Europe Economics

Response to Some Key Points on Real Price Effects (RPEs) and Frontier Shift

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Contents

1 Introduction

In this document, we respond to a number of new points that have been made by water companies and their consultants in relation to frontier shift and real price effects (RPEs), in the context of the ongoing CMA appeals of Ofwat's PR19 determination by four water companies.

In particular, in this document we respond to the following:

- new points made by Yorkshire Water on recent productivity growth and the tendering of capital expenditure;[1]
- new points made by Oxera relating to how comparator sectors should be used to derive a frontier shift range and to embodied technical change, contained in a paper for Yorkshire Water;[2]
- new points on the impact of COVID-19 on frontier shift and input prices made by Northumbrian Water;[3] and
- new evidence in response to points made by Earwaker in his February 2020 report on frontier shift and RPEs,[4] which Anglian Water now states that it fully endorses in its Reply to Ofwat's Response to Anglian Water's Statement of Case (and which was earlier only put forward by Northumbrian Water, which had a higher frontier shift assumption than Ofwat).[5]

This document is structured as follows:

- Section 2 responds to the points that relate to frontier shift; and
- Section 3 responds to the points relating to RPEs.

While companies and their consultants have made various other points in their submissions, these have largely been addressed already in Ofwat's statement of case,[6] in Europe Economics' final PR19 report on real price effects and frontier shift,[7] and in Europe Economics' report for Ofwat on the impact of COVID-19 on RPEs and frontier shift.[8]

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1 Yorkshire Water, "PR19 Redetermination; Yorkshire Water Services: Response to Ofwat Reply", 27 May 2020, p.73,81-82

2 Oxera, "Addressing Ofwat's Response to Yorkshire Water Services' Statement of Case", 26 May 2020, p.37-39, 40-43

3 Northumbrian Water Limited, "Appendix 1; COVID-19 Appendix", Table 2 in Section 1.9

4 Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020

5 Anglian Water, "Anglian Water PR19; Part G: Reply to Ofwat's Response on Cost issues", page 59

6 Ofwat, "Reference of the PR19 final determinations: Cost efficiency – response to common issues in companies' statements of case", May 2020, available at: https://www.ofwat.gov.uk/wp-content/uploads/2020/05/Reference-of-the-PR19-final-determinations-Cost-efficiency-response-to-common-issues.pdf

7 Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, available at: https://www.ofwat.gov.uk/wp-content/uploads/2019/12/Europe-Economics-%E2%80%93-Real-Price-Effects-and-Frontier-Shift-%E2%80%93-Final-Assessment-and-Response-to-Company-Representations.pdf

8 Europe Economics, "Impact of COVID-19 Crisis on Real Price Effects (RPEs) and Frontier Shift", 27 April 2020, available at: https://www.ofwat.gov.uk/wp-content/uploads/2020/05/Europe-Economics-report-on-impact-of-COVID-19-on-RPEs-and-frontier-shift-27-April.pdf

2 Response to Some Key Points on Frontier Shift

In this section, we respond to points made by Oxera, Northumbrian Water and Earwaker in relation to the following issues:

- whether official forecasts suggest economy-wide productivity growth over AMP7;
- whether any economy-wide TFP slowdown since the (2008-09) financial crisis would be expected to affect the water sector;
- whether the Frontier Economics report for WaterUK shows productivity growth slowing in the water sector due to the (2008-09) global financial crisis;
- whether productivity growth for outsourced activities should be expected to be driven by productivity growth in the sectors that contractors come from;
- whether productivity in comparator sectors has flatlined since the (2008-09) financial crisis;
- whether a frontier shift range should be based on a composite "nature of work" index;
- whether Europe Economics has disregarded evidence from four of our comparator sectors in setting the upper limit of our range;
- whether the academic papers that Europe Economics used to provide an indicative quantification of the impact of embodied technical shift actually show that it has no effect;
- whether it is intuitive to argue that embodied technical shift has no effect; and
- whether applying a 60 per cent uplift for embodied technical shift implies that respected organisations have understated TFP growth.

We address these in turn below. In each case, we first summarise the key point made by Oxera, Northumbrian Water and/or Earwaker, and we then set out our response.

OBR forecasts from March 2020 suggest significant economy-wide productivity growth over AMP7

Yorkshire Water uses a report by Economic Insight[9] to argue that productivity growth has generally been significantly lower in recent years than its long-run level.[10] Similarly, Earwaker's report, which has now been endorsed by Anglian Water, suggests that lower economy-wider productivity growth over the next price control period needs to be taken into account.[11]

The table below shows forecasts of labour productivity growth (on an output per hour basis) published by the OBR in its latest "Economic and fiscal outlook".

[9] Economic Insight, "Financeability of the Notionally Efficient Firm: Top-Down Analysis", August 2019

[10] Yorkshire Water, "PR19 Redetermination; Yorkshire Water Services: Response to Ofwat Reply", 27 May 2020, p.81-82

[11] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.3-4

Table 2.1: OBR forecasts of labour productivity growth (on an output per hour basis)

	March 2018	October 2018	March 2019	March 2020
2020	1.0	1.0	1.0	0.8
2021	1.1	1.1	1.1	1.0
2022	1.2	1.2	1.2	1.1
2023		1.3	1.3	1.2
2024				1.3

Source: OBR "Economic and fiscal outlook" from the dates shown in column headings, available at: https://obr.uk/report/economic-and-fiscal-outlook/

The latest March 2020 forecasts show clearly that the OBR was expecting labour productivity to increase over the 2020-25 period, rising from 0.8 per cent in 2020 to 1.3 per cent in 2024. The average growth rate over these five years is 1.1 per cent. The OBR's March 2020 forecast has changed only a little from its forecast in previous years.

In its earlier March 2018 forecast,[12] the OBR looked at the respective contributions of TFP growth and capital deepening to the growth of output per hour. The analysis suggested that for the 2018 to 2022 period economy-wide TFP growth would be 0.4 per cent with an assumed depreciation of 8 per cent, and 0.6 per cent with an assumed depreciation of 9 per cent.

The latest OBR Economic and Fiscal Outlook compares its average four-quarter growth rates between Q1 2020 and Q1 2023 forecast (suggesting a productivity growth rate of 1.0 per cent over that time period) with the forecast produced by the Bank of England (a much lower figure of 0.5 per cent). Although the Bank of England was projecting the same growth in actual output, it was assuming that this would be driven by a higher current margin of spare capacity rather than by productivity growth.

What is significant about these figures is that the OBR projected a TFP growth rate above the long-run trend rate for economy-wide TFP growth. As set out in Table 2.2 below, historical NACE 1 TFP growth data (available for the period 1971-2007) show that the economy-wide TFP growth rate for "Total industries" was 0.3 per cent per annum over the last two complete economic cycles in this dataset.

