains. This is particularly the case when considering simple efficiency metrics such as RUOE.
- The **efficiency incentives the regulator chooses to apply**. As also highlighted by LECG (2008)[59], one of the original premises of RPI-X regulation is that it encourages companies to outperform against their efficiency targets. The efficiency target is therefore not typically set at simply the highest possible reasonable level, but the regulator exercises judgment on it depending on the circumstances. For example Ofwat said[60]: "*We have included only half of the scope for continuing efficiency…and just over half of the scope for catch-up… The balance represents the potential for outperformance for the companies…*" Indeed, LECG analysis performed in 2005 found that across industries and regulated sectors, the average annual efficiency target has been some 2.5% whereas actual unit costs reductions were between 4.0-4.8%[61]. This is an important feature of incentives-based regulation, and does not suggest that the efficiency targets were 'underestimated' ex ante.

6.46 As explained above, we have not performed a comprehensive analysis of the appropriate frontier shift for BT's TI or Ethernet services by reference to regulatory benchmarks – which would, in principle, reflect the above factors especially with regard to cross-industry comparisons. However, given the recent regulatory benchmarks available, we have examined them at a high level and propose which may be the best (and worse) comparators. Table 6-6 below sets out a number of qualitative factors relevant to the industries cited above.

58 Assessing Network Rail's scope for efficiency gains, LECG, 3 April 2008.

59 Assessing Network Rail's scope for efficiency gains, LECG, 3 April 2008.

60 Ofwat Final Determinations, 2004.

61 Future Efficient Costs of Royal Mail's Regulated Mail Activities, LECG, 2005.

Table 6-6: Summary of selected industry factors

Sector	Recent frontier shift estimate			Comments comparison to leased lines		
		Control period	Privatisation*/ charge controls** since	Approx. number of controlled years	Technology potential	Labour intensity
ATC	c. 1%	2011-15	2001/2001	10	High	High
Post (2006)	c. 3%	2006-10	2001/2003	5	High	High
Airports landing charges	c. 1%	2014-21	1987/1987	25	Low	High
Rail infrastructure	c. 1%	2014-19	1996/2001	15	Low	Low
Gas distribution/ transmission	c. 1%	2013-21	1990/TBC	25	Low	Low
Electricity distribution/ transmission (GB)	c. 1%	2010-15	1990/TBC	25	Low	Low
Electricity distribution/ transmission (NI)	c. 1%	2012-17	1993/1993	20	Low	Low
Water Scotland	TBC	TBC	2002/2002	TBC	Low	Low
Water NI	c. 0.5%	2016-21	2007/2010	5	Very low	Low
Water GB	c. 0.5%	2015-20	1989/1994	25	Very low	Low
BT (Ethernet)	4.5%	2013-16	1981	30	High	Low
BT (TI)	1.5%	2013-16	1981	30	Very low	Low

*Note: *Privatisation or incorporation **Refers to the first substantial charge review.*

6.47 It is our view that the electricity distribution or transmission sectors are most comparable with BT's TI services. They share the following qualities:

- they have relatively low potential for technological efficiency gains;
- they have been privatised/subject to charge control for 20+ years; and
- they are relatively capital intensive. This means the ongoing costs are weighted towards maintaining or improving a capital base.

6.48 As highlighted above, recent determinations in electricity distribution or transmission are around the 1% region. This is not inconsistent with previous BT LLCC of 1.5% efficient frontier movement for BT's TI services.

6.49 We can triangulate with two further examples, comparing to BT's TI services.

- As at 2006, a frontier shift of c. 3% was estimated for the Royal Mail. This is relatively high compared to other sectors. However, as at the time of the first control Royal Mail had only been 'privatised' for a short period of time (5 years), the industry was labour-intensive, and there was significant scope for technological efficiency gains (e.g. mechanisation of sorting offices etc.).
- By contrast, recent determinations in the water industry have estimated an industry frontier shift lower than 1%. As with the telecoms industry, the water industry has been subject to charge controls for over two decades and is relatively capital-intensive. However the potential for efficiency gains are much lower, as water treatment/processing is arguably more static than most telecoms technologies.

6.50 With respect to Ethernet services, Ofcom's previous LLCC review set an efficiency target of 4.5%. Compared to other sectors noted above, this looks high, but the main industry factor supporting this is the novelty of the technology and concomitant scope for efficiency improvements. Ethernet leased lines are newer technology, although some time has elapsed since previous LLCC. If BT is 'efficient' with respect to leased lines then the main factor is the rate at which this technology can become more efficient over time. This means general measures of productivity – and in particular, TFP – are more relevant. These are discussed below.

