FRONTIER SHIFT AT PR24

Response to Ofwat draft methodology

September 2022

Economic Insight

On behalf of a consortium of water companies, Economic Insight has been asked to develop a robust approach for deriving best-practice marginal cost estimates; a framework for establishing what level of performance is funded in cost allowances; and quality-adjusted measures of productivity. As the quality-adjusted productivity analysis is contingent on our ongoing marginal cost workstream, in this note we provide an 'early view' of what frontier shift might look like, based on the 'conventional' approach, where we use comparators, without adjusting for quality.

1 Introduction

Over recent price controls, regulators have been setting increasingly challenging frontier shift targets. At PR19 FD, Ofwat set a frontier shift challenge of 1.1% per annum, based upon an estimated range between 0.6% and 1.2%. Following its redeterminations for Anglian; Bristol; Northumbrian and Yorkshire Water, the CMA set a similar frontier shift figure of 1.0% per annum.

In this context, we have been commissioned by a consortium of 14 water companies to develop a quality-adjusted frontier shift estimate for their PR24 Business Plans. This is dependent on our broader work to estimate marginal costs for those companies, which is still ongoing. Therefore, this note provides an (initial) overview of the scope for frontier shift, using a conventional comparator-based approach (i.e. without adjusting for quality). We do not set out our own view on the frontier shift range in this paper. Rather, our focus is on providing a clearer understanding of the key issues that need to be addressed at PR24; and an assessment of recent regulatory decisions in the context of those issues (including showing what frontier shift would look like at PR24, if prior methods applied by regulators were simply updated). The remainder of document is structured as followed.

- In **Section 2**, we examine Ofwat's and the CMA's positions at PR19.
- In **Section 3**, we show the results of undertaking a straight update of this approach using a more recent EU KLEMS productivity dataset, and assess how Ofwat's target is positioned compared to all other industry performance across the UK.

- In **Section 4**, we assess Ofgem's position in its RIO-ED2 Draft Determinations, and Ofwat's position in its draft methodology.
- In **Section 5**, we set out our early view on the issues associated with setting a quality-adjusted frontier shift, and how to tackle them.

2 Ofwat and the CMA positions at PR19

Ofwat's frontier shift challenge was based upon average EU KLEMS TFP growth across comparator sectors.[1] These comparators were selected primarily based upon having similar capital intensity ratios to water. To calculate frontier shift, Ofwat used both business cycle and entire time series estimates.

- **Business cycle estimates.** The advantage of this approach is that productivity is procyclical, so it captures all extremes through the economic cycle. Ofwat used the NACE 1 EU KLEMS dataset (spanning 1970 to 2007) to analyse: (i) the most recent cycle (1990 to 2007); (ii) the previous complete cycle (1980 to 1989); and (iii) an average of the two most recent cycles.
- **Time series estimates.** The advantage of this approach is that it makes maximum use of available data. Ofwat used the NACE 2 EU KLEMS dataset (spanning 1999 to 2014) to assess: (i) the entire period (1999 to 2014); (ii) the pre-crisis period (1999 to 2007); and (iii) the post-crisis period (2010 to 2014).

The final key feature of Ofwat's analysis is that it used gross output TFP as its main measure. This is significant because the NACE 1 and NACE 2 EU KLEMS datasets are only reported as value-added TFP. Therefore, Ofwat multiplied value-added TFP (TFP_{VA}) by the ratio of value-added to gross output, in order to convert the metric into gross output TFP (TFP_{GO}). Both value-added (VA) and gross output (GO) are obtained from the same EU KLEMS dataset as value-added TFP. This is depicted by the formula below.[2]

$$TFP_{GO} = TFP_{VA} \times \frac{VA}{GO}$$

In theory, this formula adjusts TFP by the intermediate outputs included or excluded in gross output and value-added TFP respectively. Whilst this conversion is accurate if the ratio of intermediate inputs remains constant over time, these inputs will always vary to a certain extent. This means the adjustment cannot be accurately applied.