Table 2.2: Historical Gross Output TFP growth rate for the economy as a whole (NACE 1 data)

	Average (1971 - 2007)	Average cycle 1 (1980-1989)	Average cycle 2 (1990-2007)	Average 2 cycles (1980-2007)
TFP growth rate for "Total industries" (%)	0.2	0.3	0.3	0.3

Source: Europe Economics, "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, p.77

Clearly, these OBR forecasts may be affected by the COVID-19 crisis. While the OBR's published coronavirus reference scenario[13] does not appear to contain any productivity forecast, the Bank of England has suggested in its May 2020 Monetary Policy Report that the COVID-19 crisis will

[12] OBR, "Economic and fiscal outlook", March 2018, p.44, available at: https://cdn.obr.uk/EFO-MaRch_2018.pdf.

[13] Available at https://obr.uk/coronavirus-analysis/

reduce productivity growth.[14] It does, however, describe this effect on productivity as being "relatively small" under its illustrative COVID-19 scenario.[15]

Our previous analysis of the impact of COVID-19 on frontier shift and RPEs found that while the crisis may reduce economy-wide TFP growth, we would not expect potential productivity growth in the water sector to be affected.[16]

Comparator sectors have consistently exhibited better TFP growth performance than the economy as a whole

Yorkshire Water argues that lower economy-wide productivity growth has been reflected in lower productivity growth in comparator sectors.[17] The Earwaker report similarly argues that lower economy-wide productivity growth will feed through into lower productivity growth in the water sector over AMP7.[18]

Historical data shows that our comparator sectors have consistently exhibited better TFP performance than the economy as a whole. Table 3.14 in our final PR19 report[19] (reproduced below as Table 2.3, for ease of reference) presents TFP growth figures in gross output terms using the NACE 1 dataset for our selected comparator sectors and for "Total industries". As the last column of the table shows, the TFP growth rates in comparator sectors over the last two business cycles are greater than the TFP growth rate in the general economy (as shown by "Total industries"). For example, the TFP growth rate over the 1980-2007 period calculated for "Chemicals and chemical products" and "Construction" are 1.3 per cent and 0.5 per cent, respectively, while TFP growth for "Total industries" was 0.3 per cent. Further, the average TFP growth rate calculated across the comparators (0.8 per cent) is also higher than the figure reported for the general economy.

[14] Bank of England, "Monetary Policy Report", May 2020, p.7, available at: https://www.bankofengland.co.uk/-/media/boe/files/monetary-policy-report/2020/may/monetary-policy-report-may-2020.pdf

[15] Bank of England, "Monetary Policy Report", May 2020, p.10, available at: https://www.bankofengland.co.uk/-/media/boe/files/monetary-policy-report/2020/may/monetary-policy-report-may-2020.pdf

[16] Europe Economics, "Impact of COVID-19 Crisis on Real Price Effects (RPEs) and Frontier Shift", 27 April 2020, p.22-40, available at: https://www.ofwat.gov.uk/wp-content/uploads/2020/05/Europe-Economics-report-on-impact-of-COVID-19-on-RPEs-and-frontier-shift-27-April.pdf

[17] Yorkshire Water, "PR19 Redetermination; Yorkshire Water Services: Response to Ofwat Reply", 27 May 2020, p.81-82

[18] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.3-4

[19] Europe Economics, "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, p.77

Table 2.3: Comparison of historical GO TFP growth rate for comparator sectors and the economy as a whole

Industry Comparators	Average (1971 - 2007)	Average cycle 1 (1980-1989)	Average cycle 2 (1990-2007)	Average 2 cycles (1980-2007)
Chemicals and chemical products	1.3%	1.6%	1.2%	1.3%
Construction	0.3%	0.8%	0.3%	0.5%
Machinery, nec	0.5%	0.5%	0.8%	0.7%
Total manufacturing	0.6%	1.0%	0.6%	0.8%
Transport and storage	1.0%	1.3%	0.7%	0.9%
Average for comparators	**0.7%**	**1.0%**	**0.7%**	**0.8%**
Total industries (for purpose of comparison)	0.2%	0.3%	0.3%	0.3%

Source: Europe Economics, "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, p.77

Further, the 2017 release of the EU KLEMS NACE 2 dataset covering the period between 1999 and 2014 also broadly supports the finding that TFP growth in our comparator sectors over the period covered by the dataset has been greater than TFP growth in the general economy (in this dataset, represented by "Market economy" instead of "Total industries"), with the exception of construction and transport and storage.[20]

The Frontier Economics report for WaterUK shows that productivity continued to grow in the water sector during the (2008-09) global financial crisis

In its COVID-19 appendix, Northumbrian Water presents ONS labour productivity data from the (2008-09) financial crisis to argue that productivity in the water sector will be negatively affected by the COVID-19 crisis.[21] The Earwaker report argues that the Frontier Economics report for Water UK[22] provides evidence of a slowdown in water sector productivity growth at same time as the slowdown in productivity growth in other industries that was caused by the (2008-09) global financial crisis.[23]

As we identified in our final PR19 report, ONS and EU KLEMS data on water sector productivity growth is biased downwards by the fact that improvements in quality (e.g. environmental benefits) do not appear to have been taken into account in measuring water sector output.[24] This will mean that productivity estimates for the water sector will appear to be more negatively affected in a recession than is really the case, since the output measure will take account of reduced water consumption during the recession but will not take account of increased levels of quality (e.g. further environmental improvements).

In our view, Northumbrian Water and Earwaker have also ignored or not understood the evidence from the Frontier Economics report for Water UK. Figure 2.1 below is taken from the Water UK report and shows annual TFP growth rates for the water sector between 1994 and 2017 (both with and without quality adjustments). The two vertical red lines in the chart have been added by

[20] See Table 3.13 in Europe Economics, "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, p.77

[21] Northumbrian Water Limited, "Appendix 1; COVID-19 Appendix", Table 2 in Section 1.9

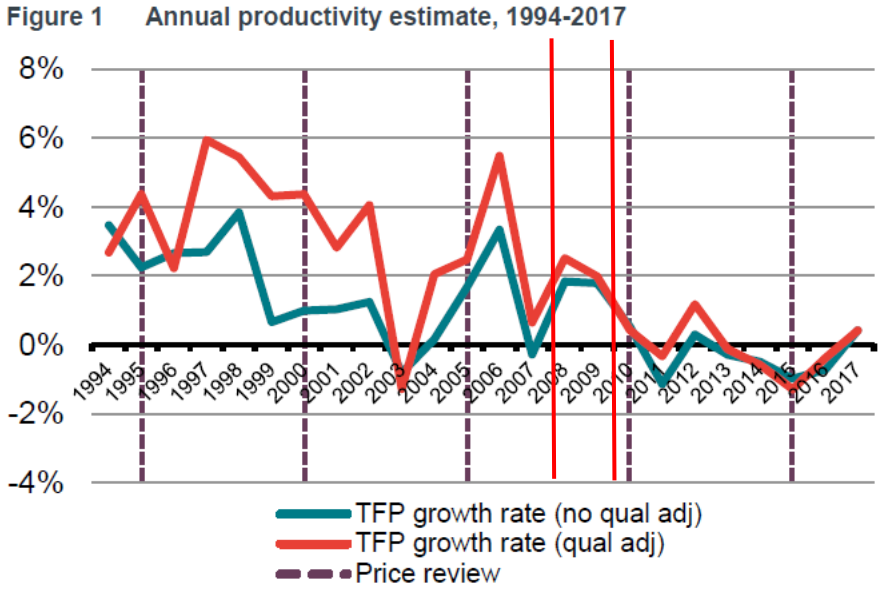
[22] Frontier Economics for Water UK, "Productivity Improvement In The Water And Sewerage Industry In England Since Privatisation", 29 July 2017