TFP Estimates

6.51 Continuing efficiency can be measured by reference to TFP. As described in chapter 3, TFP can be defined as "*is the portion of output not explained by the amount of inputs used in production*"[62]. TFP may be calculated at the whole economy level or for particular sectors in the economy. TFP estimates are particularly useful for providing a cross-check on other analysis, although it must be considered whether BT can be expected to be more or less efficient than the benchmark.

6.52 Our review of regulatory precedent shows that other regulators consider TFP as part of their efficiency analysis. Also, BT has provided Ofcom with TFP estimates as part of its response to the previous LLCC consultation and showed that these were generally consistent with the frontier shift estimated by SFA[63]. Therefore, we would have expected Ofcom to consider TFP during its estimation of the efficiency factor.

6.53 Below, we provide details of some recent TFP studies and approaches used by other regulators and authorities.

UK whole economy TFP Growth – UN world productivity database

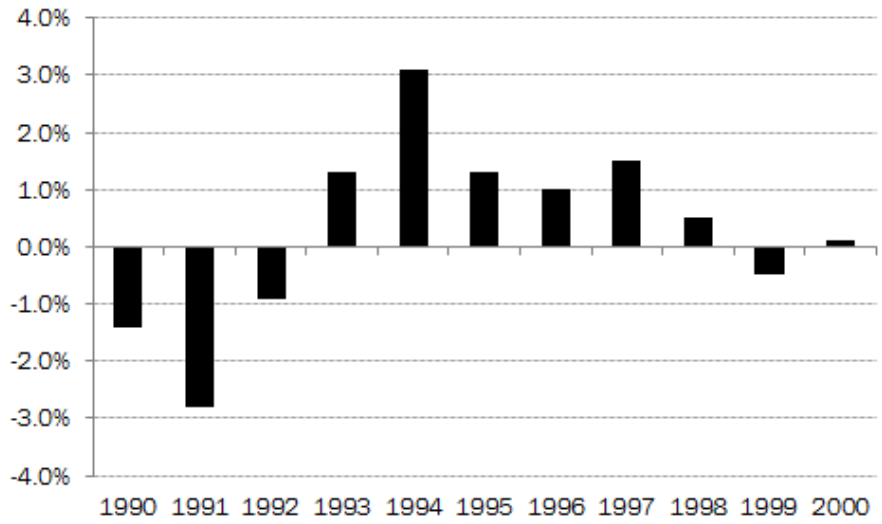
6.54 The UN provides a dataset on TFP growth data up to 2001 (with forecasts covering the period 2001 to 2010) for 112 countries around the world on a consistent basis[64]. As shown by Figure 6-2, over the period 1990 to 2000 TFP growth has been volatile.

62 See, for example, *Total Factor Productivity*, Diego Comin, New York University and NBER, August 2006.

63 Contained within the Deloitte studies considered by Ofcom in the previous LLCC

64 World Productivity Database: a technical description, UNIDO, October 2007.

Figure 6-2: UN Productivity Database – United Kingdom TFP Growth, 1990 to 2000



Source: UN Productivity Database.

UK TFP growth by sector – ONS TFP Estimate series (ONS, 2015)

6.55 ONS also provides and analyses time series data on TFP[65]. These estimates use experimental measures of quality adjusted labour inputs and capital services and a growth accounting framework to decompose output growth into the relative contributions of growth of labour and capital inputs and a residual component (i.e., TFP).

6.56 Figures 6-3 and 6-4 below show historical estimates of TFP growth for the whole UK economy and selected sectors respectively.