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1 *Ofwat's comparators were: 'Construction'; 'Total manufacturing'; 'Transport and storage'; 'Chemicals and chemical products'; 'Machinery and equipment n.e.c.'; 'Professional, scientific, technical, administrative and support service activities'; and 'Other manufacturing; repair and installation of machinery and equipment'.*

2 *Gross output (GO) is a measure of sales achieved from production of a sector. It will include intermediate inputs. Value-added (VA) calculates the value of gross output generated by primary inputs (labour and capital). It excludes the value of intermediate inputs.*

The CMA's redetermination

For the most part, the CMA agreed with Ofwat's methodology. It used the same datasets; comparators; and time series analyses as Ofwat. However, there were a few methodological differences:

- The CMA preferred assessing productivity growth over full business cycles, due to the metric's procyclical nature. It favoured the most recent full business cycle, between 1990 and 2007. We note that the procyclical nature of productivity goes to a wider point, which we discuss subsequently. Namely, that assumptions across the price control should be internally consistent (by which, in this case, we mean the assumptions regarding the UK's economic performance and associated time horizon should, logically, have implications for productivity; equity returns; and so on). This means it is inconsistent to assume that equity returns are either low or falling, whilst also assuming that productivity is high or rising.

- The CMA acknowledged that productivity has flatlined across the UK since 2007. Whilst it did not apply any downward adjustments to account for this, lower post-crisis productivity growth was more actively considered by the CMA when setting a final frontier shift challenge.

- The CMA gave more weight to value-added TFP. Its rationale was twofold: (i) the OECD manual suggests that there is empirical justification for both measures; and (ii) the gross output TFP measure is less accurate, as it can be subject to error. This is caused by its inclusion of intermediate outputs (as per our comment on Ofwat applying its own adjustment to derive an 'estimate' of a gross output metric).

3 A straight update of the Ofwat / CMA approach

In 2021, EU KLEMS released its latest dataset. This contains data spanning from 1995 to 2019. This gives us the ability to update time series estimates from PR19. We note that this data does not contain the most recent business cycle, so we cannot yet update business cycle estimates.

When updating times series estimates, we can extend the period under consideration to: (i) the entire period (1999 to 2018); and (ii) the post-crisis period (2010 to 2018). The results of this update are shown in Table 1 below, with our updated calculations next to Ofwat's estimates from PR19 in red.

Table 1: Straight update of Ofwat's PR19 approach with more recent data

Comparator	Gross output average 1999-2018 (1999-2014)	Gross output post-crisis 2010-2018 (2010-2014)	Value-added average 1999-2018 (1999-2014)	Value-added post-crisis 2010-2018 (2010-2014)
Chemicals and chemical products	0.9% (0.8%)	0.8% (-0.7%)	3.0% (2.0%)	2.4% (-2.1%)
Construction	0.0% (-0.1%)	-0.1% (0.7%)	0.0% (-0.2%)	-0.2% (0.4%)
Machinery and equipment	0.8% (0.9%)	-0.5% (1.0%)	1.5% (2.2%)	-1.1% (2.4%)
Other manufacturing	0.8% (1.0%)	0.7% (1.3%)	1.5% (2.1%)	1.3% (2.7%)
Professional, scientific, technical	0.9% (0.9%)	1.0% (1.5%)	1.5% (1.5%)	1.8% (2.6%)
Total manufacturing	0.6% (0.6%)	0.1% (0.3%)	1.6% (1.7%)	0.3% (1.0%)
Transport and storage	-0.2% (0.0%)	-0.2% (0.5%)	-0.5% (0.0%)	-0.6% (1.1%)
Average	**0.5% (0.6%)**	**0.3% (0.6%)**	**1.2% (1.3%)**	**0.5% (1.3%)**

Source: Economic Insight analysis of EU KLEMS data; and Ofwat PR19 FDs

These updated estimates are lower than those calculated by Ofwat at PR19, whilst gross output TFP figures are in line with those produced by CEPA for Ofgem in the recent ED2 DD. The inclusion of more post-crisis data explains the lower estimates. Put simply, since the 2008 financial crisis, productivity has flatlined (and continues to do so).

If Ofwat was to set a target range using this data (i.e. maintaining its prior method and rationale) it could set a range of between 0.3% and 1.2%. The 0.3% lower bound is based upon Ofwat's prior stated rationale of setting the lower bound based upon post-crisis (2010 – onwards) data. Following Ofwat's reasoning, the upper bound is based upon the average of the top four performing sectors in the pre-crisis period.[3] However, the upper bound was also justified by Ofwat on the basis that three of these four sectors were also clustered around this 1.2% level in the post-crisis period.[4] This second justification no longer holds when using the updated data. The sectors "Machinery and

[3] *Ofwat's top performing sectors were: 'Chemicals and chemical products'; 'Machinery and equipment n.e.c.'; 'Professional, scientific, technical, administrative and support service activities'; and 'Other manufacturing; repair and installation of machinery and equipment'.*

[4] *'Chemicals and chemical products' does not achieve performance close to the upper bound post-crisis.*