[23] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.4

[24] Europe Economics, "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, p.64-66

Europe Economics and surround the 2008-09 recession. The figure shows that the water sector continued to achieve positive TFP growth of around 2 per cent per annum during the global financial crisis, during a period when EU KLEMS data shows that productivity growth in the overall economy was negative. This provides clear evidence that there is no automatic link between the economy-wide slowdown in productivity caused by the 2008-09 financial crisis and productivity growth in the water sector.

Figure 2.1: Annual productivity estimate as reported by Frontier Economics (2017)



Source: Frontier Economics.

Further, our report for Ofwat on the impact of the COVID-19 crisis on RPEs and frontier shift in the water sector provides additional evidence from earlier recessions in 1973-74, 1980-81 and 1990-91 showing that productivity growth in the water sector is not affected by recessions in the same way as productivity growth in the rest of the economy or in comparator sectors.[25]

Water sector productivity growth is not necessarily the same as productivity growth in the sectors that contractors come from

Yorkshire Water argues that its capital expenditure is subject to rigorous tests for efficiency because it is competitively tendered via its framework agreements.[26] Earwaker's report states that there is a direct feed from productivity growth in other sectors (e.g. construction) to water sector productivity growth, given outsourcing by water companies.[27]

We disagree with the assumption that if water companies are outsourcing work to contractors from another sector, then the productivity improvements achieved for these water sector activities must necessarily be the same as the productivity improvements achieved in the sector that the contractors come from.

[25] Europe Economics, "Impact of COVID-19 Crisis on Real Price Effects (RPEs) and Frontier Shift", 27 April 2020, p.22-40, available at: https://www.ofwat.gov.uk/wp-content/uploads/2020/05/Europe-Economics-report-on-impact-of-COVID-19-on-RPEs-and-frontier-shift-27-April.pdf

[26] Yorkshire Water, "PR19 Redetermination; Yorkshire Water Services: Response to Ofwat Reply", 27 May 2020, p.73

[27] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.4

Water companies have a choice as to whether or not to outsource their work. If contractors have performed poorly in terms of increasing their efficiency, water companies could bring the work back in house. Hence, water companies cannot use the fact that they have chosen to outsource work to contractors from another sector as a reason for why they cannot achieve efficiency gains.

Further, the efficiency gains achieved for outsourced work depend not only on efficiencies identified by the contractors but also on how well water companies identify more efficient ways of scoping, procuring and managing the work that contractors do.

Finally, it is not correct to assume that the productivity gains achieved by (say) construction companies must necessarily be the same when they do work for the water sector as when they do work in other sectors. This may well not be the case, since construction companies may have more scope for achieving efficiency gains in some types of construction projects than they do when carrying out other construction work. For example, a new technology that allowed water networks or water treatment plants to be constructed at lower cost may not be applicable to construction work in other sectors.

Earwaker's claim of flatlining productivity is driven by his use of 2010 as a base year

Yorkshire Water argues that "productivity has generally been significantly lower in recent years than its long term level".[28] Similarly, Earwaker's February 2020 report claims that raw EU KLEMS data shows all but one comparator sector flatlining in terms of productivity growth since the (2008-09) financial crisis.[29]

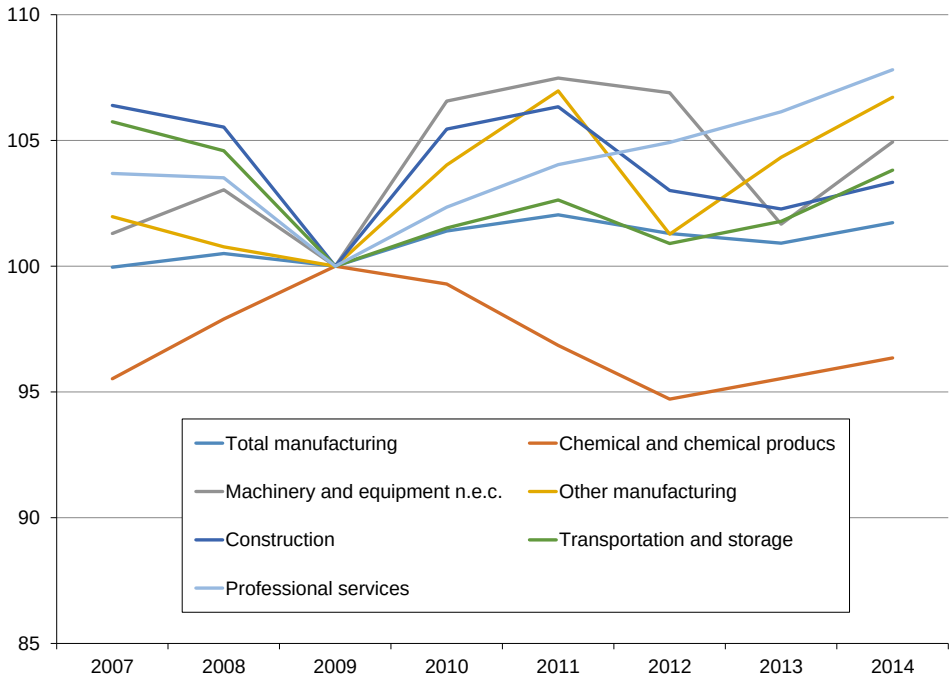
Earwaker's claim is highly sensitive to the way in which he has chosen to present the data. In particular, the appearance of the chart presented by Earwaker on page five of his report depends heavily on the choice of the base year, which Earwaker has selected to be 2010. Further, Earwaker presents data for Gross Value Added (GVA) TFP growth, whereas we focused on Gross Output (GO) TFP growth in setting the upper and lower limits of our range.

The chart below uses the same EU KLEMS TFP estimates with 2009 as the base year and using GO TFP growth rather than GVA TFP growth. The chart shows that TFP growth has been greater than zero in most of the comparator sectors in the post-crisis period.

