Europe Economics

Impact of COVID-19 Crisis on Real Price Effects (RPEs) and Frontier Shift

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Executive Summary

This report presents our analysis on the impact of the COVID-19 crisis on real price effects (RPEs) and frontier shift in the water sector. In particular, it provides our assessment in relation to the following:

- Development of high-level scenarios for the duration and economic impact of the COVID-19 crisis, which then forms the basis for the assessment of the impact of the COVID-19 crisis on RPEs and frontier shift.
- Qualitative analysis of potential RPEs in each cost area under the COVID-19 scenarios.
- Analysis of TFP growth in comparator sectors in past recessionary periods.
- Theoretical analysis of how TFP relates to frontier shift in the current COVID-19 context.

We present our methodology and results for each of these components for wholesale controls.

Scenarios for economic impact of COVID-19

We consider three scenarios for the analysis of the duration and economic impacts of the COVID-19 crisis. These scenarios are initially set out at a high-level (including some broad sense-of-scale macroeconomic impacts) and the implications for real input prices and productivity are considered subsequently.

The three scenarios considered are as follows:

- A "Shorter" scenario assuming that the COVID-19 health crisis ends after 3 months and after 6 months almost all restrictions are lifted. Under this scenario GDP is significantly reduced during the first 3 months of the period, however much of that is caught up once the restrictions are lifted after 6 months. Therefore, the COVID-19 crisis has no enduring economic impacts after 6 months. Under this scenario the effects of Suppression amount to a loss of GDP of around 10 per cent over 3 months.
- An "Extended" scenario in which the restrictions associated with the health crisis last over an 18-month period. This period is sufficiently long to create enduring economic impacts (i.e. economic "scarring") even after 18 months. These effects taper away gradually over time, and the scenario assumes that all "scarring" is gone by the end of the next control period, AMP7. Under this scenario governments apply strict Suppression rules in periods where the spread of the coronavirus means that public health services may become overwhelmed. Drawing on the analysis presented by Imperial College, the scenario assumes that Suppression follows a Sawtooth pattern whereby two months of Suppression are followed by one month of relaxation for the first 9 months, after which the Sawtooth takes the form of one month on, one month off. Further, in the periods of the Sawtooth in which Suppression is relaxed, we assume assets are used more intensively than would have been normal in the past, so as to catch up with lost output and demand. Under this scenario GDP is 5 to 10 per cent lower in the first year than it would have been in absence of the COVID-19 crisis, then 3.33 to 6.67 per cent lower during the following six months.
- A "Medium" scenario is assumed to be a shorter and more moderate version of the Extended scenario in which case the health crisis lasts a year and any enduring economic impacts after one year fade away quicker than under the Extended scenario. The Sawtooth under this scenario works in the same way as described above for the Extended scenario (i.e. two

months of Suppression followed by one month of relaxation for the first 9 months, after which it takes the form of one month on, one month off, including the assumption that assets are used more intensively during the relaxation months). The aggregate effect over the year is that GDP is 5 to 10 per cent down.

Real price effects under COVID-19 scenarios

We conducted a qualitative analysis to assess the case for a potential RPE under each COVID-19 scenario, including whether there is a case for revisiting Ofwat's previous assumptions on RPEs.

We present the results for each major wholesale cost area in turn.

In the case of labour costs, the crisis is likely to lead to a significant increase in unemployment which puts downward pressure on wage growth. This means that there is a serious possibility of stagnant or negative real wage growth over AMP7 under the Extended scenario. This implies that there is a case for revisiting Ofwat's previous assumptions on RPEs for labour in the context of the COVID-19 crisis.

For energy costs, the COVID-19 crisis has already led to plummeting oil prices which is likely to feed through into other energy prices as well. This appears to reflect existing issues in world oil markets (including the failure of Russia and Saudi Arabia to reduce oil output) along with plummeting demand caused by COVID-19.

At the same time demand for electricity during the crisis is likely to fall due to industries shutting down. The supply of electricity is unlikely to be affected given that energy is a priority sector that the government will want to ensure keeps running. These factors, along with lower input fuel costs (e.g. lower gas prices driven by lower oil prices), are likely to lead to industrial electricity prices falling during the crisis.

The above factors imply either a negative RPE if combined with the existing assumption for base energy costs, or a reduced base energy cost. If addressed in the latter way, it is possible that energy prices could recover during the period, thus implying a potentially positive RPE from a lower base energy cost.

However, there is great uncertainty over future energy prices so the argument for indexation or a true-up mechanism may be stronger. In particular, there is now a case for placing more weight on the historical periods we identified in which electricity price volatility was greater.

In the case of chemical costs, and materials, plant and equipment costs the net effect of the COVID-19 crisis on these input prices is indeterminate under all three scenarios. This is because these sectors are likely to be facing both reduced demand and restrictions in supply over AMP7.

TFP growth in past recessionary periods

Our assessment of wholesale frontier shift in the context of the COVID-19 crisis looked at evidence on how Total Factor Productivity (TFP) growth rates for the comparator sector varies over the cycle. In particular, we analysed TFP growth in comparator sectors in four past recessionary periods covered by the EU KLEMS datasets. There periods are: the 1973-1974 recession, the 1980-1981 recession, the 1990-1991 recession and the 2008-2009 recession. In addition, we also explored the multi-factor productivity (MFP) dataset – currently classed as experimental statistics – published by the ONS.

Our analysis examined TFP growth over a 5-year period from the start of each recession as the outbreak of the COVID-19 pandemic and the measures introduced by governments to mitigate the health impacts of the crisis began around the start of AMP7, the next 5-year price control period for the water sector.

Based on the evidence gathered from the EU KLEMS and ONS datasets on TFP growth in past recessionary periods we considered whether there was a case for changing our proposed range for frontier shift. For the reasons we set out below we do not find strong evidence to change our proposed frontier shift range for wholesale totex of 0.6 to 1.2 per cent.

TFP growth rates suggest that for 3 of the 4 recessionary periods considered (with the exception of the 1973-74 recession) productivity growth typically slows down (and on a number of occasions goes negative) in the recession years, followed by a bounce back in the years immediately following the recession.

Although average TFP growth for the comparator sectors shows substantial variation across the 4 recessions, the average across recessions is 0.6 per cent (including when scale effects are adjusted for). This implies that there is no strong evidence to change the lower bound of our recommended range which was also 0.6 per cent. Similarly, we do not find strong evidence to change our recommended upper bound of 1.2 per cent either. This is because when focusing on the TFP growth performance of the stronger performing comparator sectors a figure of 1.2 is supported by 2 of the 4 recessions considered, with a third recession supporting a figure of up to 1.1 per cent.

Further, our analysis of asset betas for the comparator and water sectors suggest that all our comparators are much more exposed to business cycle than the water sector. Consequently, any reduction in productivity growth of comparators over recessionary periods is likely to overstate the impact on the frontier shift the water sector may be expected to achieve.

In addition, analysis of the EU KLEMS dataset shows that water sector TFP growth is decoupled from the wider economy, given that in 3 out of the 4 recessionary periods analysed our comparator sectors typically experienced a slowdown during the recessions followed by a bounce-back in the immediate aftermath of the recession while opposite movements in water sector TFP were observed. We note that this finding is generally not supported by past ONS MFP evidence. Further, a Water UK report shows significant continued TFP growth in the water sector in the last recession (2008-09) despite the fact that productivity was falling across the economy.

Finally, as explored in the section below, TFP can be affected by factors such as capacity utilisation. Therefore, even if the TFP growth rate is lower in a recessionary period, it needs to be carefully considered whether this lower TFP growth rate directly translates to a lower frontier shift figure in the specific context of the water sector.

Read-across from TFP to frontier shift in current context

We explored the theoretical question of whether there is anything about the challenges facing the water industry in the next five years that has changed sufficiently to mean that evidence gathered from comparator industries on productivity gains in the past is no longer informative.

To this end – drawing on first principles – we decomposed TFP growth into the following components and explored the implications of the COVID-19 crisis for each of these elements:

- A scale component – Simple calculations based on our three scenarios suggest that industrial and overall demand for water during the crisis could be materially lower. Therefore, scale

effects may justify a change in base totex and botex, but such changes should occur outside the exercise considering changes in frontier shift.

- Catch up (consisting of a technical efficiency change component and an allocative efficiency component) – Our approach to estimating TFP growth in our final assessment already sought to generate estimates that were not distorted by catch-up effects.
- Frontier shift – Evidence generally supports the finding of procyclical TFP growth, but most explanations for this finding would not warrant expecting a similar relationship in the water industry. To the extent that the driver for such procyclicality is technology shocks, and the measures taken to control COVID-19 are akin to such a shock, then there may be a case for temporarily reducing the frontier shift expected in the water industry during the period of the health crisis, although a better, alternative approach would be for Ofwat / the CMA to consider separately whether companies will incur any additional costs during the period of the health crisis.

Finally, while theory suggests that negative frontier shift is possible, we do not think it would be an appropriate assumption for the water sector for AMP7. For the reasons set out in this report, the water sector is likely to be less affected than other sectors by the COVID-19 crisis. For instance, our analysis assumes that the water sector would be excluded from lockdown under all scenarios given its key role.

Conclusions

Under the Medium and Extended scenarios, there is a case for revisiting Ofwat's previous assumptions on RPEs for real wages and energy prices. Real wages are likely to grow more slowly than Ofwat has assumed, with stagnant or negative real wage growth over AMP7 being a possibility under the Extended scenario. Energy prices are also likely to be lower, albeit with the future path of energy prices subject to greater uncertainty. We note that the reduction in energy prices could either be captured through a negative RPE or through a lower base energy cost allowance (with a positive RPE as prices revert during to historical levels during AMP7).

We are maintaining our frontier shift range for wholesale totex of 0.6 to 1.2, as the evidence from past recessions as well as theoretical considerations suggest that the water sector is shielded from the negative productivity impacts likely to be observed elsewhere in the economy.

1 Introduction

In this chapter we first summarise the objectives of the study, followed by a summary of the data and research methodology employed. Finally, we outline the structure of the report.

Aims of the study

Under the PR19 Delivery Partner contract, Europe Economics provided Ofwat with a report on real price effects and frontier shift.[1]

Subsequently, the global outbreak of the COVID-19 crisis and the attempts by governments to suppress the coronavirus with lockdowns and social distancing across much of the developed world, including the UK, raises questions for the setting of RPEs and frontier shift in the water sector.

This report presents our analysis on the impact of the COVID-19 crisis on RPEs and frontier shift. In particular, it provides our assessment in relation to the following:

- Development of high-level scenarios for the duration and economic impact of the COVID-19 crisis, which then forms the basis for the subsequent assessment of the impact of the COVID-19 crisis on RPEs and frontier shift.
- Qualitative analysis of potential RPEs in each major wholesale cost area (labour, energy, chemicals, and materials, plant and equipment) under each of the COVID-19 scenarios, considering the impacts both during the health crisis and after the health crisis has ended.
- Analysis of TFP growth in comparator sectors in past recessionary periods using EU KLEMS data, adjusting for any TFP effects that relate to loss of scale economies due to falling demand.
- Theoretical analysis of how TFP relates to frontier shift in the current context, including whether frontier shift can be less than zero on theoretical grounds.

Data and methodology

Our analysis makes use of publicly available data and information. In addition, where relevant, it also draws on the information and arguments set out our final assessment published in December 2019 (including the information and data submitted to Ofwat in water company business plans).

For the development of the high-level scenarios for the duration and the economic impact of the COVID-19 crisis we draw on existing published analysis of the health crisis by Imperial College.

We conduct a qualitative assessment of potential RPEs in each major wholesale cost area (labour, energy, chemicals, and materials, plant and equipment) under each of the COVID-19 scenarios, considering the impacts both during the health crisis and after the health crisis has ended.

To assess the impact of the COVID-19 health crisis on the frontier shift water companies should achieve in AMP7, we conduct an analysis of TFP growth in comparator sectors in past recessionary periods. The key sources of data for our frontier shift analysis are the EU KLEMS

[1] Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 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

productivity datasets while values calculated using the ONS MFP estimates are also reported. Our analysis also adjusts for any TFP effects that relate to loss of scale economies due to falling demand, and also takes account of issues such as whether or not comparators have the same low level of exposure to the macroeconomic cycle as the water sector does.