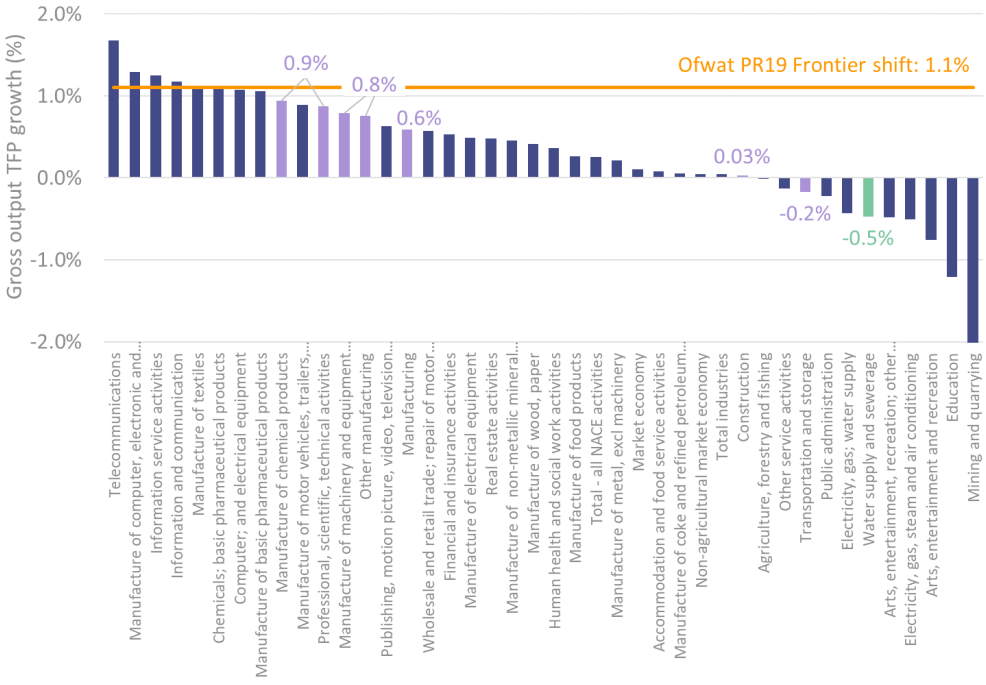
equipment n.e.c."; "Other manufacturing; repair and installation of machinery and equipment"; and "Professional, scientific, technical, administrative and support service activities" had TFP growth rates of 1.0%, 1.3% and 1.5% respectively in Ofwat's analysis, but TFP growth rates of -0.5%, 0.7% and 1.0% in the updated period. Therefore, objectively, if Ofwat maintained its method and rationale, it seems somewhat harder to support an upper bound of that level.

It is, of course, possible that Ofwat will revise its method (such as something similar to Ofgem's for its ED2 DD). Ofgem set frontier shift at the estimate that sat at the top of its value-added range (the pre-crisis period between 1999 and 2007).

Ofwat's target compared to UK industry-wide productivity performance

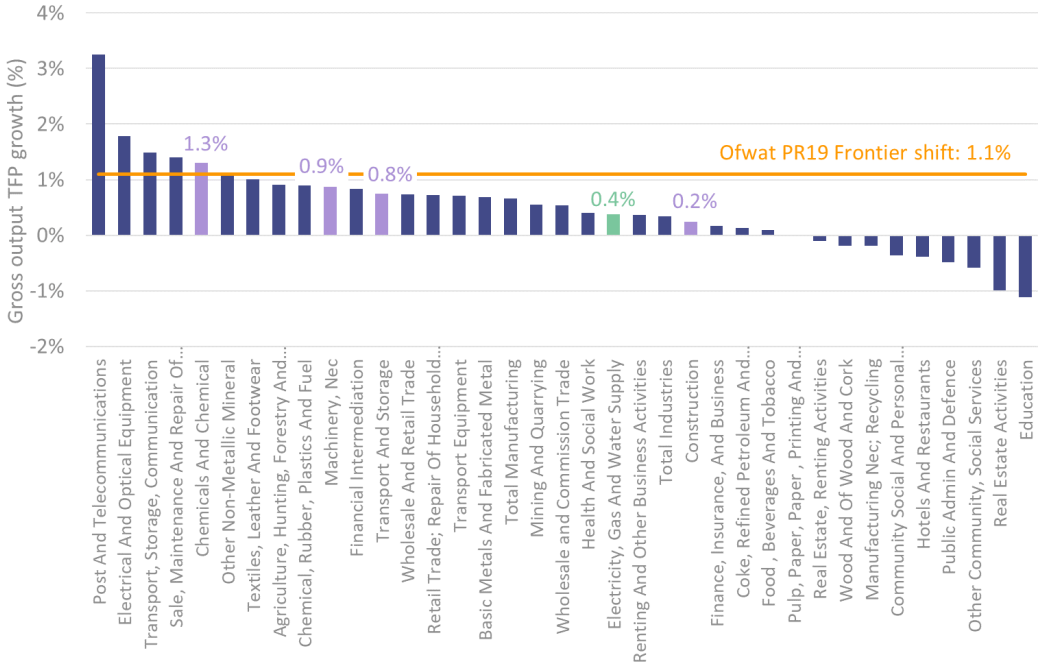
In the following figures, we examine Ofwat's assumed frontier shift (1.1% pa) at PR19 against the distribution of TFP growth across industries; and over four time periods. These periods include: the full updated dataset (1999 to 2018); the most recent business cycle (1990 to 2007); the pre-crisis period (1999 to 2007); and the post-crisis period (2010 to 2018). The graphs present all sectors in the EU KLEMS database, with Ofwat's comparators shown in purple, and the *'electricity, gas and water'* sector shown in green.