[28] Yorkshire Water, "PR19 Redetermination; Yorkshire Water Services: Response to Ofwat Reply", 27 May 2020, p.81

[29] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.5-6

Figure 2.2: EU KLEMS TFP data in gross output terms with 2009 as base year

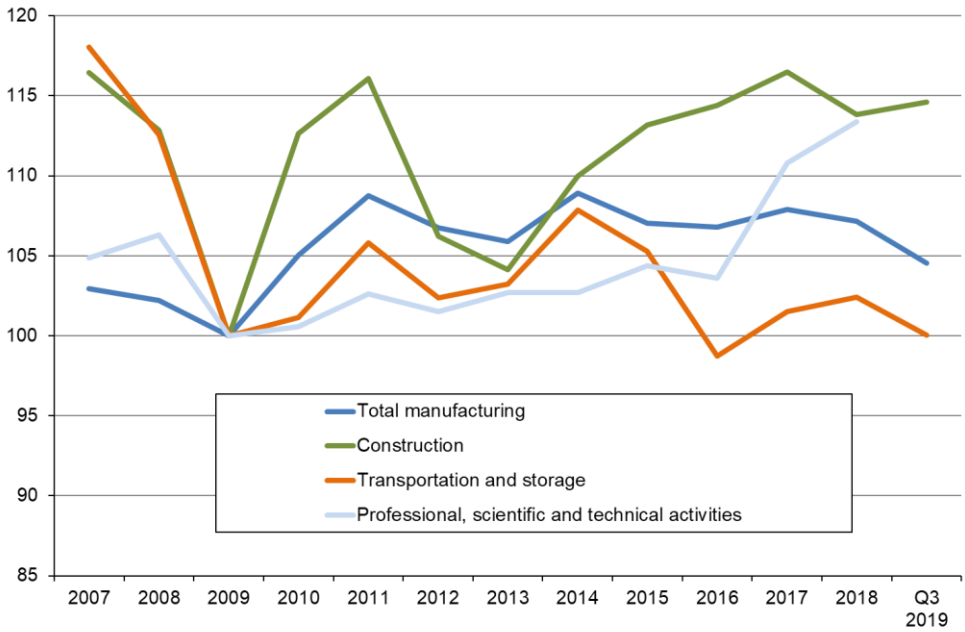


Source: Europe Economics' analysis of EU KLEMS data.

In Annex 1 to his report, Earwaker argues that ONS multi-factor productivity (MFP) data also shows flatlining productivity in all but one comparator sector in the post-crisis period.[30]

Again, the appearance of the chart presented by Earwaker in Annex 1 of his report depends heavily on the choice of the base year, which Earwaker has selected to be 2010. The chart below uses the same MFP estimates published by the ONS with 2009 as the base year and shows that TFP growth has been greater than zero in all but one comparator sector in the post-crisis period.

Figure 2.3: ONS MFP data with 2009 as base year



[30] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.16

Source: Europe Economics' analysis of ONS data.

As we stated in our final PR19 report,[31] in our view Earwaker's use of 2010 as the base year represents cherry-picking of the data. This is because — as shown in the table of year-by-year post-crisis TFP growth figures below — it would exclude the positive productivity growth rates in 2010 (corresponding to an average of 2.7 per cent across our comparator sectors in gross output terms using EU KLEMS data) while including the negative TFP growth observed in 2012 (corresponding to an average of -1.9 per cent across our comparators). We note that when both 2010 and 2012 are excluded from the calculations, the TFP growth observed for the last two years of the dataset give an average TFP growth rate of 0.9 per cent – a figure which is higher than the post-crisis average for 2010-14 presented in our report. Our final PR19 report showed that similar conclusions can be drawn when looking at year-by-year data from the ONS MFP dataset which includes more recent years of data.[32]

Table 2.2: Year-by-year TFP growth rates in post-crisis period (per cent), EU KLEMS data

Industry comparators	2010	2011	2012	2013	2014
Manufacturing	1.4	0.6	-0.7	-0.4	0.8
Chemicals and chemical products	-0.7	-2.5	-2.2	0.9	0.9
Machinery and equipment n.e.c.	6.4	0.9	-0.5	-5.0	3.2
Other manufacturing; repair and installation of machinery and equipment	3.9	2.8	-5.5	3.0	2.3
Construction	5.3	0.8	-3.2	-0.7	1.0
Transport and storage	0.0	1.2	-2.3	1.3	2.2
Professional, scientific, technical, administrative and support service activities	2.3	1.6	0.8	1.2	1.6
Average for above comparators	**2.7**	**0.8**	**-1.9**	**0.0**	**1.7**

Source: Europe Economics, "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, p.139

A composite "nature of work" index can often be based on arbitrary weights and naïve assumptions

Oxera (for Yorkshire Water) argues in favour of a composite measure of comparator productivity growth in which explicit weights are placed on comparator sectors based on the proportion of the water sector cost base for which they are deemed to be a comparator.[33] The Earwaker report argues that all of the comparator sectors need to be taken into consideration to provide a composite "nature of work" comparator.[34]

We disagree with this view that frontier shift figures need to be based on a composite "nature of work comparator" constructed by placing explicit weights on comparator sectors.

A key disadvantage of a composite index approach is that it incorporates subjective judgments about which sectors are comparators for which parts of the value chain and what weights should be applied to each comparator, without making clear the sensitivity of the results to those subjective assumptions. Consequently, this approach can lead to a spurious accuracy.

[31] Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", p.139-140

[32] Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", p.139-140

[33] Oxera, "Addressing Ofwat's Response to Yorkshire Water Services' Statement of Case", 26 May 2020, p.36,37-39

[34] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.7

Oxera claims, for example, that its approach is backed up by a recent court decision in the Netherlands.[35] This court decision related to energy transmission networks, a sector not dissimilar to water networks. However, this court decision placed a substantially different weight on the construction sector (24 per cent)[36] compared with the weight that Oxera has placed on the construction sector in its PR19 analysis of frontier shift (a weight of around 80 per cent for opex and 50 per cent for capex).[37] This illustrates the highly subjective judgments that are inherently involved in constructing a composite index.

A further problem with this approach is that it can often involve making naive assumptions about the relevance of comparator sectors for different parts of the water sector cost base. For example, Earwaker suggests that the construction sector represents the most appropriate comparator sector for the construction and installation work carried out the water sector.[38] In making this assertion, Earwaker appears to overlook the fact that comparator sectors involve a mix of capital and operating expenditure. There may be some link between the capex spent by the water industry and the opex of the construction industry, given that items purchased by water companies for capital projects (e.g. pipelines) might represent opex for construction companies (i.e. they would represent the ongoing costs of materials for construction work). However, the kind of capital equipment purchased by the construction industry is likely to be very different from the capital equipment purchased by water companies. By contrast, the capex of other sectors such as "Other manufacturing; repair and installation of machinery and equipment" may be more similar to the capex undertaken by the water sector.