We also explore theoretical considerations around how TFP relates to frontier shift in the current COVID-19 context. Our theoretical analysis also considers whether frontier shift can be negative on theoretical grounds.

Structure of the report

Our report is structured as follows:

- Section 2 set outs the scenarios for the economic impact of the COVID-19 crisis.
- Section 3 provides a qualitative analysis of potential RPEs in each area under the COVID-19 scenarios.
- Section 4 provides our analysis of TFP growth in comparator sectors in past recessionary periods.
- Section 5 gives a theoretical analysis of how TFP relates to frontier shift in the current context.
- Section 6 concludes.

The report also contains two appendices: the first reports figures for the Gross Value Added measure of TFP during past recessions, and the second presents the TFP figures (for both the Gross Output and Gross Value Added measure) during past recessions using the MFP dataset published by the ONS.

2 Scenarios for the COVID-19 Crisis

In this section we set out the scenarios we use for the analysis of the duration and impacts of the COVID-19 crisis. We shall set out high-level scenarios, including broad sense-of-scale macroeconomic impacts. Subsequent sections of the report will consider impacts in specific areas (such as productivity or real input prices) under these scenarios. In our scenarios it is important to distinguish between the period of the health crisis and the period of economic impacts. In some of the scenarios economic impacts continue long after the initial health crisis is complete.

2.1 The Scenarios

We consider three scenarios. We shall sometimes refer to them as the "first", "second" and "third" scenarios, reflecting the order in which we present them in later tables, but for explanatory purposes it will be most convenient to set out our first and third scenarios first, then move on to our second (which lies between the first and third).

2.1.1 "Shorter" scenario

In our Shorter scenario, after three months the health crisis is at an end and after 6 months almost all restrictions are lifted. Although there are some enduring social and organisational impacts (e.g. health spending may be a higher proportion of GDP), they are not relevant for the purposes of our analysis of impacts on the water sector.

There are a range of potential interpretations of this scenario. We do not need to commit to any one interpretation for our purposes here, but some interpretations include:

- When large-scale testing is available, it transpires that a high percentage of the population has already contracted the novel coronavirus with few if any material medical effects.[2]
- A therapy is developed that allows almost all novel coronavirus patients to recover without entering the "severe" or "critical" phases.[3]
- Case management, case isolation and case tracking techniques akin to those used in East Asia are successfully deployed across the world.
- Within the next few weeks, in countries in Africa and Central and South America where Suppression[4] is not applied (or applied only unsuccessfully) the virus spreads very rapidly and it emerges that fatality rates are much lower than currently thought or that the disease peaks at a much lower percentage of the population than OECD health officials are anticipating.

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[2] This would, for example, be consistent with the scenario set out in the widely-reported study published on 25 March 2020, which suggested it is possible that half the UK population has already contracted the novel coronavirus with few ill effects. https://www.ft.com/content/5ff6469a-6dd8-11ea-89df-41bea055720b

[3] For example, the US announced on 25 March that it is engaging in a large-scale trial of a range of novel coronavirus therapies in New York. https://abcnews.go.com/Politics/clinical-trials-coronavirus-treatments-begin-york/story?id=69777957

[4] Suppression is defined as the government mandating of social distancing and requiring of people to stay in their homes for all non-essential purposes.

Under this scenario there is a large drop in GDP in the first three months, but a large portion of that is caught up subsequently once restrictions are lifted. By six months after the crisis began the only enduring impacts are those akin to the enduring impacts of the Hong Kong Flu pandemic of 1968.

2.1.2 "Extended" scenario

In this scenario health crisis restrictions apply over an 18 month period. This is sufficiently extended to create economic "scarring" – i.e. enduring impacts on productivity growth, investment, real input prices, the cost of capital and other parameters potentially relevant to Ofwat – that tapers away only gradually even after the health crisis is complete. All scarring is gone by the end of the price control period (i.e. by end-March 2025).

There are again a number of potential interpretations of this scenario, but the key feature is that the novel coronavirus continues to be regarded as too dangerous for governments to allow normal economic life to proceed (e.g. evidence from the less-controlled spread of the virus in other parts of the world does not support claims that current concerns about its risk are exaggerated) and successful vaccines or therapies take some time to be developed and ready for widespread use (18 months).

During this 18 month period we assume governments apply the following policy. Strict Suppression rules are applied for periods where the spread of novel coronavirus cases has reached a level where if it continues NHS capacity to treat novel coronavirus patients risk being overwhelmed. When the number of cases falls back sufficiently, Suppression rules are relaxed until the spread accelerates again to a level where, if unchecked, NHS capacity would again be overwhelmed, whereupon Suppression is once again applied. Since under this scenario the number of cases rises up rapidly then falls back before rising rapidly, such that if plotted on a graph they would resemble the teeth of a saw, this policy is referred to as the Sawtooth.

In the Imperial College paper[5] the Sawtooth is initially expected to take the form of two months Suppression followed by one month of relaxation. However, it is anticipated that over time NHS resources will increase to allow relaxation periods to be extended. It is also possible that, over time, case management and some limited therapies may allow a lower proportion of cases to require the most intensive NHS care.

Accordingly, we assume that for the first nine months the Sawtooth takes the form of two months on, one month off, then for the following nine months it takes the form of one month on, one month off.

2.1.3 "Medium" scenario

The Medium scenario is a shorter and more moderate version of the Extended scenario. In this case the health crisis (and thus Sawtooth) lasts for one year, and economic scarring is less and fades away more rapidly, with all effects relevant to the water sector fully dissipated by the end of March 2023.

The Sawtooth in this scenario is again two months on, one month off for the first nine months, then one month on one month off for the final three months. That final three months would therefore include two months of Suppression and one month of relaxation. However, we assume

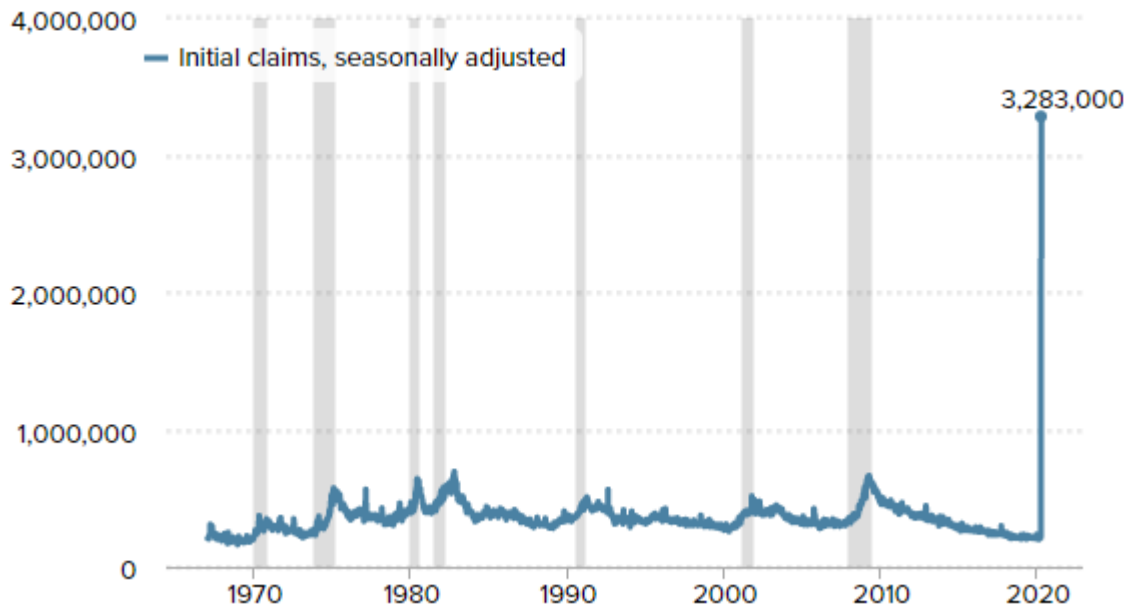
[5] Ferguson et al (16 March 2020): "Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand", available at: https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf

that the month following the end of the health crisis is like a relaxation month during the health crisis (see below for the implications of this).

2.2 GDP impacts during the scenarios

GDP impacts during the period of shutdown are expected to be extremely large – indeed unprecedentedly so. The very earliest data supports this. On 26 March 2020 the US published its latest jobs data.

Figure 2.1: Initial weekly US unemployment claims



Source: US Employment and Training Administration, ICSA, 26 March 2020
Note: Gray periods are recessions

A rough figure being widely used in casual commentary is a 20 per cent contraction in GDP in the first quarter. Europe Economics has analysed data on the economic sectors most affected (e.g. restaurants and aviation affected negatively, but communications and medical devices affected positively) and considered scenarios for their likely level of contraction or expansion. We estimate first-round effects to equate to a contraction of GDP of around 11 per cent of GDP.

The next question is what indirect and induced effects there could be upon the broader economy from lost output in these sectors. The usual techniques for analysing this would be either to use whole-economy multipliers or to use input-output modelling. If the period of Suppression were short (e.g. three months, as in our Shorter scenario), such input-output modelling might give a greater exaggerated indication of impacts, since input-output tables reflect the full pass-through of effects over time and in a shortened health crisis there might be some catch-up after the crisis was complete. Furthermore, in a shortened crisis the spillover effects into other sectors could also be reduced by factors such as rent payments or fixed cost payments for services such as electricity or cleaning contracts being kept in place. In a more extended crisis we should therefore expect that multiplier effects will be larger.

An extended crisis might also involve larger impacts through international effects on trade. Sovereign defaults in countries very seriously affected by death and sickness or by the economic impacts of Suppression could trigger banking sector problems and wider economic turmoil.

Domestically there could also be discontinuities in an extended crisis (e.g. a large domestic financial institution going bankrupt).

In our view, the uncertainties here are sufficiently high that attempts at a very exact estimate are not likely to be robust and would involve false precision. Further, for our purposes it would not be proportionate to attempt highly precise estimates in any event. Accordingly, we shall assume that effects of Suppression are as follows.

- Under the Shorter scenario, a loss of GDP equivalent to 10 per cent over three months, made up of a loss larger than this during those three months followed by some catch-up later.
- Under the Medium and Extended scenarios, a loss of GDP of 10 to 20 per cent during periods of Suppression.

In the periods of the Sawtooth in which Suppression is relaxed, we assume assets are used more intensively than would have been normal in the past, so as to catch up with lost output and demand. For example, manufacturing operations that had been mothballed during Suppression might be run on double or triple shifts. Coffee shops and luxury retailers that had had to shut down during Suppression might put on extra staff and have very high demand from people taking the opportunity to go out whilst they can do so.

We assume that the net effect of this more intensive use of otherwise-idle assets is that the 10 to 20 per cent of the economy that becomes unused during Suppression parts of the Sawtooth runs, instead, at an additional one third of output during relaxation months.[6]

The overall effect of this is as follows.

- In the Medium scenario, over nine months GDP is 10 to 20 per cent lower for two thirds of the time and 3.33 to 6.66 per cent higher for one third of the time, and over 3 months GDP is 10 to 20 per cent lower half the time and 3.33 to 6.66 per cent higher for half the time.[7] The aggregate effect over the year is that GDP is 5 to 10 per cent down over the year.
- In the Extended scenario, over the first nine months GDP is 10 to 20 per cent lower for two thirds of the time and 3.33 to 6.66 per cent higher for one third of the time, and over the following nine months GDP is 10 to 20 per cent lower half the time and 3.33 to 6.66 per cent higher for half the time. The aggregate effect on GDP is that it is 5 to 10 per cent lower in the first year, then 3.33 to 6.67 per cent lower during the following six months.

2.3 Summary of the scenarios

The table below summarises our three COVID-19 scenarios.