65 Multi-factor Productivity (experimental), Estimates to 2013, ONS, January 2015.

Figure 6-3: TFP Growth for UK whole economy

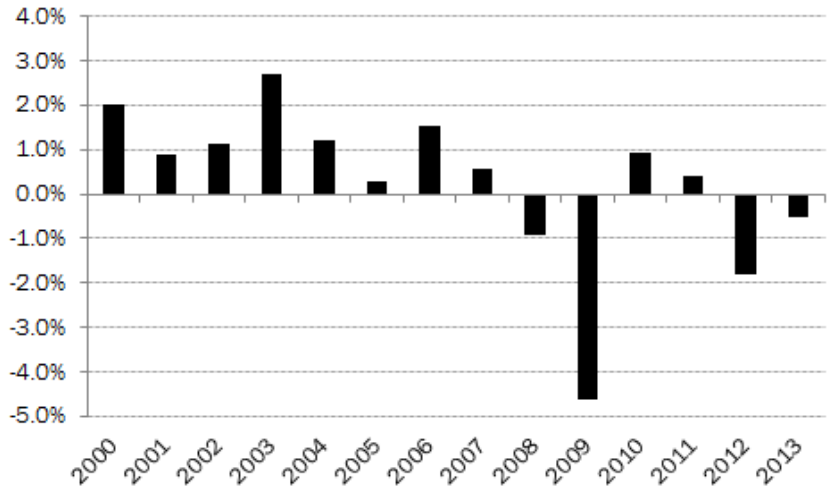
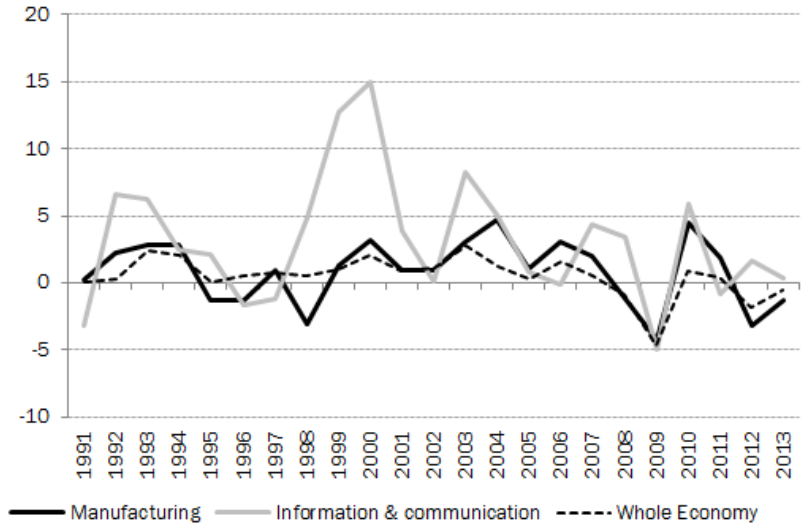


Figure 6-4: TFP Growth for UK by sector



Source: ONS

UK TFP growth by sector - ONS micro data

6.57 ONS published a report analysing TFP growth using firm-level (rather than national growth accounting) data[66]. This article reports some new perspectives on UK productivity up to 2010, using a large dataset assembled from firm-level micro-data. A central finding is that productivity performance over 2008-10 has varied widely, by industry, firm size and a range of other firm-level characteristics.

6.58 This is different to many TFP studies as it is not based on macroeconomic data but individual firm data, and therefore highlights the variation between firms in TFP trends.

6.59 The analysis suggests compound average growth of TFP between 2001 and 2010 is[67]:

- 4.0% for manufacturing (excluding electrical machinery);
- 7.3% for electrical machinery, telecommunication services; and
- 1.3% for market services (excluding telecommunication services).

Telecoms TFP – EU KLEMS database (Reckon, 2011)

6.60 The EU KLEMS database which includes measures of growth and productivity is a frequently used dataset for calculating TFP. For example, the ORR commissioned this analysis in 2011 in relation to its network access charge control[68].

6.61 The EU KLEMS database provides TFP estimates for whole economies and for specific sectors, across different time periods. For example, Reckon (2011) for ORR found, based on EU KLEMS data, that telecoms TFP growth was between 1.7% and 2.5% depending on the period in question and 2.2% to 3.1% on a "LEMS" basis which attempts to remove the impact of capital from the calculation. This is shown in Table 6-7 below.

Table 6-7: Telecoms TFP Growth, Reckon (2011)

Time period	Gross output TFP	LEMS TFP	Gross output OLS	LEMS OLS
1970-2007	1.70%	2.20%	1.80%	2.40%
1987-2007	2.40%	2.90%	NA	NA

66 Micro-data Perspectives on the UK Productivity Conundrum - An Update, ONS, October 2013.

67 Note: for this study ONS used subsets of SIC03 codes. For examples their grouping 'electrical machinery, telecommunication services' comprises SIC codes 30 (Manufacture of Office Machinery and Computers), 31 (Manufacture of Electrical Machinery and Apparatus Not Elsewhere Classified), 32 (Manufacture of Radio, Television and Communication Equipment and Apparatus) and 64(Post and Telecommunications). See ONS SIC03 classifications.