Figure 1: Sector level productivity growth (1999 to 2018)



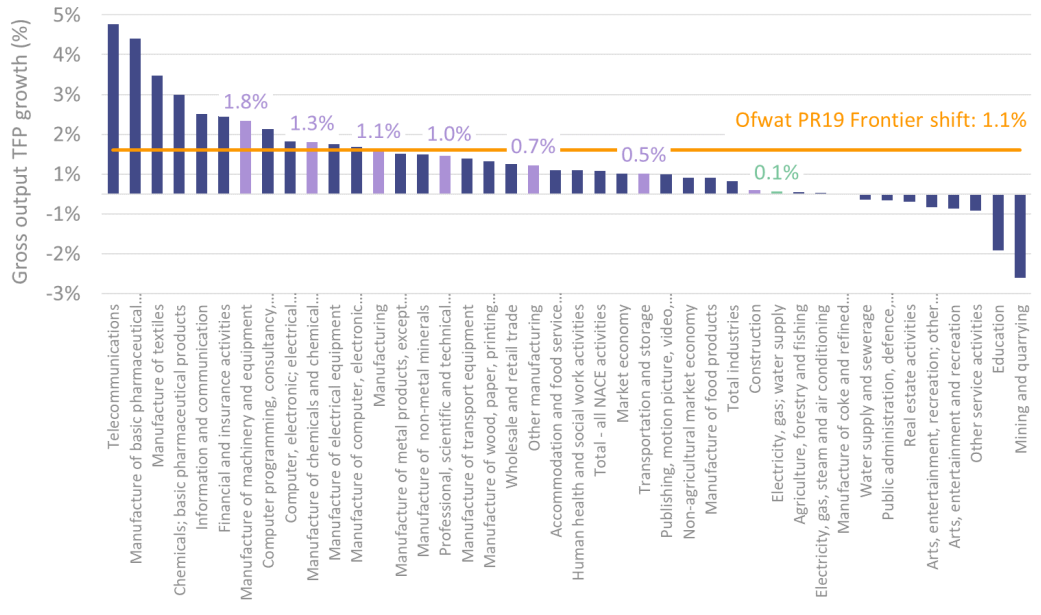
Source: Economic Insight analysis of EU KLEMS data

Figure 2: Sector level productivity growth (1990 to 2007)