[6] There is an imperfect parallel, but for a highly indicative sense of scale we note that DixonsCarphone reported that, in the three weeks before the UK introduced its prohibition on all non-essential social contact, demand was up 35 per cent. https://www.retailgazette.co.uk/blog/2020/03/dixons-carphone-online-sales-soar-but-warns-on-missing-profit-forecasts/

[7] We note that this assumption of elevated GDP half the time reflects our assumption that the first month following the end of the Sawtooth has GDP elevated by the same amount as would have happened during a Relaxation period in the Sawtooth.

Table 1.1: Summary of COVID-19 scenarios

Scenario	Length of health crisis	GDP loss	Economic scarring after end of health crisis	End of scarring
Shorter	3-6 months	10% of output for 3 months	No	N/A
Medium	12 months	5-10% of GDP	Yes	End March 2023
Extended	18 months	5-10% of GDP in 12 months; 3.33-6.66% of GDP for 6 months	Yes	End March 2025

Source: Europe Economics' analysis.

3 Real Price Effects (RPEs) under COVID-19 Scenarios

In this section we set out our assessment of the impact of COVID-19 on RPEs. RPEs relate to input prices increasing or decreasing in real terms relative to general consumer price inflation (as measured, for example, by CPIH). To assess the impact of COVID-19 on RPEs we first look at the impact of COVID-19 on overall inflation. We then assess the potential effect on RPEs in each cost area in turn, namely labour, energy, chemicals, and materials, plant and equipment.

3.1 Impact of COVID-19 on general consumer price inflation[8]

The COVID-19 crisis represents both a demand side and a supply shock to the economy, and hence the overall effect on the general level of inflation will depend on which of these effects dominates.

Under all the scenarios discussed in the previous section, there will be a significant drop in the demand for certain goods and services included in the CPIH (e.g. restaurants, transport) during the period of lockdown. While in the Shorter scenario this impact will not be lasting and the demand for goods will increase once the restrictions are lifted, in the Medium and Extended scenarios, a negative demand shock may be more enduring. In particular, the recession and job losses caused by the COVID-19 crisis may reduce demand for various products even once the measures implemented to control COVID-19 have been lifted. This reduction in demand is likely to place downward pressure on the price of the affected products.

At the same time, demand for some other products (e.g. hand sanitisers, groceries) has increased as a result of the COVID-19 crisis. This is likely to place upward pressure on the price of these products.

There are also likely to be restrictions to the supply of some products caused by the lockdown e.g. due to some manufacturing companies temporarily closing down production, both in the UK and overseas. Supply chains may also be disrupted by the crisis, even in sectors where businesses remain open. This could place upward pressure on the price of affected products.

The overall effect on inflation will depend on how these various demand and supply effects balance out, and hence it is not clear *a priori* what the overall impact on CPIH may be.

That said, there could be a measurement issue which means that measured inflation may temporarily be subdued before increasing again. In particular, the CPIH basket is a weighted basket of goods and services that reflect the spending of the average consumer. However, there is a lag before any change in the breakdown of consumer spending feeds through into the weights used in calculating the basket. This means that in the short term, the weights used will reflect an out-of-date breakdown of consumption, thus placing too much weight on items for which demand has fallen and for which prices may be falling. As the weights are updated,

[8] Europe Economics has produced a separate working paper examining the specific issue of whether changes in the breakdown of consumer spending caused by the COVID-19 crisis could materially affect CPIH inflation by changing the weights placed on different products in the CPIH basket.

measured inflation may increase as more weight is placed on products for which demand has increased and for which prices have risen.

CPIH includes rental costs faced by tenants and a measure of Owner Occupiers' Housing Costs (based on an imputed rental cost). It is likely that, under the Medium and Extended scenarios, the COVID-19 will place downwards pressure on both house prices and rents, due to job losses and reduced immigration. This will tend to reduce CPIH compared to what it would otherwise be.

KPMG has published inflation forecasts for the UK economy under a main scenario for the COVID-19 crisis (which appears closest to our Shorter scenario).[9] Under this scenario, inflation continues on a low trend, averaging 1.4 per cent in 2020 and rising to 2.0 per cent in 2021.

A CEBR forecast for the UK economy published on 30 March predicted that inflation would remain low over the coming months, but that it would then increase in 2021 and 2022, with CPI reaching a peak of 3.2 per cent in Q1 2021.[10]

3.2 Labour

The crisis has already transformed into a labour market shock, impacting both the supply of labour and the demand for labour.

On the supply side, there is likely to be a reduction in the supply of labour. This will arise partly from the disease itself, as workers take time off sick and in a minority of cases die. Government measures to control the disease will also reduce the supply of labour, as some workers have to self-isolate because someone in their households has coronavirus symptoms or because they have an underlying health condition that makes them vulnerable. During the period of the health crisis, there is also likely to be little immigration, further reducing labour supply.

At the same time, the COVID-19 crisis is likely to lead to a substantial reduction in the demand for labour as substantial parts of the economy are shut down, which is likely to be only partially offset by an increase in employment in other sectors (e.g. supermarkets). Under the "Shorter" scenario the decrease in demand will be temporary with no enduring impact on the demand once the restrictions are lifted. By contrast, under the "Medium" and "Extended" scenarios the decrease in demand for labour will last for longer as firms go out of business and workers lose their jobs due to the financial distress the restrictions will cause for companies.

While government policies (such as the commitment that the state will pay 80 per cent of the wages of furloughed workers up to limit of £2,500 a month) may mitigate the impact, it seems unlikely that it will entirely prevent a rise in unemployment. Further, such policies may prove not to be financially sustainable for the government if the health crisis continues for an extended period.

There is already substantial evidence of job losses caused by the COVID-19 crisis. For example, there have been reports in the media suggesting that 500,000 jobs have already been lost in the hospitality sector alone[11] and that almost a million people have submitted new claims for Universal Credit over a two-week period.[12]

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9 https://home.kpmg/content/dam/kpmg/uk/pdf/2020/03/uk-economic-outlook-march-2020.pdf

10 https://cebr.com/reports/uk-gdp-expected-to-contract-by-15-in-q2-as-consumers-under-lockdown-rein-in-spending/

11 Yahoo Finance article, 20 March 2020, accessible here.

12 https://www.bbc.co.uk/news/uk-politics-52129128

KPMG's main scenario for the impact of COVID-19 (which as mentioned earlier, is closest to our Shorter scenario) shows UK unemployment increasing from 3.8 per cent in 2019 to 4.7 per cent in 2020, before falling back to 4.1 per cent in 2021. By contrast, CEBR has forecast a sharp rise in unemployment to 7 per cent by Q3 2020, even after taking account of government policies aimed at preventing job losses.

Overall, we would expect rising job losses in the Medium and Extended scenarios to place downward pressure on real wages compared with the OBR forecasts that Ofwat used in its final determinations. While the COVID-19 crisis may not cause job losses in the water sector itself, the availability of a large pool of unemployed workers may place downward pressure on the wages that water companies have to offer in order to attract and retain workers. In the Extended scenario, the possibility that the crisis may lead to stagnating or negative real wage growth over AMP7 (as happened after the last financial crisis) cannot be ruled out.

At the same time, measured indices of wages could be less affected than the above outlook for the labour market might initially suggest if the jobs that are lost are predominantly lower-wage jobs. In this case, measured wage indices might hold up as lower-wage jobs drop out of the calculation and higher wage jobs make up a larger proportion of the remaining wage data.

Given that Ofwat has already included a true-up mechanism for real wage growth in its final determinations, it could be argued that wage impacts from the COVID-19 crisis will automatically be taken into account. At the same time, this true-up will only be applied at the next review, meaning that a labour RPE based on the OBR forecast that Ofwat used in its final determinations may over-compensate water companies during the course of AMP7 itself. Given that many households may be struggling financially during this period under the Medium and Extended scenarios (due to the rise in unemployment and a decrease in real wages across the economy), this could be politically controversial and would not sit comfortably with Ofwat's statutory duty to protect the interest of consumers. Hence, there would a strong case for revisiting the current labour RPE for those companies which have appealed to the CMA.

We also note that the COVID-19 crisis could have differential impacts on wage rates for different types of labour. For example, jobs which cannot be done at home and which involve substantial interaction with other people may command a "hazard premium" during the health crisis due to the higher risk of exposure to COVID-19. Further analysis of the composition of water sector employees would be needed to examine the potential impact of such differential effects on the water sector.

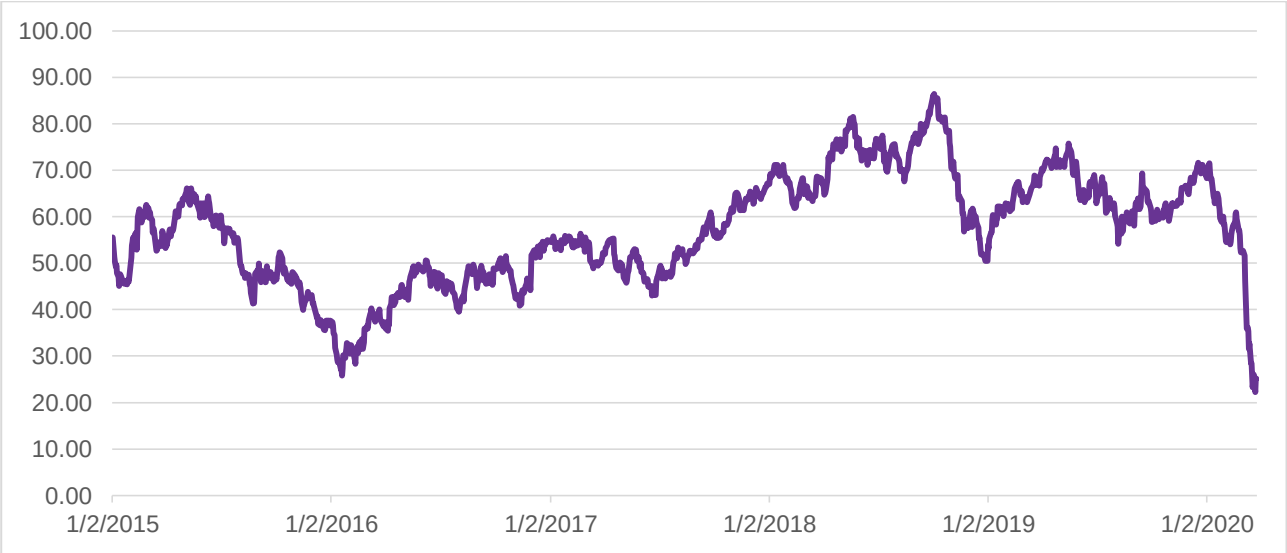
The COVID-19 crisis could also lead to a reduction in regional wage dispersion as businesses adopt a working-from-home model which allows their workers to be located anywhere in the country. Indeed, it is conceivable that many businesses may continue to operate a working-from-home model even after government restrictions are lifted, given that they will have set up the required infrastructure and processes and that it will lead to ongoing cost savings (e.g. on rent). As jobs become less tied to physical location, the labour market may become less segmented between regions, leading to greater convergence of wages across the country, at least for desk-based work. This would imply a relative decrease in wages in high-wage parts of the country (e.g. London) and a relative increase in wages in low-wage parts of the country (e.g. in the North of England). This raises the possibility that different labour RPEs might be appropriate for companies located in different parts of the country.

3.3 Energy

In our final PR19 report on RPEs and frontier shift, we explained that there is a relationship between oil, gas and electricity prices. The relationship between these prices is likely to reflect the fact that some long-term gas contracts on the Continent are indexed to oil prices, and arbitrage across the UK-Continent interconnector in turn links UK wholesale gas prices to continental gas prices. Further, the important role played by gas-fired generation in the UK means that wholesale electricity prices will be influenced by wholesale gas prices.

There was already a significant downward pressure on world oil prices due to the ongoing oil price war between Saudi Arabia and Russia, and this has been reinforced by collapsing demand for oil as a result of the COVID-19 crisis. This is illustrated in the figure below, where we see a huge dip in crude oil prices since the start of 2020, from 68.97 dollars a barrel at the start of the year to 25.10 dollars as of 25 March.[13] Given the linkage between oil, gas and electricity prices, this fall in world oil prices is likely to reduce energy prices for the water sector.