68 Reckon (2011).

Time period	Gross output TFP	LEMS TFP	Gross output OLS	LEMS OLS
1997-2007	2.50%	3.10%	NA	NA

Source: Reckon (2011)

6.62 This is a large dataset, covering a long time period with a large number of sectors. However, the statistics are backwards looking and a degree of judgement is required as to which sectors to include in the benchmarking estimation. Also, the database is only updated periodically.

6.63 Reckon (2011) uses EU KLEMS data to estimate whole UK economy TFP growth between 1981 and 2007 at an average annual rate of 0.8%.

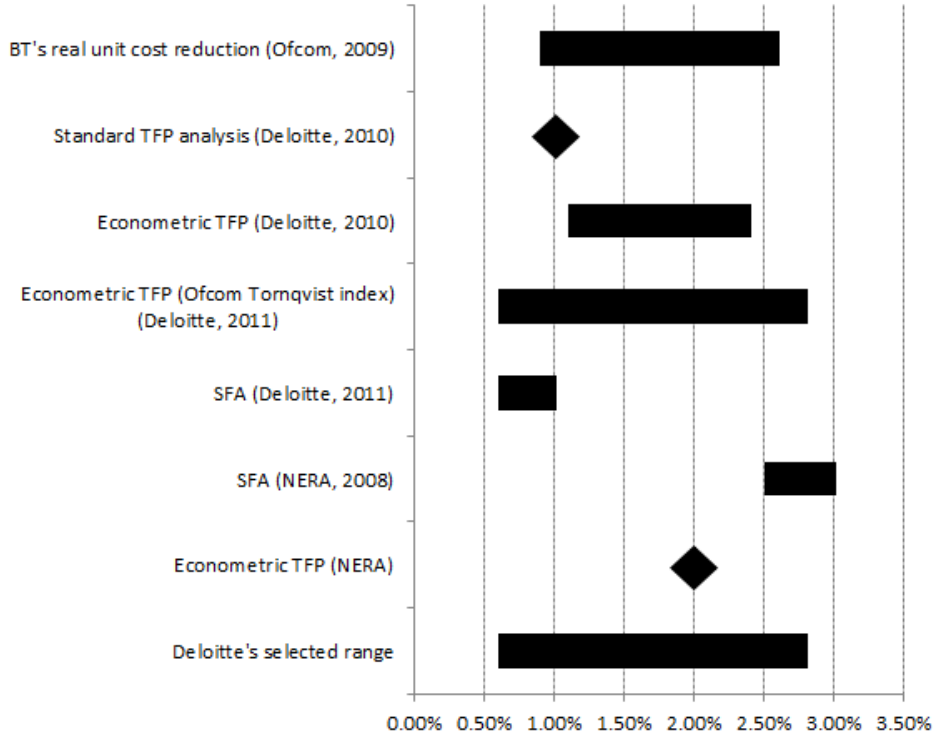
BT TFP - Deloitte (2011)

6.64 In 2011 Deloitte prepared a report for BT for the purposes of supporting BT in understanding its relative efficiency using a particular econometric modelling approach[69]. The report focuses on the validity of the frontier shift range proposed by Ofcom for the purposes of the WBA market.

6.65 Ofcom had proposed a range of 2% to 5%, whereas Deloitte argued that a range of 0.6% to 2.8% was supported by the analysis. The analysis relied upon was largely time-series econometric models that captured TFP separately.

69 BT WBA Consultation Response, Deloitte, March 2011.

Figure 6-5: Summary of TFP estimates used in Deloitte (2011)



Summary of TFP estimates

6.66 We have examined a range of TFP estimates from different sources and with different estimation methodologies. We are cognisant of some criticisms and difficulties with TFP analysis, including:

- Some commentators (e.g. Reati, 1991) critique TFP as being "*manna from heaven*"[70] in the context of a neoclassical production function but bearing "*no relation with the real world*". If there are increasing returns to scale (the production function is not convex), input shares will not equal output elasticities and a positive Solow residual is estimated, even though there is no (disembodied) technical change.
- Care must be taken on what is being measured in outputs. The World Bank notes that estimates of the variation in TFP growth over time can be quite sensitive to the period for which they are calculated and the robustness of the results to the sample period should be checked carefully[71]. TFP estimation is especially sensitive to where the economic business cycle is in relation to the sample term.
- In practice the MFP residual may also capture a number of other effects such as adjustment costs, economies of scale and measurement error in inputs and outputs. For example an improvement in the quality of the labour force not captured by the quality adjusted labour inputs or returns from expenditures that are not currently treated as capital formation within the national accounts framework, such as workplace based training, design and branding, will be incorporated into the MFP residual.