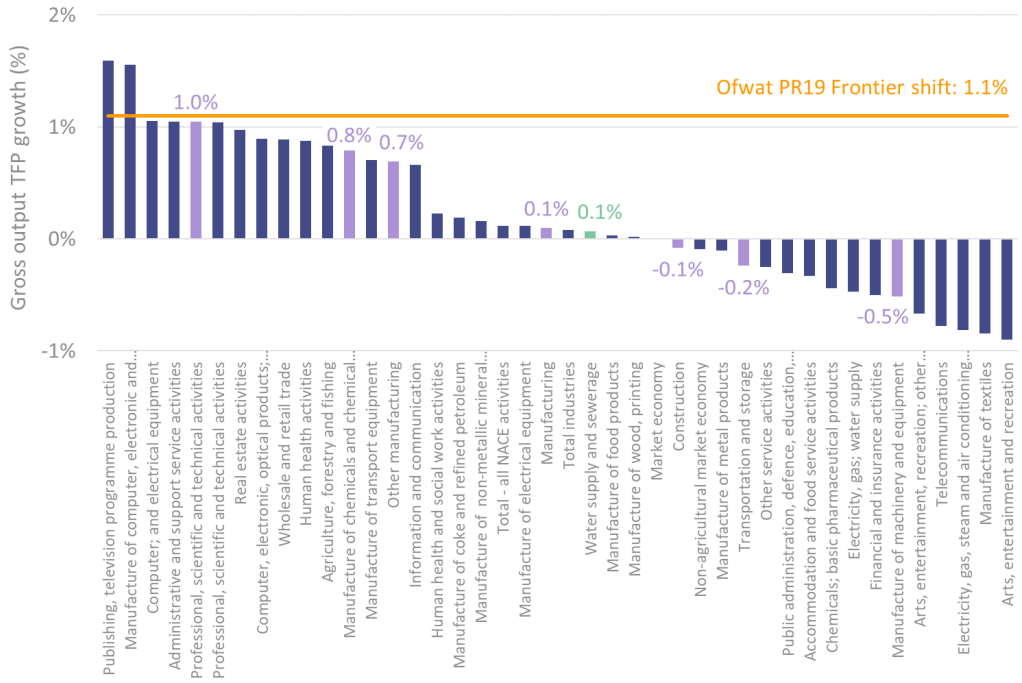
Source: Economic Insight analysis of EU KLEMS data

Figure 3: Sector level productivity growth (1999 to 2007)



Source: Economic Insight analysis of EU KLEMS data

Figure 4: Sector level productivity growth (2010 to 2018)



Source: Economic Insight analysis of EU KLEMS data

These graphs show that: (i) the comparators selected by Ofwat at PR19 generally have 'high' productivity relative to most; and (ii) 'electricity, gas and water supply' is both below average productivity and at the bottom of Ofwat's comparator range. This would seem to suggest that Ofwat's comparator choice (and selection of time periods) is driving a frontier shift position that, increasingly, *is an 'outlier'* (although clearly this is a matter of degree). This is borne out by the number of sectors that would meet Ofwat's frontier shift challenge over the various time periods.

- Between 1999 and 2018, 6 sectors would achieve Ofwat's challenge out of the 42 considered in the dataset (as shown in Figure 1).
- Between 1990 and 2007, 5 sectors would achieve Ofwat's challenge out of the 38 considered in the dataset (as shown in Figure 2).
- Between 1999 and 2007, 13 sectors would achieve Ofwat's challenge out of the 42 considered in the dataset (as shown in Figure 3).
- Between 2010 and 2018, 2 sectors would achieve Ofwat's challenge out of the 42 considered in the dataset (as shown in Figure 4).

Put another way, Ofwat's position suggests that the water industry should have productivity growth well above most (and for some time periods, 'almost all') other industries in the UK. One must therefore consider how plausible that implied relative performance is. Specifically, one might expect industries with very high TFP to have certain characteristics. For example, 'tech industries' tend to have high productivity (i.e. because, by definition, they have high rates of technological change / and / or high utilisation of technology, which drives greater productivity growth than a UK industry average). Consistent with this, industries that outperform most in the data are

computing, communications, and electrical equipment sectors. It is intuitively questionable as to whether the water industry could be similarly characterised.

4 Ofgem's position in its RIO-ED2 Draft Determinations; and Ofwat's position in its draft methodology.

Ofgem selected a frontier shift of 1.2% in its recent DD, based upon a range of 0.5% to 1.2%. The underlying data used was the 2019 EU KLEMS, which covered the period between 1995 and 2016. It is notable that although Ofgem commissioned CEPA to estimate frontier shift for them, the lowest values included in CEPA's 0.3% to 1.2% range were excluded from Ofgem's. In particular, the values excluded were post-crisis gross output TFP estimates. Ofgem also chose a frontier shift estimate above the submissions in DNOs business plans, which ranged between 0.5% and 1.0%. Its rationale was that "*there is an intrinsic incentive for DNOs to submit relatively modest OE targets compared with what they think they can realistically achieve*".[5]