Figure 3.1: Brent Crude Spot price ($)



Source: Thomson Reuters Eikon

In addition, within the UK there may be a large reduction in industrial demand for gas and electricity as parts of the economy shut down in response to the COVID-19 crisis. (This may be partially offset by increased energy consumption in homes, though it seems likely that overall energy consumption will fall.) Under the Shorter scenario, demand will drop for three to six months, but as soon as the restrictions are lifted demand will increase and there will be no long term effects on energy prices. By contrast, under the Medium and Extended scenarios the period of lockdown will be longer, and the recession induced by the COVID-19 crisis may lead to reduced energy demand even after the health crisis has ended.

We would not expect any restriction on the supply of energy under any of our COVID-19 scenarios, as energy is likely to be treated by the government as a key sector which needs to continue operating. Staff employed by the oil, gas and electricity sectors have been identified as key workers by the government.[14]

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[13] Source: Thomson Reuters Eikon.

[14] https://www.gov.uk/government/publications/coronavirus-covid-19-maintaining-educational-provision/guidance-for-schools-colleges-and-local-authorities-on-maintaining-educational-provision

The combination of falling world oil prices, reduced demand for energy and maintained energy supply mean that the real energy prices faced by the water sector are likely to fall as a result of the COVID-19 crisis. In the Shorter scenario, whereby the crisis lasts for 3-6 months, there will be a downward pressure on real energy prices during the shutdown period, but there would not be enduring impacts once the shutdown ends. Under the "Medium" scenario there would be a decrease in real energy prices but this effect will fade away by partway through the price control period. Finally, under the "Extended" scenario there will be more sustained downward pressure on real energy prices as there will be low industrial demand for up to 18 months due to government restrictions. Even after the restrictions are lifted, energy prices will only gradually return to previous levels due to the economic scarring caused by the crisis, with the impact lasting for most part of AMP7.

The above factors imply that Ofwat should either argue for:

- A negative energy RPE, if combined with its existing PR19 assumptions for base energy costs; or
- A reduced base energy cost, in which case it may be necessary to allow a positive energy RPE to take account of the potential increase in energy prices from this lower starting position as the economic scarring caused by the COVID-19 crisis fades during the course of AMP7.

The COVID-19 crisis also substantially increases uncertainty around the future energy prices faced by the water sector. In our final PR19 report on RPEs and frontier shift, we stated that the case for an indexation mechanism for energy depended partly on the weight that was placed on pre-2010 data when energy prices were more volatile. In the current context, we consider that there is a strong case for placing greater weight on past periods of energy price volatility, and hence that there is a stronger case for including an indexation or true-up mechanism for real energy prices.

Finally, we have considered the impact of the COVID-19 crisis on the extent to which energy price movements faced by water companies are captured by CPIH indexation. In our final PR19 report, we argued that such energy price movements were partially but not wholly captured by CPIH indexation. In particular, we identified that energy accounted for 9 per cent of water company totex compared with 5.2 per cent of the CPIH basket (taking account of both "Electricity, gas and other fuels" and "Fuels and lubricants"). We have used the modelling carried out for our separate working paper on the impact of the crisis on CPIH to investigate how the 5.2 per cent share of CPIH might change under each of the COVID-19 scenarios during the period of lockdown. The results are presented in the table below.

Table 3.1: Share of energy in CPIH under COVID-19 scenarios (percentage of total basket)

	Shorter scenario	Medium scenario	Extended scenario (Year 1)	Extended scenario (Year 2)	January 2020 actual
Electricity, gas and other fuels energy use share	**2.95**	**3.39**	**3.39**	**2.94**	**2.70**
- Electricity	1.66	1.94	1.94	1.65	1.50
- Gas	1.08	1.23	1.23	1.08	1.00
- Liquid fuels	0.10	0.11	0.11	0.10	0.10
- Solid fuels	0.10	0.11	0.11	0.10	0.10
Fuels and lubricants energy use share	**2.04**	**1.27**	**1.27**	**2.03**	**2.50**
Total household energy use share	**4.98**	**4.66**	**4.66**	**4.97**	**5.20**

Source: Europe Economics' analysis of ONS data.

The modelling shows that the overall impact of the COVID-19 crisis is likely to be a small reduction in the share of energy in the CPIH basket during the lockdown period, with the effect being greater under the Medium and Extended scenarios. While the share of "Electricity, gas and other fuels" increases as other products that are no longer being purchased by consumers drop out of the basket, this is more than offset by reductions in consumption of road fuel (shown by the reduced share for "Fuels and lubricants").

3.4 Chemicals

The impact of COVID-19 on chemicals prices will depend on whether demand-side or supply-side effects dominate in chemicals markets.

On the supply side, there may be a direct and an indirect impact on chemical manufacturing. The direct impact of COVID-19 will be due to the possible closure of chemical factories as companies choose to temporarily halt production during the health crisis. The indirect impact of COVID-19, however, will be driven by possible disruptions in the supply chain of inputs needed for chemical manufacturing.

This impact on the supply side will vary under the 3 scenarios. Under the "Shorter" scenario, the impact will be temporary i.e. will only last during the health crisis and the supply will restore to normality as soon as the government restrictions are lifted. The impact on supply under the "Medium" scenario will last for longer, with the longer health crisis potentially leading to some chemicals manufacturers going out of business with consequent impacts on the supply of chemicals after the health crisis is over. The impact will, however, fade away, with supply reverting to normal levels by June 2023. Finally, the impact on the supply of chemicals under the "Extended" scenario will last for most of AMP7.

On the demand side, there will potentially be a large drop in the demand for chemicals across the economy due to the shutdown of businesses which use chemicals as an input. This drop in demand will also vary in magnitude and duration across the three scenarios. Under the "Shorter" scenario the drop in demand will be temporary and revert to previous levels as soon as the government restrictions are lifted. By contrast, under the "Medium" scenario the fall in demand will last throughout 2020 and will only start to recover as the economic scarring caused by the health crisis starts to fade away. Finally, under the "Extended" scenario the fall in demand will endure even after the health crisis and could last throughout the AMP7 period.

Overall, we conclude that:

- In the Shorter scenario, it is unlikely that there will be a significant impact on chemical prices over AMP7 as any demand or supply shock is likely to be only temporary.
- It is difficult to determine what the overall impact of COVID-19 will be on chemical prices under the "Medium" and "Extended" scenarios, as it is not clear whether the reduction to demand will outweigh the restriction to supply or vice versa.

3.5 Materials, plant and equipment

The COVID-19 crisis could also have an impact on real prices for materials, plant and equipment, although as with chemicals it is unclear what the direction of effect will be.

In the short run, there could be both a reduction in the demand for materials, plant and equipment as large parts of the economy are shut down and a reduction in supply as some companies that

manufacture materials, plant and equipment choose to halt production or experience problems caused by supply chain disruptions.

Once government restrictions aimed at controlling COVID-19 are removed, there is likely to be an increase in demand for materials, plant and equipment driven by the re-opening of various sectors that had closed due to COVID-19. On the other hand, there will potential also be an increase in supply as the manufacture of materials, plant and equipment is restored.

Under the "Shorter" scenario, both the supply and demand of materials, plant and equipment will go back to their normal levels as soon as the COVID-19 restrictions are lifted, with no lasting impact. By contrast, under the "Medium" scenario supply and demand will possibly decrease in the short run and then rise once the restrictions are lifted. However, supply and demand will only gradually return to pre-crises levels due to the economic scarring caused by the COVID-19 crisis. Finally, the longer "Extended" scenario is similar in qualitative terms to the "Medium" scenario, but the effects will last for longer as both the health crisis and the subsequent economic scarring are more prolonged.

Overall, we conclude that:

- There is unlikely to be any material effect on real prices for materials, plant and equipment over AMP7 under the Shorter scenario, as any impact will only last for a small number of months.
- By contrast, effects on the real price of materials, plant and equipment could be greater under the "Medium" and "Extended" scenarios. However, it is not certain at this stage whether the real prices faced by water companies for these inputs will rise or fall, as it is unclear whether supply-side or demand-side effects will dominate in these input markets.

4 TFP Growth in Past Recessionary Periods

In this section we present figures on TFP growth in four past recessionary periods covered by the EU KLEMS dataset. These periods are: the 1973-1974 recession, the 1980-1981 recession, the 1990-1991 recession and the 2008-2009 recession. We look at TFP growth over a 5-year period from the start of each recession as the outbreak of the COVID-19 pandemic and the measures introduced by governments to mitigate the health impacts of the crisis take place around the start of the next 5-year price control period for the water sector in the UK.

The chapter is structured as follows:

- Section 4.1 considers the comparability of our comparators in terms of exposure to macroeconomic cycle.
- Section 4.2 presents the TFP figures for the 1973-1974 recession.
- Section 4.3 reports the TFP figures for the 1980-1981 recession.
- Section 4.4 presents the TFP figures for the 1990-1991 recession.
- Section 4.5 reports the TFP figures for the 2008-2009 recession.
- Section 4.6 summarises the lessons from past recessions.

In addition, Appendix 1 reports figures for the Gross Value Added measure of TFP using the EU KLEMS dataset, and Appendix 2 presents the TFP figures (for both the Gross Output and Gross Value Added measure) using the MFP dataset published by the ONS.

4.1 Comparability of sectors in terms of exposure to macroeconomic cycle

Our choice of comparator sectors from those available within the EU KLEMS dataset in our final assessment[15] was guided by two principal criteria, one of which considered whether the comparator sector selected is similar to the water sector in terms of the nature of activities undertaken.

In this section we consider the comparability of sectors in terms of exposure to macroeconomic cycles. Given that the analysis in this chapter focuses on just part of the business cycle, it is relevant to consider how the exposure of the comparators to the macroeconomic cycle compares with that of the water sector, as if the water sector and our selected comparators have similar exposure to systematic risk then these will experience similar changes to productivity growth rates during a recession. However, if compared to the water sector the comparators all have higher systematic risk, then any reduction in productivity growth of comparators over recessionary periods may overstate the impact on the frontier shift the water sector may be expected to achieve.

[15] Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", pp. 68-71, 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

Below we present an analysis of sectoral asset betas to compare the systematic-risk exposure of the water sector in relation to other sectors. To this end, we have estimated asset betas for the following sectors of the UK economy:

- Chemicals sector.
- Construction sector.
- Manufacture of machinery sector.
- Manufacturing sector as a whole.
- Transport and storage sector.
- Professional, scientific, technical, administrative and support service activities.
- Energy sector.
- Water sector

In section 4.1.1 we set out the methodology we have used to identify relevant sectors and to estimate sectoral betas. In section 4.1.2 we present the beta evidence.

4.1.1 Methodology

We have first identified all UK publicly listed company through the Thomson Reuters Eikon platform and assigned each company to a specific business sector. The business classification methodology we have chosen is the NAICS[16] as it matches closely our sectors of interest. For the energy and water sector we have considered the following regulated utilities:

- Water sector: United Utilities, Severn Trent, and Pennon.
- Energy Sector: National Grid, Centrica, and SSE.

The mapping between the other sectors of interest and the NAICs classification is provided below.

Table 4.1: Sectors of interest and NAICS classification

Sectors of interest	NAICS Sector Name
Chemicals	Chemical Manufacturing*
Construction	Construction
Manufacturing	Manufacturing
Manufacturing of machinery	Machinery Manufacturing*
Transport and storage	Transportation and Warehousing
Professional, scientific, technical, administrative and support services	Professional, Scientific, and Technical Services

* These is a NAICS sub-sector name under the broader Manufacturing sector name.
Source: Europe Economics' analysis.

For each company belonging to the relevant sectors listed above we have collected daily return data, daily market capitalisation figures, and net debt-to-enterprise value ratios. We have used these data to construct sector-specific return indices and sector-specific gearing figures[17]. For practical purposes we have considered only companies with a market capitalisation of at least 1 billion USD. The number of constituents considered in each sector is reported below.

[16] North American Industry Classification System

[17] The sector-specific return index is calculated as the weighted average return of the constituent companies, where the weights are proportional to the companies' market capitalisations. Similarly, the sector-specific gearing value is weighted average gearing of the constituent companies, where the weights are proportional to the companies' market capitalisations, and where gearing is defined as net debt to enterprise value.