Further, infrastructure projects represent only a minority of the work undertaken by the construction sector (19 per cent of new orders in 2018, as shown in the table below). The scope for efficiency gains may clearly be quite different between infrastructure projects and (say) the construction of new housing.

Table 2.3: Breakdown of new orders in construction sector, 2018

	£ billion	% of total
Private housing	20.3	33
Private commercial	15.2	25
Infrastructure	11.5	19
Public other new work	8.2	13
Private industrial	5.1	8
Public housing	1.3	2
Total	61.7	100

Source: Office of National Statistics, Data behind Table 4 at:
https://www.ons.gov.uk/businessindustryandtrade/constructionindustry/articles/constructionstatistics/2018

In our view, a more transparent approach is to identify a range for potential productivity growth based on the variation in TFP growth observed across comparator sectors, and then to explain explicitly what factors are informing a judgment about where in the range to select a point figure from. Indeed, in other parts of the price control (e.g. the cost of capital), it is standard regulatory

[35] Oxera, "Addressing Ofwat's Response to Yorkshire Water Services' Statement of Case", 26 May 2020, p.39

[36] Ecorys (2019): "Wegingsfactoren voor frontier shift TSO's - Eindrapportage", p.21, available at: https://www.acm.nl/sites/default/files/documents/2019-01/rapport-ecorys.pdf, referenced on p.65 of ACM (2019): "Gewijzigd Methodebesluit GTS 2017-2021", available at: https://www.acm.nl/sites/default/files/documents/2019-01/herstel-methodebesluit-gts-2017-2021.pdf

[37] South East Water, "Wholesale efficiency assessment – PR19 Supporting Appendix 13", September 2018, p.73, Table 4.8.

[38] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.7

procedure to identify a range based on the data and then to select a point figure from within that range.

The upper end of our range is consistent with evidence from six out of seven comparator sectors when GVA TFP growth estimates and embodied technical shift are taken into account

Oxera (for Yorkshire Water) argues that we have disregarded some of the comparator sectors in defining our range.[39] In his February 2020 report, Earwaker similarly argues that our upper bound disregards post-crisis evidence from four out of our seven comparator sectors.

We disagree with this argument, as once GVA-based TFP growth estimates and embodied technical shift are taken into account, our upper bound is consistent with post-crisis evidence for six out of seven of the comparator sectors. This is shown in the table below. The first column sets out our GO TFP growth estimates, and is what Earwaker bases his claim on. However, when the focus is on GVA TFP growth estimates (shown in the second column), six out of seven of our comparator sectors have a post-crisis growth figure in the region of our upper bound or higher, and the average across comparator sectors (1.3 per cent) is slightly above our upper bound. The third column shows the impact of applying an indicative 60 per cent uplift for embodied technical shift to our GO TFP growth estimates.[40] This column shows four out of the seven sectors have a growth figure in the region of our upper bound or higher, with an average across comparator sectors of 1.0 per cent. The final column shows the effect of applying the indicative uplift for embodied technical shift to our GVA TFP growth figures. In this column, six out of the seven comparator sectors have a growth figure substantially higher than our upper bound.

Table 2.3: TFP growth for comparator sectors in post-crisis period (2010-14) (%)

	Average GO TFP growth	Average GVA TFP growth	Average GO TFP growth with indicative uplift for embodied technical shift	Average GVA TFP growth with indicative uplift for embodied technical shift
Chemicals and chemical products	-0.7	-2.1	n/a (see note)	n/a (see note)
Construction	0.7	1.6	1.0	2.6
Machinery and equipment n.e.c.	1.0	2.4	1.5	3.9
Other manufacturing; repair and installation of machinery and equipment	1.3	2.7	2.1	4.3
Professional, scientific, technical, administrative and support service activities	1.5	2.6	2.4	4.2
Total manufacturing	0.3	1.0	0.5	1.6
Transport and storage	0.5	1.1	0.8	1.7
Average for comparators	0.6	1.3	1.0	2.1

Source: Europe Economics calculations
Note: Given the negative TFP growth figures for chemicals and chemical products, it is not straightforward to apply an uplift for embodied technical change to the data for this sector.

[39] Oxera, "Addressing Ofwat's Response to Yorkshire Water Services' Statement of Case", 26 May 2020, p.37-39

[40] See section 3.7.2 of our final PR19 report (p.66-68) for an explanation of this indicative figure of 60 per cent for the uplift that may be appropriate to take account of embodied technical shift.

In our final PR19 report, we explained that while our upper bound was based on the GO TFP growth rates for the stronger performing sectors, our recommendation that Ofwat should use a figure from the top end of the range took account of GVA-based TFP growth estimates and embodied technical shift.[41] The above table demonstrates clearly that when GVA TFP growth estimates and embodied technical shift are taken into account, our upper bound is supported by post-crisis evidence from six out of seven comparator sectors, and hence does not disregard evidence from four of the sectors as Earwaker claims.

Oxera has misinterpreted the academic papers we used to quantify the potential impact of embodied technical change

Oxera argues that the academic papers by Uri[42] and Hulten[43] that we have used to calculate our indicative uplift for embodied technical shift actually show that embodied technical change makes no difference. In particular, it states:[44]

> … even explicitly accounting for the presence of quality effects on capital—which are assumed to equate to embodied technical change—Hulten finds that the resulting productivity estimate is roughly equal to the unadjusted TFP. Similarly, the TFP estimate in Uri's study is between 3.3% and 3.7% and 2.7% and 3.2% (depending on the labour variable used), regardless of the assumed level of embodied technical change.
>
> As a result, the very same studies that Europe Economics considers to inform the 60% uplift in fact provide consistent TFP estimates, irrespective of whether embodied technical change is included in the estimation.

In our view, Oxera is misinterpreting the academic papers that we used in our quantification of the uplift for embodied technical shift.

Uri presents results for a number of different models which involve different levels of embodied technical change. The TFP ranges that Oxera quotes from Uri's paper are based on the estimated coefficients for Uri's variable for disembodied technical progress across these different models. By definition, this variable excludes embodied technical progress, and hence all that Oxera's argument shows is that Uri's estimates of disembodied technical change are similar regardless of the amount of embodied technical shift in the model. Since embodied technical shift is by definition separate from disembodied technical shift, this finding makes no difference to the validity of applying an uplift to take account of embodied technical change.