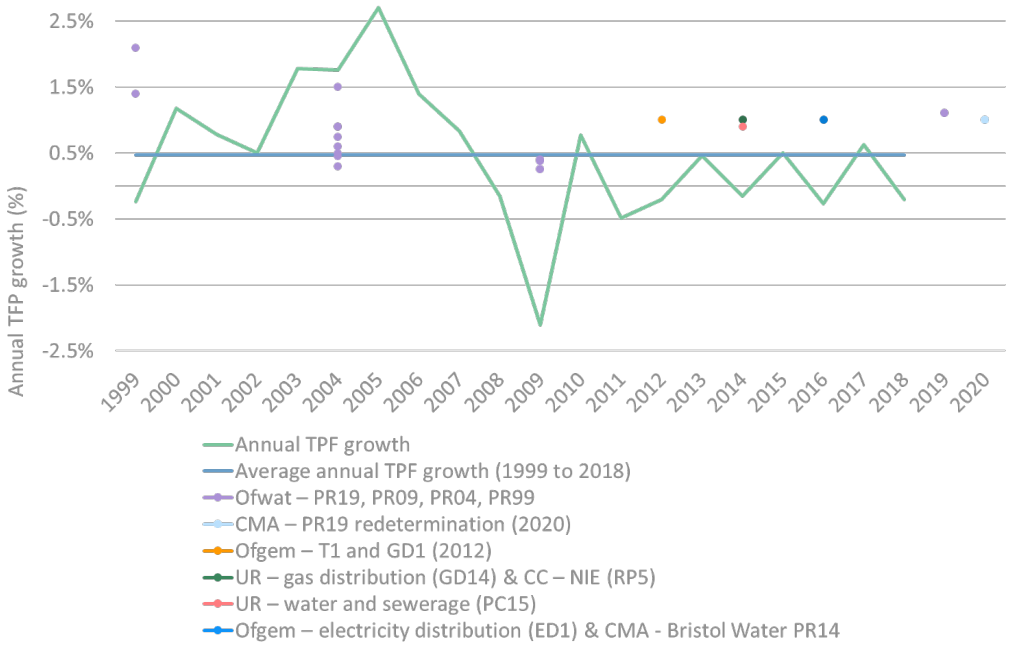
Whilst Ofgem agreed with Ofwat/CMA that embodied change was excluded from TFP, and values should be weighted equally, there were a couple of methodological differences. The most significant was that much greater weight was placed upon value-added TFP. Other notable features of Ofgem's approach included: (i) the target not controlling for macroeconomic events (Brexit, Covid, and Ukraine), as the regulator believed the price control structure insulated companies from adverse effects; and (ii) Ofgem's belief that its innovation fund should enable firms to achieve increased efficiency. It stated "*the evidence provided in the DNOs' Business Plan submissions in relation to what extent past innovation funding awarded in previous price controls could lead to further efficiencies beyond those in competitive sectors in RIIO-ED2; and to what extent the efficiencies arising from innovation could already be captured in the comparative benchmarking*".[6] In effect, this means that Ofgem's rationale is that the fund allows firms to unlock efficiencies that could not be achieved in the competitive sector, so should enable improved productivity performance.

In Ofwat's draft methodology for PR24, it made the same argument as Ofgem about the innovation fund. It felt that the fund would enable firms to achieve its 'aggressive' frontier shift target. Ofwat states that in PR19 the fund has enabled "*a significant increase in levels of collaboration between regulated companies which is stimulating greater levels of innovation and is helping to reduce the total cost of innovation in the sector*".[7] Ofwat indicated that it plans to challenge firms to improve productivity over PR24 due to its sentiment that since 2011 productivity growth in water has been below achievable levels. It notes that "*while the water sector showed relatively strong productivity post privatisation with growth of 3 to 4% per year between 1994 and 2000, it appears to have stagnated since 2011 with weak growth since then*".[8] As we have shown, this is not true (and more broadly, a very similar trend in productivity pre- and

[5] '*RIIO-ED2 Draft Determinations – Core Methodology Document*' *Ofgem; (2022); 7.476*
[6] '*RIIO-ED2 Draft Determinations – Core Methodology Document*' *Ofgem; (2022); 7.464*
[7] '*Consulting on our methodology for PR24' Ofwat; (2022); p.78*
[8] '*Consulting on our methodology for PR24' Ofwat; (2022); p.68*

post-crisis is seen across all industries in the UK. In contrast, in the water industry, frontier shift has migrated up from <0.5% pa in earlier price controls; to 1.1% at PR19).

Figure 5: UK TFP over time against recent regulatory decisions



Source: Economic Insight analysis of EU KLEMS data.[9]

Ofwat has indicated that, in addition to the £200 million innovation fund, it will consider two other areas when setting the target. Firstly, efficiency improvements that have been achieved in the rest of the economy. Secondly, the efficiency improvements that could become possible as the water sector moves in line with competitive sectors.