Table 4.2: Number of constituents per sector

Sector	Number of constituents
Chemical	13
Construction	10
Manufacturing	63
Manufacturing of machinery	7
Transport and storage	7
Professional, scientific, technical, administrative and support services	11
Energy	3
Water	3

Source: Europe Economics' analysis.

4.1.2 Evidence

We present below the rolling sectoral asset betas estimated with 1-year, 2-year and 5-years of daily return data. All betas are estimated with reference to the FTSE All Share Total Return index and the time period considered is 01-January-2000 to 26-March-2020.

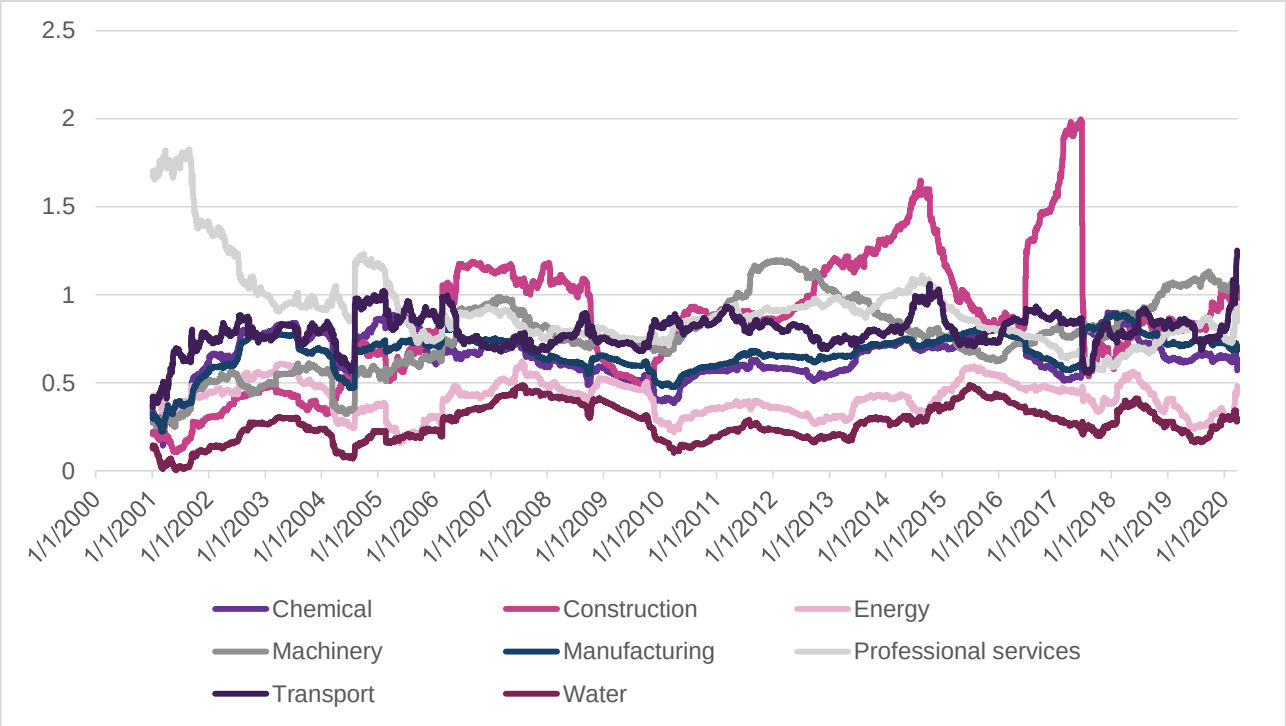
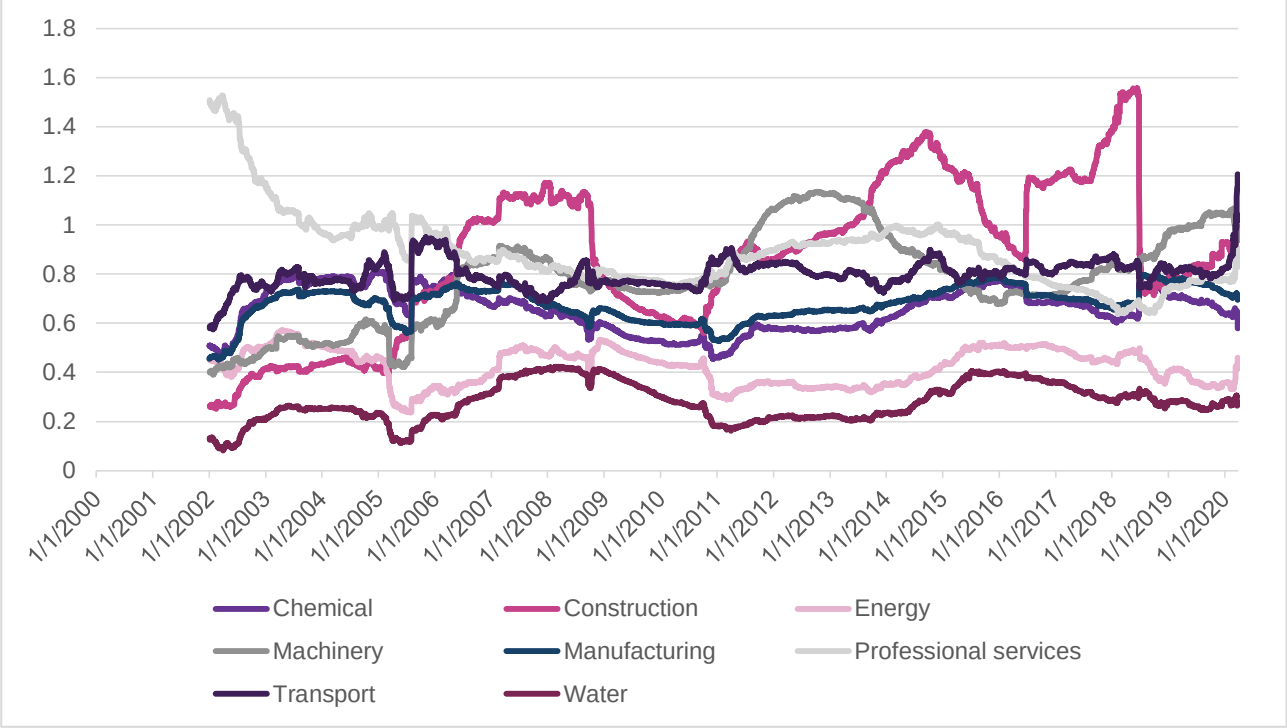


Figure 4.1: 1-year sectoral asset beta

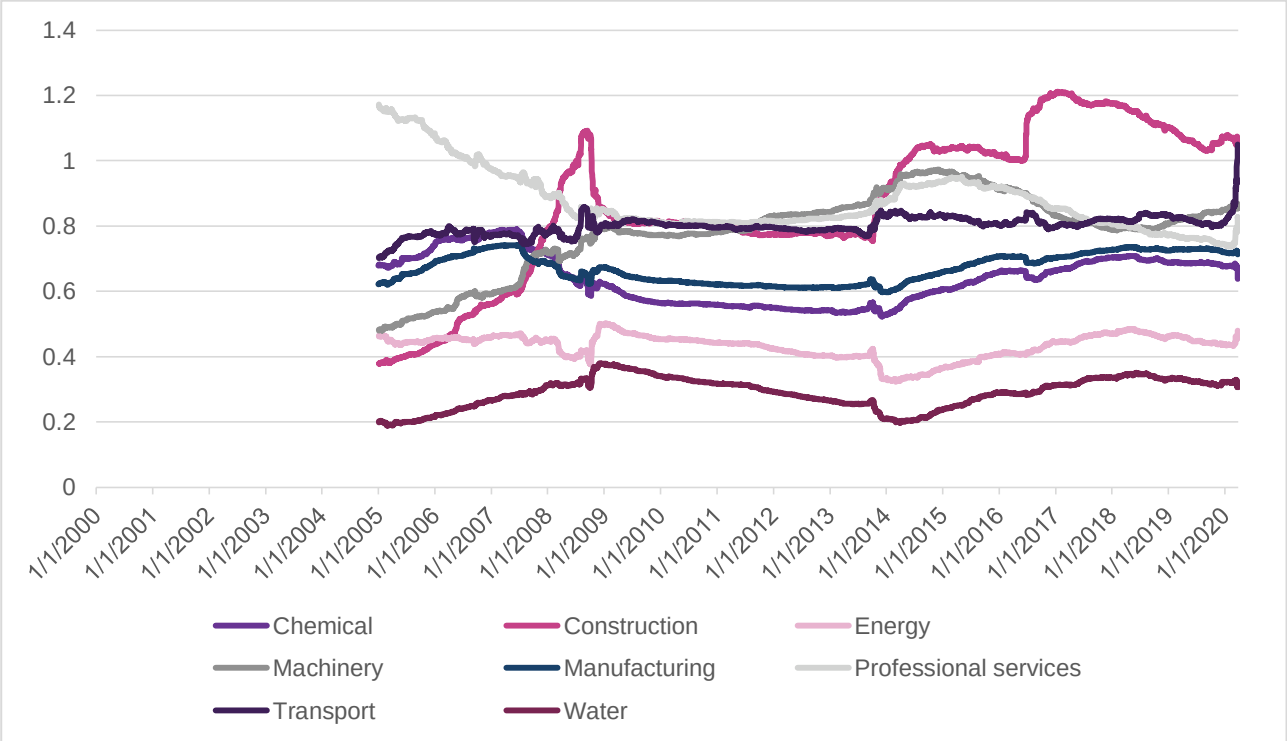
Source: Thomson Reuters, Europe Economics' calculations.

Figure 4.2: 2-year sectoral asset beta



Source: Thomson Reuters, Europe Economics' calculations.

Figure 4.3: 5-year sectoral asset beta



Source: Thomson Reuters, Europe Economics' calculations.

The figures above show that the asset betas for the water sector are much lower than for the comparator sectors. Therefore, the evidence regarding the asset betas presented above suggest that all the comparators are much more exposed to the business cycle than the water sector. Consequently, any reduction in productivity growth of comparators over recessionary periods may overstate impact on the frontier shift the water sector may be expected to achieve.

While we believe that the above analysis of sectoral asset betas is informative, two caveats around this analysis should be borne in mind. First, the sectors' correlation with the market may reflect responsiveness to different market-wide shocks (maybe one sector moves with the market during pandemics, while another is highly correlated during oil-price shocks but otherwise a good hedge). Second, productivity and profitability may cycle in different ways across the sectors – maybe water industry output is unchanged but bad debts plunge profits, while other sectors face falling demand and reduce output.

4.2 The 1973-74 recession

One of the causes of the 1973-74 recession was the 1973 oil crisis when the Organization of Arab Petroleum Exporting Countries imposed an oil embargo, primary aimed at countries perceived to be supporting Israel in the Yom Kippur war, including the United Kingdom. This resulted in a fourfold increase in oil prices and caused a shock to the global economy.

At the time of the oil crisis, inflationary problems already existed in the United Kingdom due to the "Barber boom" approach adopted by the Heath government attempting to raise output in response to accelerating inflation. Further, industrial unrest followed by a miners' strike led to the "Three-day week" (in addition to the impact of the oil price shock) when the UK government restricted energy use for commercial users to only 3 days a week between 1 January and 7 March 1974. Overall, the crisis was characterised by rising unemployment and high inflation (also called a "stagflation").

Some characteristics of the 1973-74 recession are directly relevant for examining the impact of COVID-19 under certain scenarios. The oil shock introduced a supply-side shock to the economy, similarly to the current outbreak of the COVID-19 pandemic, and this affected the world economy. The shock was then amplified by a centrally coordinated attempt by the government to bring down economic activity through measures such as the Three-day week, which are in some broad sense analogous to attempts to suppress coronavirus by governments with lockdowns and social distancing. Given the duration of the measures adopted and that the ultimate effect of the recession was not huge, the 1973-74 recession appears to be a reasonable qualitative comparator for our "Shorter" scenario (though the scale was much lower than is expected for the impact of the COVID-19 shutdown).