Uri further finds that the models which fit the data best have embodied technical progress of 3 to 4 per cent per annum, which is roughly the same order of magnitude as disembodied technical shift. In particular, he states:[45]

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41 Europe Economics, "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, p.79-80, 84-85

42 Uri (1983), "Embodied and disembodied technical change and the constant elasticity of substitution production function". Journal of Applied Mathematical Modelling, Vol. 7(6), pp. 399-404

43 Hulten (1992), "Growth Accounting When Technical Change is Embodied in Capital", The American Economic Review, Vol. 82, No. 4 (Sep., 1992), pp. 964-980

44 Oxera, "Addressing Ofwat's Response to Yorkshire Water Services' Statement of Case", 26 May 2020, p. 42

45 Uri (1983), "Embodied and disembodied technical change and the constant elasticity of substitution production function". Journal of Applied Mathematical Modelling, Vol. 7(6), p.403

> One can conclude that disembodied technical progress can be estimated at around 3% annually, embodied technical progress in the capital stock is in the neighbourhood of 3-4% …

Given that embodied technical change is not captured in the ranges quoted by Oxera, the embodied technical change identified by Uri is clearly separate and additional to Oxera's ranges. Hence, the results presented in Uri's paper clearly justify applying an uplift to the TFP ranges that Oxera quotes in order to take account of embodied technical progress.

In the case of Hulten's paper, it is unclear whether Oxera has understood the purpose for which we used this paper. Uri's paper on its own would have suggested that TFP estimates should be uplifted by 100 per cent to take account of embodied technical shift. However, applying a 100 per cent uplift would have assumed that EU KLEMS has succeeded in fully adjusting for changes in the quality of inputs, such that all of the estimated TFP growth represents disembodied technical change. However, we identified in our final PR19 report that in practice a proportion of embodied change may end up being captured in TFP estimates due to difficulties in fully taking account of changes in input quality.[46] Consequently, to avoid over-stating the appropriate uplift for embodied technical shift, we required an estimate of the amount of embodied technical shift that may already be included within TFP estimates due to difficulties in fully adjusting inputs for quality. We used Hulten (1992) to provide this estimate.

It is not clear that Oxera have correctly understood the table in Hulten (1992) that it references in its argument.[47] The top row in the table shows TFP estimates measured in an inadequate way by the US Bureau of Labor Statistics, with insufficient adjustments for the quality of output and for the quality of capital inputs. The following lines then show how such estimates would change if appropriate adjustments are made for the quality of capital inputs (row 2) and the quality of outputs (row 3) to give a correct estimate of the residual (row 4).

For our purposes, however, the key table in Hulten's paper is Table 4.[48] As Hulten explains, this table shows that changes in the quality of capital inputs accounted for approximately 20 per cent of the residual growth in quality-adjusted output not attributable to inputs. In the light of this evidence, we therefore assumed that 20 per cent of TFP growth estimates already represents embodied technical shift due to inadequate adjustment of inputs for quality.

This means that a 100 per cent uplift for embodied technical shift (as would be implied by Uri's paper on its own) would be an overestimate, as some embodied technical change has already "leaked" into TFP due to the difficulty of adequately adjusting inputs for quality.

As explained in our final PR19 report on RPEs and frontier shift[49] and in our previous note responding to Oxera on the issue of embodied technical shift,[50] when the evidence from Hulten is taken into account alongside the evidence from Uri it implies that an uplift of only 60 per cent

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46 Europe Economics, "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, p.67

47 Table 5 on p.976 of Hulten (1992), "Growth Accounting When Technical Change is Embodied in Capital", The American Economic Review, Vol. 82, No. 4 (Sep., 1992), pp. 964-980

48 Table 4 on p.975 of Hulten (1992), "Growth Accounting When Technical Change is Embodied in Capital", The American Economic Review, Vol. 82, No. 4 (Sep., 1992), pp. 964-980

49 Europe Economics, "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 7 December 2019, p.67-68

50 Europe Economics, "Europe Economics' Response to Oxera's Arguments on Embodied Technical Shift", 30 April 2020, p.5, available at: https://www.ofwat.gov.uk/wp-content/uploads/2020/05/Europe-Economics-note-on-embodied-technical-shift-30-April.pdf

(rather than 100 per cent) is required to capture the impact of embodied technical change. This is because total amount of embodied technical shift (the 20 per cent of TFP that is already embodied technical shift plus the 60 per cent uplift) would then equate to the amount of disembodied technical shift (the residual 80 per cent of TFP), in line with Uri's finding that the two are roughly equal in magnitude.

Oxera is misguided in claiming that its position on embodied technical shift is intuitive

Oxera argues that its view that the inclusion of embodied technical change makes no difference is "intuitive". In particular, it states:

> This result is intuitive, as one would expect that incorporating quality adjustments into inputs would imply similar adjustments for outputs (as the inputs of an industry downstream largely correspond to the outputs of an industry upstream).

We consider that Oxera is confused at this point. In order for TFP to be a correct estimate of disembodied technical shift (which is what TFP is intended to measure), both outputs and inputs should already be appropriately quality adjusted.

For example, the following quote from the OECD manual on measuring productivity explains how inputs should be adjusted for quality in order to calculate Multi Factor Productivity (MFP) correctly:[51]

> When capital inputs are measured as indicated by production theory, with a differentiation between types of assets, and based on price indices of capital goods that reflect the improvement in quality and design between vintages, the capital term … captures both changes in the quantity and in the quality of capital as an input to production. A similar point can be made for labour input, and for intermediate inputs. … It follows that when labour and capital are carefully measured, taking into account their heterogeneity and quality change, the effects of embodied technical change (in capital and intermediate inputs) and of improved human capital (in labour) should be fully reflected in the measured contributions of each factor of production. It also follows that the MFP term … does not reflect the effects of embodiment.

Our understanding is that EU KLEMS attempts to control for labour quality with its labour composition term and to control for the quality of outputs and of capital and intermediate inputs by using quality-adjusted price deflators.

Consequently, our argument that embodied technical shift needs to be taken into account is not about introducing quality adjustments into the measurement of outputs or inputs — those quality adjustments should have already have been included.

Applying an uplift for embodied technical shift does not imply that respected organisations have underestimated TFP growth

Oxera argues that applying an uplift as high as 60 per cent would suggest that TFP estimates or output measures published by national statistical agencies and some of the most credible

[51] OECD, "Measuring Productivity; OECD Manual; Measurement of Aggregate and Industry-Level Productivity Growth", 2001, p.116, available at: http://www.oecd.org/sdd/productivity-stats/2352458.pdf

international economic organisations (e.g. Eurostat and OECD) are severely understated. It argues that such an adjustment is simply too large to be credible.[52]

We disagree with Oxera's reasoning, which appears to be based on a misunderstanding about what TFP growth estimates are trying to measure.

TFP growth is intended to be a measure of disembodied technical shift. For example, the OECD manual on measuring productivity states:[53]

> Conceptually, **the KLEMS productivity measure captures disembodied technical change**. [*Europe Economics emphasis*]

Hence, TFP estimates are intended to exclude embodied technical shift. This is achieved by quality adjustment of inputs, so that improvements in the quality of inputs are treated as an increase in the quantity of (quality-adjusted) inputs and thus do not show up in the TFP residual. The OECD manual on measuring productivity states:[54]

> When capital and intermediate input measures are aggregators of detailed types of assets and products, each weighted by their respective share in total cost, and based on prices that reflect quality change, **the effects of embodied technical change are picked up by the capital and intermediate inputs terms, and only disembodied technical change enters the MFP measure**. [*Europe Economics emphasis*]

Consequently, our arguments about embodied technical shift do not imply that TFP estimates published by reputed organisations are under-estimated, since TFP estimates are not meant to capture embodied technical shift in the first place.