5 Our view on the key issues to address in setting frontier shift

Frontier shift cannot be directly observed. Instead, it is estimated from a variety of measures, such as TFP and MFP (used interchangeably). However, these measures are not strict equivalents of frontier shift. Whilst frontier shift is defined as the efficiency improvements that it is possible for even the most efficient firms to make over a period of time, TFP is measured as the change in 'outputs' relative to a change in 'inputs'. Due to TFP's broader definition, there is debate over what is captured within the metric, and the most appropriate way to apply it. Below we highlight the main issues.

[9] *Note: Ofwat's decision by price control component/period are as follows: PR99 base opex and capex: 1.40%, PR99 enhancement opex and capex: 2.10%; PR04 enhancement opex water: 0.90%, PR04 enhancement opex wastewater: 1.50%, PR04 base capex water: 0.30%, PR04 base capex wastewater: 0.50%, PR04 enhancement capex water: 0.45% , PR04 enhancement capex wastewater: 0.75%, PR04 base opex water: 0.60% , PR04 base opex wastewater: 0.90%, PR09 base opex: 0.25%, PR09 enhancement opex: 0.38%, and PR09 capex: 0.40%, PR19: 1.1%.*

- **TFP captures other efficiency savings that can be achieved.** This includes catch-up efficiency, economies of scale, and allocative efficiency. Accounting for these factors is important to ensure that frontier shift is neither over- nor under-stated.

- **The extent to which TFP excludes embodied technological change.** Whilst TFP uses quality-adjusted output measures, there is debate over whether its input measures are quality-adjusted. The significance of this is that if outputs are quality-adjusted, but inputs are not, then the frontier shift challenge could be overstated.

- **The overall result is highly sensitive to the choice of time period over which comparators are assessed.** Therefore, selecting the right time period is important to ensure that an estimate is calculated that provides a representative picture of the period under review.

TFP captures other efficiency savings that can be achieved

Our proposal is to isolate the frontier shift element of TFP through comparator choice. We explain how each of catch-up efficiency, allocative efficiency, and economies of scale would be expected to bias a frontier shift element; and our solution for how to address this.

- **The inclusion of catch-up efficiency within TFP would lead to frontier shift being over-stated.** This is because no sectors are perfectly competitive. This means that in any industry there are always some firms that operate behind the efficient frontier, so their TFP figures will contain a degree of catch-up. To mitigate this as best as possible, comparators can be selected that operate in as 'competitive' markets as possible.

- **The inclusion of allocative efficiency within TFP is likely to have a symmetrical effect on frontier shift (i.e. frontier shift is just as likely to be under- or over-stated).** This is because there is always a margin of error in measuring this effect, so some comparators will overstate the effect whilst others will understate. To mitigate this as best as possible, we will choose comparators that undertake activities that are as similar to those undertaken in water as possible.

- **Economies of scale will either over- or under-state frontier shift, depending on whether comparators benefit from more or less scale effects respectively.** As there is generally a relationship between the proportion of fixed cost and achievable scale effects, we will ensure comparators have similar fixed costs to the water industry. However, it is also possible that the rate of change of scale effects varies over time. This could mean that comparators benefit more or less from scale effects over the time period than the water industry. In reality, this will likely occur as comparator sectors grow or contract, whilst the output rates of the water industry remain relatively stable. As a mature sector, the output growth of the water industry will remain fairly stable over time, meaning the sector should benefit from a consistent rate of change of scale effects. However, over a period of time, it is likely that some comparator sectors will experience growth or contraction in their output growth rates. For an industry that benefits from scale effects, output growth/contraction will correspondingly increase/decrease the sector's rate of change of scale effects – by growing/shrinking the sector will be able to harness more/less scale effects. To control for this as best as possible, we will make sure that comparator output growth rates are approximately the same as those of the water industry.

Selection of time period

When considering which time periods to prioritise, there are three main factors to consider:

(i) To assess productivity over the entirety of a business cycle. This is because productivity is procyclical, so it is important to take an average of all of the extremes to avoid bias.

(ii) To account for productivity both before and after the financial crisis. The rationale is that the UK economy exhibited a clear structural break in productivity performance during this period. Therefore, it would be an omission to not account for performance both before and after the event.

(iii) To make maximum use of the data available. In general, there is merit in averaging over a long time period.

As these points require a trade-off, to understand which factors to prioritise, one must be clear on the question that data is being used to answer. In this case, we want to use data to understand 'what is the scope for frontier shift specifically over PR24?'. As productivity and economic outlook are well correlated, it is important to begin addressing this question by understanding the UK economic outlook over PR24.

From forecast data, it is clear that the UK is going to enter into a period of high volatility, with low growth and high inflation. The main UK forecast agencies all agree upon this, although there is slight disagreement over the scale of the effect (likely due to the publication dates of their various reports).