In Table 4.3 we present the TFP growth values in gross output terms using the EU KLEMS database which uses NACE 1 sector definitions. The first five columns in the table report year by year TFP growth for 5 years from the start of the 1973-74 recession for our comparator sectors while the last three columns show the averages calculated for the recessionary period (1973-1974), for the post-recession period (1975-1977), and for the full 5-year period from the start of the recession (1973-1977), respectively. The second last row shows the corresponding figures for "Total industries" to show the difference between productivity growth in our comparator sectors and the overall economy. For reference, corresponding values for the Electricity, gas and water supply sector are reported in the final row.

Table 4.3: TFP growth in gross output for 1973-1974 recession, unadjusted for scale effects (NACE 1, per cent)

Industry Comparators	1973	1974	1975	1976	1977	Average for recessionary period (1973-1974)	Average for post-recession period (1975-1977)	Average for full 5-year period (1973-1977)
Chemicals and chemical products	3.6	-0.6	-1.0	2.6	0.4	1.5	0.7	1.0
Construction	-2.0	-4.4	-0.9	-0.1	0.8	-3.2	-0.1	-1.3
Machinery, nec	1.9	0.4	1.8	-1.0	-0.6	1.1	0.1	0.5
Total manufacturing	2.0	-1.8	-0.7	0.8	0.3	0.1	0.2	0.1
Transport and storage	3.8	-1.5	-0.6	0.4	1.1	1.1	0.3	0.6
Average for comparators	**1.8**	**-1.6**	**-0.3**	**0.5**	**0.4**	**0.1**	**0.2**	**0.2**
Total industries (for purpose of comparison)	0.6	-2.7	-0.4	0.1	0.1	-1.1	-0.1	-0.5
Electricity, gas and water supply	3.0	-1.1	1.4	0.7	2.1	1.0	1.4	1.2

Source: Europe Economics' analysis of EU KLEMS data.

In Table 4.4 we present the TFP growth values in gross output terms adjusted for scale effects. As noted in Appendix 2 of our final report[18] we source the input elasticities used in our calculations from two academic papers focusing on manufacturing sectors only. Therefore, TFP growth values adjusted for scale effects are not available for some of the sectors considered above.

Table 4.4: TFP growth in gross output for 1973-1974 recession, adjusted for scale effects (NACE 1, per cent)

Industry Comparators	1973	1974	1975	1976	1977	Average for recessionary period (1973-1974)	Average for post-recession period (1975-1977)	Average for full 5-year period (1973-1977)
Chemicals and chemical products	3.6	-0.3	-1.2	2.8	0.6	1.6	0.7	1.1
Construction	No comparable scale elasticities available							
Machinery, nec	1.8	0.3	1.8	-1.0	-0.6	1.0	0.1	0.5
Total manufacturing	2.1	-1.5	-1.0	0.7	0.4	0.3	0.0	0.1
Transport and storage	3.9	-1.3	-0.5	0.4	1.2	1.3	0.4	0.7
Average for comparators	**2.9**	**-0.7**	**-0.2**	**0.7**	**0.4**	**1.1**	**0.3**	**0.6**
Total industries (for purpose of comparison)	No comparable scale elasticities available							
Electricity, gas and water supply	No comparable scale elasticities available							

Source: Europe Economics' analysis of EU KLEMS data.

[18] Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", pp. 99-100, 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

Overall, the averages calculated for the recessionary period are higher than those reported for the post-recessionary period in several of our comparator sectors, suggesting lower productivity growth in the years immediately following the 1973-74 recession.

The highest TFP growth rate reported over the full 5-year period is 1.0 per cent for the Chemicals and chemical products sector, which increases to 1.1 per cent when we adjust for scale effects. The average across the comparator sectors for the full 5-year period from the start of the recession is 0.2 per cent.

With respect to TFP growth in the water sector during the period examined, as the final row of Table 4.3 shows, productivity growth in the sector was somewhat lower in the recessionary period than post-recession, in line with the TFP movements reported for most of the comparator sectors. At the same time, as shown in Table 0.11 and Table 0.13 in Appendix 2, the MFP growth figures calculated using the dataset published by the ONS point at decoupling for the water sector as the average MFP growth reported for "Water Supply; Sewerage, Waste Management and Remediation Activities" for the recessionary years is higher than the average reported for the post-recession years.

Further, given that our chosen comparators all have higher systematic risk than the water sector, any reduction in performance of sectors over recessionary periods may overstate impact on water sector frontier shift.

4.3 The 1980-81 recession

The 1980-81 recession was also a global recession, linked to the second oil price shock in 1979 due to a decrease in oil supply following the Iranian revolution. In the UK, the impacts and events of the 1980-81 recession are closely linked to economic events during the mid-1970s, when in 1976 the International Monetary Fund (IMF) was called in. This was followed by industrial action partly as a response to the austerity measures imposed by the IMF, a resistance from the unions through 1978-79 and the Conservative Party winning the general election in 1979 when Margaret Thatcher, a monetarist, became prime minister.

Thatcher's approach to controlling the increasingly high levels of inflation and unemployment was though controlling the increase in money stock which meant controlling the increase in public expenditure, via the Medium Term Financial Strategy (at the time public expenditure was partially funded through increases in the money supply rather than fully funded via debt). This eventually led to significant reductions in inflation over the next few years. However, the attempts to control inflation also raised the exchange rate. The Bank of England's interest rate was at 17 per cent for the first half of 1980 and fell only to 16 per cent in July. By October, these high interest rates had driven sterling up above $2.40 (versus only around $2.05 at the time the Thatcher government was elected).

Although not as serious as the widespread unrest of 1979's "Winter of Discontent", 1980 was nonetheless also a year of widespread industrial action, with 12 million working days lost to strikes. Furthermore, there was a clash between expected inflation and actual inflation. Even though inflation was falling, down to 15.4 per cent by October 1980 from 21.9 per cent in May, expectations of a U-turn in policy were widespread, with average earnings growth peaking in October at 22.6 per cent (very significant real wage growth, almost certainly indicating an expectation that inflation would rise again so that real wage growth was necessary to provide a buffer from erosion by later inflation).

The combination of public spending controls, tighter monetary policy, an elevated exchange rate, industrial action and the clash between expected and actual inflation led to a deep recession with a sharp negative impact on manufacturing and increases in structural unemployment (with the number of unemployed exceeding 3 million between 1983 and 1986).

The 1980-81 recession again represented a supply-side shock to the economy through the second oil crisis, as well as a shock to labour cost (through wages) and to hours worked (through industrial action). However, in this case there was no centrally coordinated response to these shocks as for the 1973-74 crisis or the COVID-19 pandemic. Nonetheless, the recession led to a significant increase in unemployment and had long-lasting economic implications. Overall, this suggest that the 1980-81 recession may be a reasonable partial comparator for our "Extended" scenario with enduring impacts on productivity growth, investment, and real input prices.

In Table 4.5 we present the TFP growth values in gross output terms using the EU KLEMS database which uses NACE 1 sector definitions for the 1980-81 recession. Similarly to the tables included in section 4.2, the first five columns in the table report year by year TFP growth for 5 years from the start of the recession while the last three columns show the averages calculated for the recessionary period (1980-1981), for the post-recession period (1982-1984), and for the full 5-year period from the start of the recession (1980-1984), respectively. The last two rows report the corresponding figures for "Total industries" and for the "Electricity, gas and water supply" sector.

Table 4.5: TFP growth in gross output for 1980-1981 recession, unadjusted for scale effects (NACE 1, per cent)

Industry Comparators	1980	1981	1982	1983	1984	Average for recessionary period (1980-1981)	Average for post-recession period (1982-1984)	Average for full 5-year period (1980-1984)
Chemicals and chemical products	-1.9	1.3	2.0	3.9	2.6	-0.3	2.8	1.6
Construction	-2.1	-1.4	4.8	2.8	0.9	-1.8	2.8	1.0
Machinery, nec	-2.0	-1.5	3.4	0.7	1.0	-1.7	1.7	0.3
Total manufacturing	-2.0	0.4	1.8	2.3	1.5	-0.8	1.9	0.8
Transport and storage	-3.4	2.6	1.1	3.5	0.7	-0.4	1.8	0.9
Average for comparators	**-2.3**	**0.3**	**2.6**	**2.6**	**1.3**	**-1.0**	**2.2**	**0.9**
Total industries (for purpose of comparison)	-1.8	0.2	1.3	1.4	-0.2	-0.8	0.8	0.2
Electricity, gas and water supply	0.2	2.1	0.6	1.3	-4.8	1.1	-1.0	-0.1

Source: Europe Economics' analysis of EU KLEMS data.

In Table 4.6 we present the TFP growth values in gross output terms adjusted for scale effects.

Table 4.6: TFP growth in gross output for 1980-1981 recession, adjusted for scale effects (NACE 1, per cent)

Industry Comparators	1980	1981	1982	1983	1984	Average for recessionary period (1980-1981)	Average for post-recession period (1982-1984)	Average for full 5-year period (1980-1984)
Chemicals and chemical products	-2.0	0.9	1.6	3.5	2.5	-0.5	2.5	1.3
Construction	No comparable scale elasticities available							
Machinery, nec	-1.9	-1.4	3.5	0.8	1.0	-1.7	1.7	0.4
Total manufacturing	-2.2	0.0	1.4	2.0	1.4	-1.1	1.6	0.5
Transport and storage	-3.2	2.3	1.1	4.3	1.6	-0.4	2.3	1.2
Average for comparators	**-2.3**	**0.4**	**1.9**	**2.6**	**1.6**	**-0.9**	**2.1**	**0.9**
Total industries (for purpose of comparison)	No comparable scale elasticities available							
Electricity, gas and water supply	No comparable scale elasticities available							

Source: Europe Economics' analysis of EU KLEMS data.

Overall the figures reported in both tables above suggest that TFP growth in the recessionary period decreases and in fact goes negative for all of our comparator sectors. This is then followed by a bounce-back (characterised by higher and in all cases positive TFP growth values) in the post-recession years of the 5-year period from the start of the recession. The highest average TFP growth for the full 5-year period are reported for the Chemicals and chemicals products and the Construction sectors when not adjusted for scale effects (1.6 and 1.0 per cent, respectively) and for the Chemicals and chemicals products and Transport and storage sectors when adjusted for these (1.3 and 1.2 per cent, respectively).

In terms of the TFP growth values shown for the water sector, these clearly point to decoupling from the overall economy as the average TFP growth rate reported for the recessionary period is significantly higher than that reported for the post-recession period. We note, however, that decoupling is not observed in the MFP data reported in Appendix 2.

Further, given that our chosen comparators all have higher systematic risk than the water sector, any reduction in the TFP performance of these comparator sectors over recessionary periods may overstate the impact on water sector frontier shift.

4.4 The 1990-91 recession

The 1990-91 recession again was a global as well as domestic recession, linked to the stock market crash of 1987 which also raised some concerns regarding a downturn compared to that of the Great Depression. UK policymakers' response was to loosen money supply which in turn triggered a rise in inflation as well as leading to a boom in house prices. Then interest rates were increased to control inflation resulting in a short recession. In addition, one of the devices used to lock in the high interest rates was for the UK to join the European Exchange Rate Mechanism (ERM) which gave an anchor to maintain high interest rates. When the UK was forced to leave the ERM in 1992, interest rates rapidly decreased, followed by a quick economic recovery.

The 1990-91 recession in general is considered to be a demand rather than supply-side recession, unlike the previous two recessions examined or the COVID-19 crisis. To the extent that the COVID-

19 crisis is followed by a rapid recovery under the "Shorter" or "Medium" scenarios, the 1990-91 recession may be relevant to consider in terms of a quick, "V-shaped" recovery without much enduring impact or economic "scarring" following the end of the COVID-19 health crisis.

In Table 4.7 we present the TFP growth values in gross output terms using the EU KLEMS database which uses NACE 1 sector definitions for the 1990-91 recession. Similarly to the tables included in previous sections of this chapter, the first five columns in the table report year by year TFP growth for 5 years from the start of the recession while the last three columns show the averages calculated for the recessionary period (1990-1991), for the post-recession period (1992-1994), and for the full 5-year period from the start of the recession (1990-1994), respectively. The last two rows report the corresponding figures for "Total industries" and for the "Electricity, gas and water supply" sector.