However, when setting frontier shift in a regulatory setting, we consider that regulators should take account of both embodied and disembodied technical shift, since both give rise to additional cost savings through time for regulated firms. This means that alongside TFP estimates (which by definition are intended to capture only disembodied technical shift) we also need to include an uplift to take account of embodied technical shift.

[52] See page 42 in Oxera, "Addressing Ofwat's Response to Yorkshire Water Services' Statement of Case", 26 May 2020

[53] OECD, "Measuring Productivity; OECD Manual; Measurement of Aggregate and Industry-Level Productivity Growth", 2001, p.18, available at: http://www.oecd.org/sdd/productivity-stats/2352458.pdf

[54] OECD, "Measuring Productivity; OECD Manual; Measurement of Aggregate and Industry-Level Productivity Growth", 2001, p.18, available at: http://www.oecd.org/sdd/productivity-stats/2352458.pdf

3 Response to Some Key Points on Real Price Effects (RPEs)

In this section, we respond to points made by Northumbrian Water and Earwaker in relation to the following issues:

- whether there is any CMA precedent for considering a new approach to RPEs;
- whether CPIH indexation would be sufficient for a cost item which has the same share in CPIH as in water company costs; and
- whether the COVID-19 crisis is likely to reduce input power prices and input chemical prices.

We address these in turn below. In each case, we first summarise the key point made by Northumbrian Water or Earwaker, and we then set out our response.

The CMA has recognised in a previous case that the historical approach to RPEs may need to change

In section 3.2 of his February 2020 report, Earwaker states that Ofwat's methodology for assessing the case for RPEs was novel and complicated, and departed from established regulatory precedent used in at least three past inquiries conducted by the Competition Commission / Competition and Markets Authority (CMA).[55]

We explained in our final PR19 report that Ofgem's experience with the RIIO-1 controls[56] highlighted the need for caution when including allowances for RPEs, and hence demonstrated the need for regulators to change their historical approach to RPEs.

The CMA's final determination in the case "British Gas Trading Limited v. The Gas and Electricity Markets Authority" appeared to recognise that there might be a need to move away from the historical approach of providing ex ante allowances based on forecast RPEs. In particular, the CMA stated:[57]

> GEMA's decision to set an ex ante allowance for RPEs gave rise to material forecasting difficulties for the DNOs. GEMA had identified particular concerns in relation to the forecasting of RPEs during the RIIOED1 process. In its Draft Determinations, GEMA noted that while it has used an ex ante RPE forecast before, there had been a change in the trajectory of input price indices in aggregate since 2010/11 and for some indices since 2004/05. GEMA said that this indicated that there may be increased uncertainty in a forecast of RPEs which may cast doubt over the use of an ex ante forecast for an eight-year control.

[55] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.9

[56] For further details on Ofgem's experience regarding RPEs at the RIIO-1 control, please see footnote 1 on p.13, or our discussion on p.104, p.110 or p.127 of Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations".

[57] Competition and Markets Authority, "British Gas Trading Limited v. The Gas and Electricity Markets Authority; Final Determination", 29 September 2015, p.102, available at: https://assets.publishing.service.gov.uk/media/5609588440f0b6036a00001f/BGT_final_determination.pdf

GEMA considered the uncertainty associated with forecasting RPEs as raising sufficiently material issues that – following the Draft Determinations stage – GEMA initiated a new and separate consultation on whether there was a better way to deal with RPE uncertainty. In the event GEMA retained its ex ante RPE approach in the Final Determinations.

CPIH indexation would be sufficient for a cost item which has the same share in CPIH as in water company costs

In his February 2020 report, Earwaker argues that omitting to provide an RPE allowance on the grounds that the cost item has a similar share in CPIH as in the water sector cost base could wrongly mean that no RPE allowance is provided even where there is a persistent, knowable gap between input price inflation and CPIH inflation.[58]

In footnote 13 of his report,[59] however, Earwaker acknowledges that there is a scenario in which CPIH indexation would in fact be adequate to compensate companies for a positive RPE in cases where the cost item has the same share in CPIH as in the water sector cost base. He states:

"The only scenario that I can envisage in which a company is remunerated in full for the higher price it pays is if projected input price increases across the remainder of the firm's expenditure happens to exactly match projected inflation in the rest of the CPIH basket."

Earwaker then goes on to state that it would be "an extraordinary coincidence" if this were to be the case.

While it is true that input price inflation across the remainder of water companies' costs may not exactly match inflation in the rest of the CPIH basket, Earwaker does not acknowledge that any difference between the two might be in either direction. If prices for the rest of the CPIH basket are rising faster than input prices for the rest of water industry costs, then CPIH indexation will over-compensate water companies. On the other hand, if prices for the rest of the CPIH basket are rising more slowly than input prices for the rest of water industry costs, then CPIH indexation will undercompensate water companies. In the absence of any information as to the direction of effect, we consider that an assumption that the two things are equal is a neutral assumption to make.

Our final PR19 report found no evidence of a statistically significant wedge between aggregate water sector input prices[60] and CPIH since 2010,[61] which tends to support an assumption that there is not a significant difference between price inflation for the CPIH basket and input price increases for water industry costs.

The COVID-19 crisis is likely to reduce input power prices, regardless of any link with world oil prices

In its appendix on COVID-19, Northumbrian Water argue that Ofwat's expectation that COVID-19 will result in falling real energy costs, in part due to falling world oil prices, "is not tenable

[58] Earwaker, "A review of Ofwat's PR19 FD approach to estimating frontier shift", February 2020, p.11

[59] Earwaker (2020): "A review of Ofwat's PR19 FD Approach to Estimating Frontier Shift", p.11.

[60] Using the "GSI groups input PPI for water collection, treatment and supply" which looks at changes in the price of all water sector inputs.

[61] Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", p.51-52.

because there has been a weak correlation between oil prices and electricity prices for some time".[62]

The suggested link between oil and electricity prices comes from long-term gas contracts that are linked to oil prices, with wholesale gas prices in turn affecting wholesale electricity prices due to the importance of gas-fired generation as a marginal source of electricity in the UK.

While it is true that the use of oil-price indexed contracts for pipeline gas has diminished considerably in recent years, we understand that oil-price indexed contracts continue to play a significant role for Liquefied Natural Gas (LNG), which represents an important source of gas at the margin. For example, the Oxford Institute for Energy Studies stated in April 2020:[63]

> in Europe, LNG is important as the marginal supply source. … Global LNG import pricing changed rather less during 2005-18 with oil-linkage still dominant but falling from 82% to 66%, and the share of market-priced LNG rising from 13% to 34%.