6.67 With all of these caveats in mind, the data suggests that whole economy TFP estimates for the UK are quite low – as highlighted by the UN productivity database, the UK experienced some high TFP growth in the early 1990s but the more recent ONS TFP series shows that in last ten years TFP growth in the UK has only been over 1% once.

6.68 The ONS sector comparative studies also illustrate the variation between sectors; the information and communication sectors generally increase productivity at a greater rate than manufacturing (for example) and the economy as a whole. This conforms with the general expectation that newer, high-tech industries are able to produce greater TFP growth.

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70 Total factor productivity – a misleading concept, A. Reati, BNL Quarterly Review, no. 218, September 2001.

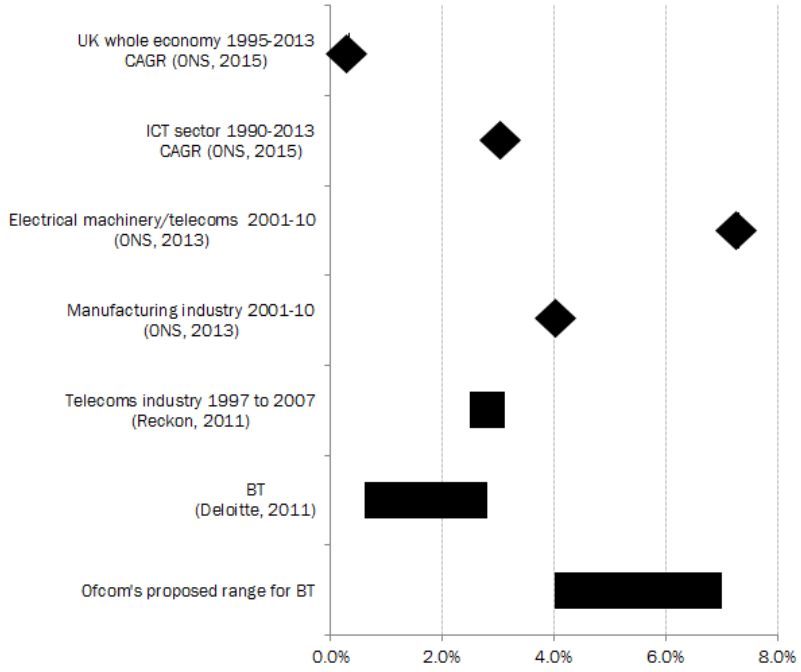
71 Measuring growth in total factor productivity, World Bank, September 2000.

6.69 Reckon (2011) used EU KLEMS data to estimate telecoms sector TFP growth over last business cycle (1997 to 2007) at a range of 2.5%-3.1%. The 'telecoms' sector of course covers a broad range of products and technologies – ranging from services such as BT's TI services to 4G and next generation mobile.

6.70 Based on these benchmarks alone, the TFP growth for BT's regulated services might be expected to be higher than the economy as a whole but lower than the telecoms sector as a whole.

6.71 This is confirmed by Deloitte (2011) which estimates a range of 0.6% to 2.8% for BT.

Figure 6-6: Summary of TFP estimates



Conclusions

6.72 We have reviewed recent regulatory decisions and determinations in other UK regulated sectors, which confirm that an array of techniques is used to derive efficiency factors. These often involving both econometric analyses and bottom-up analyses, and typically drawing on a range of complementary analyses.

6.73 This is endorsed by the CMA which typically assesses the full range of evidence presented to it when making its regulatory determinations. Notably, the CMA/CC does not have a singular 'preferred' approach to assessing efficiency and instead sees virtue in relying on a variety of approaches. The CC recently stated that "*no benchmarking analysis or cost assessment method will be perfect, and there will always be limitations in any approach*[72].

6.74 In sectors where there are fewer regulated companies, regulators are more likely to analyse efficiency trends in other sectors. For example, the ORR and CAA have both commissioned reports to assess various measures of efficiency across regulated industries over time:

- Reckon (2011) surveyed the productivity and unit cost change in UK regulated network industries and other UK sectors; and
- CEPA (2013) applied a range of top-down benchmarking techniques to assess the scope for efficiency gains at Heathrow, Gatwick and Stansted airports.