- In the OBR's July 2022 forecasts, it predicted that real GDP will grow at an average of 1.9% over the next five years. However, this growth is predicted against the backdrop of CPI inflation of 8.0% in 2022-23, 2.4% in 2023-24, and 1.7% in 2024-25, before it returns to target.

- In August 2022, the Bank of England forecast UK GDP (with world GDP in brackets) will grow by 3.5% (2.5%) in 2022, -1.5% (1%) in 2023, and -0.25% (1.5%) in 2024. Its MPC report also stated that CPI will average 13% in 2022, 5.5% in 2023, and 1.5% in 2024.

- In June 2022, HM Treasury forecast higher GDP growth of 3.6% in 2022, but this drops to 0.9% in 2023.

These forecasts are significant for a productivity study for two reasons: (i) productivity growth is lowest during economic downturns, which forecasters predict will occur at the start of PR24; and (ii) the high degree of volatility the economy is currently experiencing creates uncertainty, which makes it harder for firms to take the investment decisions required to achieve future productivity increases. Consequently, we believe data should be prioritised that most closely matches the characteristics predicted over the forthcoming time period. In our view, this means greater weight should be placed upon more recent data; and the final frontier shift challenge should not be overly ambitious, reflecting the fact that economic conditions are likely to suppress productivity over the next five year cycle.

The extent to which TFP excludes embodied technological change

To understand why the issue of whether embodied change is captured within TFP is a significant issue, it is first important to understand the mechanism behind it. One way that TFP growth can be achieved is to use higher quality inputs. This can be achieved through either embodied or disembodied technological change:

- Embodied technological change relates to productivity gains generated by improvements in the design and quality of new capital equipment and intermediate products, compared to using older iterations of the same equipment.

- Disembodied technological change relates to gains made without improvements in new equipment, for example, in knowledge and operating practice that lead to productivity gains without the need to invest in new equipment.

A TFP measure that excludes embodied change in effect has a quality adjusted output measure (i.e. prices reflect quality), but an unadjusted input measure that does not reflect the benefit of new technologies. This TFP measure would understate frontier shift.

Ofwat, Ofgem and the CMA have all stated the position that TFP largely excluded embodied change. The CMA believed that EU KLEMS TFP data "*did not seek to measure*

productivity growth resulting from changes in embodied technical change".[10] However, we have discussed the issue of embodied change with the ONS (noting that EU KLEMS draws on the ONS' data as inputs). It has informed us that "*some deflators applied to investment, e.g. the recently updated Telecoms deflator, do account for quality. On the other hand, others do not account for quality (the deflators team have told me there isn't a publication I could link you to which would have details of which deflators do account for quality, they said individual deflator QMIs are all that are available). Overall, MFP accounts for some embodied change.*" The significance of this is that it implies that it is incorrect to apply the broad-brush approach taken by regulators in recent price controls. Input measures for each sector vary substantially, so overarching conclusions cannot be drawn. Instead, for each comparator selected, the input measure used for that specific sector must be examined to understand the degree that the input measure is quality-adjusted.

Therefore, to understand whether there is a risk that TFP excludes embodied change for the frontier shift analysis, we recommend a four-stage approach:

(i) Work with companies to conduct a qualitative analysis of technical change in the water sector, and anticipated change over PR24 (putting together a 'timeline' onto which we broadly plot 'key' changes in technology).

(ii) Analyse TFP growth for the water sector and determine whether periods of technological change correlate with increased TFP growth.

(iii) Review further academic material to see if we can find more sources. From our existing research, we have identified academic articles that estimate between 20%[11] and 60%[12] of TFP growth represents embodied change. However, these estimates should be taken with certain caveats. Firstly, both studies rely upon data that is forty years old, when productivity growth was higher than it is now. Secondly, they take data from the US, whose economy is subject to higher levels of investment and greater productivity growth. Therefore, although these academic sources are informative in providing a starting point for quantifying the degree to which TFP underestimates achievable frontier shift, their calculations should not be taken as a 'rule' for any adjustments required.

(iv) For the comparator selected in the final analysis, we will review the sector-specific input metrics. We will breakdown the input composition, to see the degree to which they are quality-adjusted.

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[10] *'Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations Final report.' CMA; (2021); 4.553*

[11] *"Growth Accounting When Technical Change is Embodied in Capital." Hulten, C; The American Economic Review, 82(4); (1992).*

[12] *"Embodied and disembodied technical change and the constant elasticity of substitution production function." Uri, N; Journal of Applied Mathematical Modelling, 7(6); (1983).*