Table 4.7: TFP growth in gross output for 1990-1991 recession, unadjusted for scale effects (NACE 1, per cent)

Industry Comparators	1990	1991	1992	1993	1994	Average for recessionary period (1990-1991)	Average for post-recession period (1992-1994)	Average for full 5-year period (1990-1994)
Chemicals and chemical products	0.3	3.9	2.2	1.4	3.0	2.1	2.2	2.1
Construction	0.7	0.0	2.7	0.6	0.4	0.4	1.3	0.9
Machinery, nec	0.3	-1.1	0.6	2.3	2.3	-0.4	1.8	0.9
Total manufacturing	0.5	0.8	1.3	1.1	1.0	0.7	1.1	0.9
Transport and storage	0.6	-0.6	-0.5	0.3	2.6	0.0	0.8	0.5
Average for comparators	**0.5**	**0.6**	**1.3**	**1.2**	**1.9**	**0.5**	**1.4**	**1.1**
Total industries (for purpose of comparison)	-0.1	0.7	0.8	1.2	0.5	0.3	0.9	0.6
Electricity, gas and water supply	0.5	1.2	-0.4	0.7	-0.2	0.9	0.0	0.4

Source: Europe Economics' analysis of EU KLEMS data.

In Table 4.8 we present the TFP growth values in gross output terms adjusted for scale effects.

Table 4.8: TFP growth in gross output for 1990-1991 recession, adjusted for scale effects (NACE 1, per cent)

Industry Comparators	1990	1991	1992	1993	1994	Average for recessionary period (1990-1991)	Average for post-recession period (1992-1994)	Average for full 5-year period (1990-1994)
Chemicals and chemical products	0.3	3.5	2.0	1.3	2.8	1.9	2.0	2.0
Construction	No comparable scale elasticities available							
Machinery, nec	0.3	-1.0	0.7	2.4	2.3	-0.4	1.8	0.9
Total manufacturing	0.4	0.4	1.0	1.0	1.1	0.4	1.0	0.8
Transport and storage	0.5	-0.7	-0.2	0.6	2.9	-0.1	1.1	0.6
Average for comparators	**0.4**	**0.5**	**0.9**	**1.3**	**2.3**	**0.5**	**1.5**	**1.1**
Total industries (for purpose of comparison)	No comparable scale elasticities available							
Electricity, gas and water supply	No comparable scale elasticities available							

Source: Europe Economics' analysis of EU KLEMS data.

Overall the figures reported in the two tables above suggest that TFP growth in the recessionary period decreases for the comparator sectors (with negative TFP growth rate reported for some sectors) which is followed by a bounce-back in the years immediately after the recession. The highest average TFP growth for the full 5-year period are reported for the Chemicals and chemicals products (2.1 per cent) and the Construction, Machinery nec and Total manufacturing sectors (0.9 per cent for each sector) when not adjusted for scale effects and again for the Chemicals and chemicals products and Machinery nec sectors when adjusted for these (2.0 and 0.9 per cent, respectively).

In terms of the TFP growth values shown for the water sector, similarly to the 1980-81 recession, these clearly point to decoupling from the overall economy as the average TFP growth rate reported for the recessionary period is higher than that reported for the post-recession period. We also note that decoupling is not observed in the MFP data reported in Appendix 2.

Further, given that our chosen comparators all have higher systematic risk than the water sector, any reduction in the TPF performance of comparator sectors over recessionary periods may overstate the impact on water sector frontier shift.

4.5 The 2008-09 recession

The 2008-09 recession is often characterised[19] as beginning with a bubble in the US housing market and the collapse of the sub-prime mortgage market that provided mortgages also to those with poorer credit histories and with higher risk of default. The sub-prime mortgage market is typically linked to the housing market through mortgage-backed securities, which following repackaging and financial manipulation were sold to investors. In the years preceding the crisis the US shadow banking system (including institutions such as investment banks) which was not

[19] We give here a brief summary of a standard popular analysis of the 2008/09 crisis. For a more detailed version of our own, rather different, view, see Annex VII of http://www.europe-economics.com/publications/ex_ante_evaluation.pdf

subject to the same regulatory requirements as the traditional banking system had also expanded significantly.

Defaults on sub-prime mortgages led to a credit crunch and the fall of Lehman Brothers in 2008 led to a bank run on the shadow banking system which eventually required huge bailouts of financial institutions from governments. The recession that followed was characterised – among other things – by a sharp rise in unemployment and a slow recovery, creating long-lasting economic impacts and enduring "scarring".

The 2008-09 recession was again more a demand-side recession, but this time triggered by the private sector rather than policymakers' response, followed by a monetary recession. The impacts of the 2008-09 recession run much deeper than the potential impacts set out under any of the scenarios considered in this report. To the extent that the measures introduced by governments (such as lockdowns) to suppress coronavirus may lead to another credit crunch, the 2008-09 recession could become relevant under a more severe version of our current "Extended" scenario with economic impacts and "scarring" lasting beyond the end of the price control period.

In Table 4.9 we present the TFP growth values in gross output terms using the 2019 EU KLEMS statistical database which uses NACE 2 sector definitions for the 2008-09 recession. Similarly to the tables included in previous sections of this chapter, the first five columns in the table report year by year TFP growth for 5 years from the start of the recession while the last three columns show the averages calculated for the recessionary period (2008-2009), for the post-recession period (2010-2012), and for the full 5-year period from the start of the recession (2008-2012), respectively. We report numbers for both the previous chemical and chemical products classification used in the 2017 release of the EU KLEMS dataset that included pharmaceutical products and the new classification excluding them used in the latest, 2019 release of the EU KLEMS dataset. The last three rows report the corresponding figures for "Market economy" and separately for the "Electricity, gas, steam and air conditioning supply" and the "Water supply; sewerage; waste management and remediation activities" sectors.

Table 4.9: TFP growth in gross output for 2008-2009 recession, unadjusted for scale effects (NACE 2, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for full 5-year period (2008-2012)
Chemicals and chemical products incl. pharmaceuticals	3.0	0.7	-0.2	-1.9	-2.6	1.9	-1.5	-0.2
Chemicals and chemical products excl. pharmaceuticals	1.9	-2.4	1.4	1.3	-1.3	-0.3	0.5	0.2
Construction	-0.9	-4.4	5.2	1.3	-2.8	-2.6	1.2	-0.3
Machinery and equipment n.e.c.	1.8	-5.2	6.6	1.3	-0.2	-1.7	2.5	0.8
Other manufacturing; repair and installation of machinery and equipment	-0.9	-0.7	4.5	2.9	-5.7	-0.8	0.6	0.0
Professional, scientific, technical, administrative and support service activities	0.6	-3.4	3.3	1.6	0.9	-1.4	1.9	0.6
Total manufacturing	0.9	-1.4	2.0	0.8	-0.6	-0.3	0.7	0.3
Transport and storage	-0.9	-6.2	1.6	1.4	-1.2	-3.6	0.6	-1.1
Average for comparators (using Chemicals and chemical products incl. pharmaceuticals)	**0.5**	**-2.9**	**3.3**	**1.0**	**-1.7**	**-1.2**	**0.9**	**0.0**
Average for comparators (using Chemicals and chemical products excl. pharmaceuticals)	**0.3**	**-3.4**	**3.5**	**1.5**	**-1.5**	**-1.5**	**1.2**	**0.1**
Market economy (for purpose of comparison)	-0.1	-2.6	1.1	0.2	-0.4	-1.3	0.3	-0.4
Electricity, gas, steam and air conditioning supply	-0.9	-3.4	-0.5	-1.9	-1.1	-2.1	-1.1	-1.5
Water supply; sewerage; waste management and remediation activities	-1.1	-7.8	-1.0	-0.1	-0.8	-4.5	-0.7	-2.2

Source: Europe Economics' analysis of EU KLEMS data.

In Table 4.10 we present the TFP growth values in gross output terms adjusted for scale effects.

Table 4.10: TFP growth in gross output for 2008-2009 recession, adjusted for scale effects (NACE 2, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for full 5-year period (2008-2012)
Chemicals and chemical products incl. pharmaceuticals	0.8	0.5	0.5	0.1	-0.1	0.7	0.2	0.4
Chemicals and chemical products excl. pharmaceuticals	0.7	0.5	0.6	0.1	-0.1	0.6	0.2	0.4
Construction	No comparable scale elasticities available							
Machinery and equipment n.e.c.	-0.1	-0.1	0.0	0.1	0.0	-0.1	0.0	0.0
Other manufacturing; repair and installation of machinery and equipment	0.1	0.1	0.3	0.1	-0.2	0.1	0.1	0.1
Professional, scientific, technical, administrative and support service activities	No comparable scale elasticities available							
Total manufacturing	0.4	0.4	0.1	0.0	0.0	0.4	0.0	0.2
Transport and storage	-0.1	-0.2	0.0	0.0	-0.1	-0.2	0.0	-0.1
Average for comparators (using Chemicals and chemical products incl. pharmaceuticals)	**0.2**	**0.1**	**0.2**	**0.1**	**-0.1**	**0.2**	**0.0**	**0.1**
Average for comparators (using Chemicals and chemical products excl. pharmaceuticals)	**0.2**	**0.1**	**0.2**	**0.1**	**-0.1**	**0.2**	**0.1**	**0.1**
Market economy (for purpose of comparison)	No comparable scale elasticities available							
Electricity, gas, steam and air conditioning supply	No comparable scale elasticities available							
Water supply; sewerage; waste management and remediation activities	No comparable scale elasticities available							

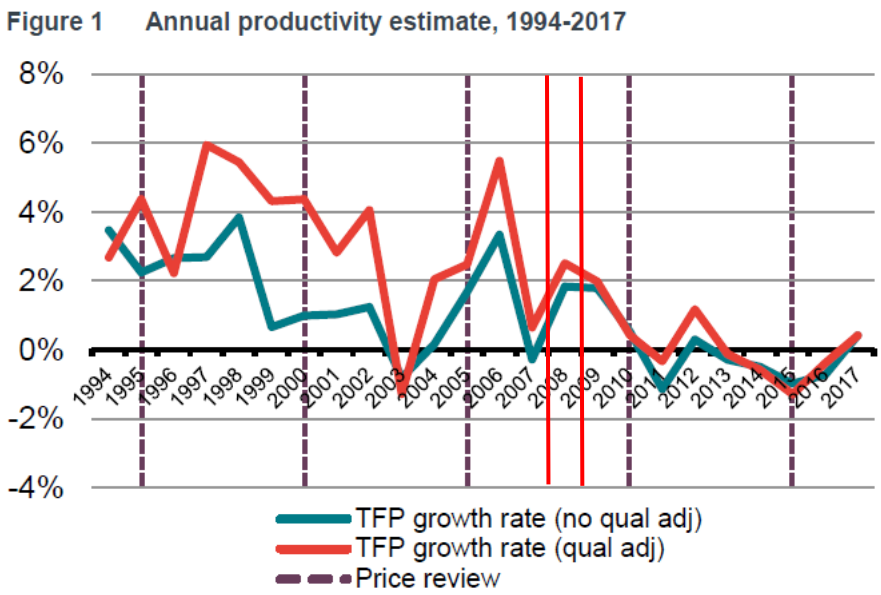
Source: Europe Economics' analysis of EU KLEMS data.

The TFP growth values reported above suggest that productivity growth in the recessionary period decreases for the comparator sectors (with negative TFP growth rates reported for some sectors) which is followed by a bounce-back in the years immediately after the recession. The highest average TFP growth for the full 5-year period is reported for the Machinery and equipment n.e.c. sector (0.8 per cent when not adjusted for scale effects and 0.9 per cent when adjusted for these).

In terms of the TFP growth values shown for the water sector, these do not support any decoupling from the overall economy as the average TFP growth rate reported for the recessionary period is lower than that reported for the post-recession period in the case of the water sector as well. We also note that no decoupling is observed in the MFP data reported in Appendix 2 either.