6.75 We have looked at these reports and performed a survey of more recent regulatory decisions to assess the range of frontier shift efficiency factors applied in UK regulatory contexts. Frontier shifts are assessed in the range 0%-2%, with a prominent cluster around 1%. This range is a result of a wide variety of techniques, including many that Ofcom have not put forward in its current LLCC.

6.76 There are obvious difficulties with comparing across regulated sectors but we consider that electricity distribution and generation are probably most appropriate benchmarks, so on this basis a range of 0 to 2% may be appropriate. We also look to Ofcom's previous LLCC estimate of 1.5%, based on benchmarking studies, and suggest this could arguably be the upper limit for a product which has further aged.

6.77 We have reviewed some estimates of TFP generally from a range of sources, looking at historical TFP growth estimates in the UK economy, in selected sectors of the economy, and for BT itself.

- TFP growth in the UK economy has been low in recent years: for example, in the last ten years has only been over 1% once (in 2006 where 1.5%).

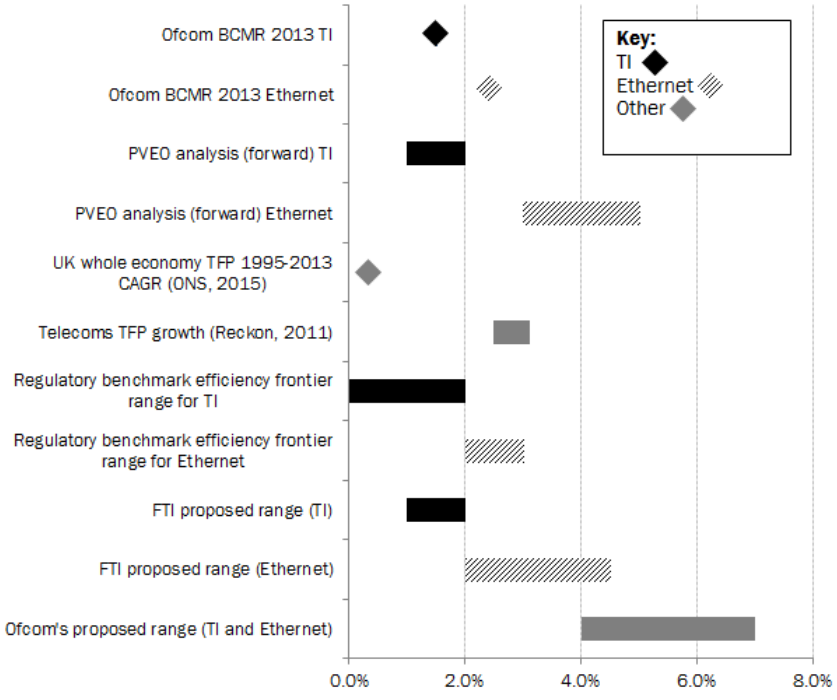
72 Bristol Water Price Determination, July 2015.

- TFP growth varies between sectors. Telecoms TFP growth as a whole is higher (e.g. Reckon (2011) uses EU KLEMS data to estimate telecoms sector TFP growth over last business cycle (1997 to 2007) at 2.5%-3.1%[73]. This range relates to the entire telecoms sectors, which of course ranges in products and services from more novel (such as 4G and next generation mobile) to less novel (such as BT's TI services or copper landlines).

6.78 These TFP estimates can help inform a reasonable range for BT's Ethernet services. We would suggest one key benchmark is Reckon (2011) which analysed the telecoms industry over the whole business cycle using EU KLEMS data and assessed an upper estimate of annual TFP growth at 3.1%. If there is any scope for 'catch-up' in the efficiency of BT's Ethernet services, then the appropriate efficiency factor may be higher – but we would consider that the efficiency factor from the previous control (of 4.5%) should be an upper limit, on the basis that it is unlikely that scope for efficiency gains can increase over time. We note also that BT's own PVEO analysis suggests an upper limit of 5% may be appropriate.

6.79 In Figure 6-7 below we summarise the key benchmarks referred to in this report.

Figure 6-7: Summary of key benchmarks



73 Reckon (2011).

Appendix 1 Bibliography

A1.1 Table A1-1 below shows the public information relied upon in this report.

Table A1-1: Bibliography of public information relied upon in this report

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Section 2
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Section 3
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