A special feature on trends in trade in LNG in the UK and Europe published by the UK Department for Business, Energy & Industrial Strategy stated the UK imported 18.7 bcm of LNG in 2019, accounting for 39 per cent of natural gas imports and one-fifth of total supply.[64] The same document also mentions the role of LNG contracts with Qatar that are indexed to the oil price.[65]

Regardless of whether or not there is a continuing link between oil and power prices, the COVID-19 crisis would in any case be expected to reduce UK power prices directly due to reductions in the demand for electricity. Analysis by National Grid ESO showed that the UK lockdown reduced overall electricity demand by 10 per cent due to reduced demand from industrial customers, with demand in the morning falling by almost 18 per cent.[66] Electricity demand is likely to recover somewhat as the UK lockdown is eased. Nonetheless, under some COVID-19 scenarios there may be continuing impacts on electricity demand over the first part of AMP7 due to potential further lockdowns if the virus starts spreading again and due to economic scarring from the recession caused by COVID-19.

Analysis published by Independent Commodity Intelligence Services (ICIS) considered a scenario in which power demand drops by one-tenth from March until June as a result of measures taken to control coronavirus, with a steady recovery in demand from July to December. ICIS modelling

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[62] Northumbrian Water Limited, "Appendix 1; COVID-19 Appendix", Table 2 in Section 1.9

[63] The Oxford Institute for Energy Studies, "A Comparative History of Oil and Gas Markets and Prices: is 2020 just an extreme cyclical event or an acceleration of the energy transition?", April 2020, available at: https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/04/Insight-68-A-Comparative-History-of-Oil-and-Gas-Markets-and-Prices.pdf

[64] Department for Business, Energy & Industrial Strategy, "Energy Trends: March 2020, special feature article - Trends in trade of Liquefied Natural Gas in the UK and Europe", March 2020, p.55, available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/875383/Trends_in_trade_of_Liquefied_Natural_Gas_in_the_UK_and_Europe.pdf

[65] Department for Business, Energy & Industrial Strategy, "Energy Trends: March 2020, special feature article - Trends in trade of Liquefied Natural Gas in the UK and Europe", March 2020, p.54, available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/875383/Trends_in_trade_of_Liquefied_Natural_Gas_in_the_UK_and_Europe.pdf

[66] National Grid ESO, "What does lockdown mean for electricity in Great Britain?", available at: https://www.nationalgrideso.com/news/what-does-lockdown-mean-electricity-great-britain

suggested that this scenario would lead to a drop on average of €1.60/MWh (or 4 per cent) in UK power prices over 2020.[67]

Energy Brainpool (independent energy market experts from Germany) used three scenarios (a reference scenario, a COVID-19 oil crisis scenario and a recession scenario) to look at the impact of the COVID-19 crisis on electricity prices in European countries.[68] The article finds that under both the COVID-19 oil crisis and recession scenarios the average level of electricity prices is lower than under the reference scenario over the next few years. The article does not mention which countries are included so the analysis may not cover the UK, but nonetheless it illustrates the potential for COVID-19 to reduce power prices over the next few years.

The COVID-19 crisis is likely to reduce input prices for chemicals

In its appendix on COVID-19, Northumbrian Water argues that the COVID-19 crisis has put upward pressure on the prices of chemicals that it purchases.[69]

We note first of all that Northumbrian Water have not provided the evidence needed to evaluate its claim that input prices of chemicals that it purchases have increased. Without further evidence, it is unclear whether any price increases that it claims to have experienced for some chemicals might actually be offset by price reductions for other chemicals.

In our report for Ofwat on the impact of COVID-19 on RPEs and frontier shift, we identified that the effect of the COVID-19 crisis on input prices for chemicals was indeterminate on *a priori* grounds, given that the sector faced both a slump in demand and supply-side difficulties.[70]

However, the emerging empirical evidence suggests that in fact the COVID-19 crisis is reducing the price of industrial chemicals. In our final PR19 report, we briefly considered some World Bank price forecasts for certain chemicals in analysing whether there was a case for an RPE for chemicals (although this was not the key evidence that informed our conclusion).[71] The table below shows the latest World Bank forecasts for these chemicals published in April 2020. These forecasts imply that the COVID-19 crisis will materially reduce the price of these chemicals during 2020. While these may not be the chemicals of most relevance to water companies, we suggest that similar impacts are likely to materialise for other industrial chemicals prices as well.

[67] ICIS, "Virus demand hit to wipe 9% off 2020 European power prices", 23 March 2020, available at: https://www.icis.com/explore/resources/news/2020/03/23/10485642/virus-demand-hit-to-wipe-9-off-2020-european-power-prices

[68] Energy Brainpool, "Coronavirus pandemic and the energy market: a quantitative assessment of medium-term developments", 9 April 2020, available at https://blog.energybrainpool.com/en/coronavirus-pandemic-and-the-energy-market-a-quantitative-assessment-of-medium-term-developments/

[69] Northumbrian Water Limited, "Appendix 1; COVID-19 Appendix", Table 2 in Section 1.9

[70] Europe Economics, "Impact of COVID-19 Crisis on Real Price Effects (RPEs) and Frontier Shift", 27 April 2020, p.20.

[71] Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", p.42-43

Table 3.1: World Bank forecasts of change in chemicals prices in 2020 (constant US dollars)

	April 2019 forecast[72]	April 2020 forecast[73]
DAP	0.3	-6.5
Phosphate Rock	0.0	-10.2
Potassium Chloride	0.9	-3.5
TSP	-0.6	-12.8
Urea	0.0	-10.1

Source: World Bank

Similarly, Argus Media has published the following commentary on chemicals markets:[74]

> "European chemical prices remain under pressure from the falls in upstream costs and weaker demand owing to Covid-19 lockdowns, offset partly by firm demand into certain segments and a reduction in derivative imports."

Hence, we consider it likely that input chemicals prices for the water industry will be lower as a result of the COVID-19 crisis, in contrast to what Northumbrian Water claims.

[72] World Bank Commodities Price Forecast (April 2019) (constant US dollars), page 2. Available at: http://pubdocs.worldbank.org/en/598821555973008624/CMO-April-2019-Forecasts.pdf

[73] World Bank Commodity Market Outlook (April 2020) (constant US dollars, 2010=100), page 46. Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/33624/CMO-April-2020.pdf?sequence=9&isAllowed=y

[74] Argus Media, "Update: Coronavirus impact on European petrochemical market", 28 April 2020, p.2 available at: https://www.argusmedia.com/-/media/Files/white-papers/argus-white-paper-coronavirus-impact-on-european-petrochemical-market.ashx