On the other hand, a different picture of water sector performance in this recession is provided in a 2017 report commissioned by UK Water[20] that investigated the productivity gains achieved by the water sector in the UK. Figure 4.4 from the report below show annual TFP growth rates for the water sector between 1994 and 2017 (both with and without quality adjustments). The two vertical red lines on the figure surround the 2008-09 recession, the period of analysis of interest here. The figure shows that the water sector continued to achieve positive TFP growth in the last recession, during a period when the EU KLEMS data shows that productivity growth in the overall economy was negative. The report also states that quality adjustments are likely to be conservative (i.e. under-estimates) for the later years examined, meaning that the low (and on occasions negative) figures in the most recent years in the chart are likely to be underestimates.

Figure 4.4: Annual productivity estimate as reported by Frontier Economics (2017)



Source: Frontier Economics.

Further, given that our chosen comparators all have higher systematic risk than the water sector, any reduction in TFP performance of comparator sectors over recessionary periods may overstate the impact on water sector frontier shift.

[20] Frontier Economics for Water UK, "Productivity Improvement In The Water And Sewerage Industry In England Since Privatisation", 29.07.2017.

4.6 Summary of lessons from past recessions

Table 4.11 below summarises the evidence and lessons from the 4 past recessionary periods examined in this chapter. The first two columns show the average TFP growth rates for the strongest performing sector(s) in the recessionary period, and the average TFP growth rate for comparators for the full 5-year period from the start of the recession without scale adjustments while the final two columns show the same information with scale adjustments. The final row reports the average TFP growth rates for comparators across recessions.

Table 4.11: Summary of evidence from past recessionary periods

Recession	Without scale adjustment		With scale adjustment*	
	Strongest performing sector(s)	Average for comparators (for full 5-year period from start of recession)	Strongest performing sector(s)	Average for comparators (for full 5-year period from start of recession)
1973-74	1.0 (Chemical and chemical products)	0.2	1.1 (Chemical and chemical products)	0.6
1980-81	1.6 (Chemical and chemical products) 1.0 (Construction)	0.9	1.3 (Chemical and chemical products) 1.2 (transport and storage)	0.9
1990-91	2.1 (Chemical and chemical products) 0.9 (Construction, Machinery n.e.c., Total manufacturing)	1.1	2.0 (Chemical and chemical products) 0.9 (Machinery n.e.c.)	1.1
2008-09	0.8 (Machinery and equipment n.e.c.)	0.1	0.9 (Machinery and equipment n.e.c.)	0.0
Average across recessions		**0.56**		**0.63**

*Note that construction disappears from comparator set due to absence of data on scale elasticity.
Source: Europe Economics' analysis.

Each of the 4 recessions examined in this report may be relevant under our three COVID-19 scenarios.

- Under our "Shorter" scenario – characterised by 3 months of health crisis with almost all restrictions lifted after 6 months – the 1973-74 recession appears to be the most relevant past recession to consider given certain parallels between the two periods. First, the oil shock preceding the 1973-74 crisis involved a supply-side shock to the economy, similarly to the current outbreak of the COVID-19 pandemic. This shock was then exaggerated through a centrally coordinated attempt to decrease economic activity for a limited amount of time through measures such as the Three-day week, much like attempts to suppress coronavirus by governments with lockdowns and social distancing. Finally, even though the 1973-74 crisis led to significant short-term economic impacts, the majority of these did not lead to any enduring impacts or economic "scarring", consistent with our assumptions regarding a catch up once the restrictions are lifted under this scenario.
- Under our "Medium" scenario – where the restrictions associated with the health crisis last over a year creating some lasting impacts and economic "scarring" afterwards – the 1990-91 recession appears to be the most relevant to consider. This is because the 1990-91 recession was followed by a relatively rapid, "V-shaped" recovery (once the UK was forced to leave the

ERM) without much enduring impacts or economic "scarring", consistent with our assumptions under the "Medium scenario".

- Under our "Extended" scenario – characterised by a health crisis lasting over an 18-month period with lasting impacts and economic "scarring" afterwards – the 1980-81 recession appears to be the most relevant past recession to consider. This is again due to a number of parallels that may be drawn between the 1980-81 recession and the impact of the COVID-19 pandemic assumed under the "Extended" scenario. These include a supply-side shock to the economy through the second oil crisis in 1979 (as well as shocks to labour cost and hours worked), leading to a significant increase in unemployment and other long-lasting economic implications, much like the impacts assumed under our "Extended" scenario.
- The impacts of the 2008-09 recession run much deeper than the potential impacts set out under any of our three scenarios. Nonetheless, to the extent that the measures introduced by governments (such as lockdowns) as a response to the COVID-19 health crisis may lead to another credit crunch, the 2008-09 recession could become relevant under a more severe version of our current "Extended" scenario with economic impacts and "scarring" lasting beyond the end of the price control period.

The TFP growth values presented above suggest that for 3 of the 4 recessionary periods considered above (with the exception of the 1973-74 recession) productivity growth typically slows down (and on a number of occasions goes negative) in the recession years, followed by a bounce back in the years immediately following the recession.

We do not consider it to be useful to develop different frontier shift ranges for each COVID-19 scenario, as Ofwat needs a single frontier shift range for AMP7 without knowing at this stage which COVID-19 scenario will materialise. Instead, our scenario analysis looking at four different recessionary periods in the past can be useful in examining and checking that our recommended frontier shift range is robust to different potential scenarios for the COVID-19 crisis.

Our recommended lower bound of 0.6 per cent for the frontier shift range was based on the average post-crisis TFP value (NACE 2 data for 2010-2014) across the comparator sectors. As Table 4.11 above shows, the averages reported across the 4 recessions for the full 5-year period from the start of the recession show substantial variation. The lowest reported average is 0.1 (when not adjusted for scale effects) and 0.0 per cent (when adjusted for scale effects), both for the 2008-09 recession while the highest reported average is 1.1 per cent, for the 1990-1991 recession (both unadjusted and adjusted for scale effects). At the same time the average figure across recessions is 0.6 per cent (rounded to 1 decimal place, both unadjusted and adjusted for scale effects), which is very close to the lower bound in our final assessment. Therefore we do not find strong evidence to change the lower bound of our recommended range.

Our recommended upper bound of 1.2 per cent was based on various pieces of evidence (using both the more recent NACE 2 dataset as well as the NACE 1 dataset offering a longer term view of TFP growth performance) focusing on the TFP growth performance of the stronger performing comparator sectors.

- When looking at the average TFP growth reported in the recessionary periods, a figure of 1.2 is supported by 2 of the 4 recessions examined within this chapter. Namely, in the case of the 1980-81 recession the TFP growth figures for the strongest performing sector (Chemicals and chemical products) are above 1.2 both unadjusted and adjusted for scale effects (1.3 per cent and 1.6 per cent respectively). Further, when adjusted for scale effects, the TFP growth rate for the Transport and storage sector provides further support to our recommended upper bound (with a TFP growth rate of 1.2 per cent). In the case of the 1990-91 recession the TFP figures

reported for the strongest performing sector (Chemicals and chemical products, similarly to the 1980-81 recession) are well above 1.2 both unadjusted and adjusted for scale effects (2.0 per cent and 2.1 per cent respectively).

- In addition, a third recessionary period analysed in this chapter (the 1973-74 recession) would also support a figure of up to 1.1 per cent (which is the point estimate used by Ofwat from our recommended range in its final determinations for frontier shift on an annual basis[21]) based on the strongest performing sector (Chemicals and chemical products) when scale effects are adjusted for (with a TFP growth rate of 1.2 per cent in the recessionary period).
- Further, only one of the recessions (the 2008-09 recession) would point to a substantially lower figure for the upper bound of the recommended range. In this case, the TFP figures for the strongest performing sector (Machinery and equipment n.e.c.) would suggest a range of up to 0.8 per cent (when scale effects are not adjusted for) and to 0.9 per cent (when scale effects are adjusted for). However, this recession is the least relevant to the COVID-19 scenarios that we are examining.

Hence, even when we look at our comparator sectors which have much greater systematic risk exposure than the water sector, we still find that the strongest performing sectors have been able to achieve TFP growth rates of 1.1 per cent (coinciding with Ofwat's overall efficiency challenge in the final determinations) and 1.2 per cent (the upper bound of our recommended range) or more in all but one of the past recessions (the 2008-09 recession). Given that the water sector is likely to be much less affected than these comparator sectors (as shown by its lower asset beta), we find no strong basis for adjusting the top end of our range.

In addition, while the levels of water sector TFP growth rates are not conclusive due to the problems in measuring the quality of output in the water sector,[22] comparisons between different periods could still be instructive. In particular, analysis of the EU KLEMS dataset shows that water sector TFP growth is decoupled from the wider economy, given that in 3 out of the 4 recessionary periods analysed our comparator sectors typically experienced a slowdown during the recessions followed by a bounce-back in the immediate aftermath of the recession while opposite movements in water sector TFP were observed. We note that decoupling is not generally supported by past ONS evidence.

Various explanations could be offered for the finding supported by the EU KLEMS dataset that water sector TFP growth is decoupled from the wider economy. For example, during the nationalised period (relevant for the first 2 of the recessionary periods examined) political pressure for efficiency such as to reduce government deficit or customer bills may have been greater in recessionary periods may explain the higher TFP growth rates reported for the recessions. The 1990-91 recession occurred just after the water sector was privatised (in 1989) and therefore at the time there was significant scope for the newly privatised companies to become more efficient, in particular in the early years of the price control period. This is because early price controls may have given companies incentives to achieve efficiency gains early on in the price control period so that efficiency gains from later on in the price control can be kept for

[21] For further details, please see: Annex 3 of Ofwat (2019): "PR19 Final determinations - Securing cost efficiency technical appendix", available at: https://www.ofwat.gov.uk/wp-content/uploads/2019/12/PR19-final-determinations-Securing-cost-efficiency-technical-appendix.pdf

[22] For further discussion regarding changes in the quality of output please refer to section 3.7.1 of our final assessment: Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 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

longer.[23] Whatever the explanation, the results from the EU KLEMS dataset show that water sector TFP is not necessarily affected negatively as comparators are in periods on recessions.

This finding is supported by the report commissioned by Water UK which shows that the water sector continued to achieve positive TFP growth in the last recession (i.e. 2008-09), during a period when the EU KLEMS data shows that productivity growth in the overall economy was negative.

Finally, as discussed in the next chapter, TFP can be affected by factors such as capacity utilisation. Therefore, even if TFP growth rate is lower in a recessionary period, it needs to be carefully considered whether this lower TFP growth rate directly translates to a lower frontier shift figure in the specific context of the water sector.

[23] This may have particularly been the case before the introduction of rolling incentive allowance by Ofwat at PR99 for the 2000-2005 price control period which allowed companies to retain any gains from outperformance for a 5-year period. For further details, please refer to: Ofwat (1999): "Final determinations - Future water and sewerage charges 2000–05", available at: https://webarchive.nationalarchives.gov.uk/20150603222823/http://www.ofwat.gov.uk/pricereview/pr99/det_pr_fd99.pdf

5 Read-across from TFP to Frontier Shift in Current Context

5.1 How TFP maps to frontier shift

The basic rationale for using TFP was to use productivity growth as an approximation for what frontier shift was possible. TFP was deemed more appropriate for totex, given it considers all measurable factors of productivity, capturing the change in output not explained by a change in inputs. It is the residual growth of outputs less the weighted average growth in different inputs.

Using estimates of TFP growth to forecast possible frontier shift in the water industry in the future requires some implicit assumptions that ordinarily are not spelled out. One issue is how we go from findings for other sectors' historic productivity growth to making a forecast for potential productivity growth in the water industry. One approach might be to argue that the comparator industries had features that accord with what we expect the water industry to face in the next five years, and therefore the historic TFP growth in those sectors is a suitable forecast for the water industry. An alternative, subtly different, approach would be to argue that the comparator industries are likely to have similar features as the water industry in the coming years. The best forecast we have for productivity growth in these other industries is their historic performance, so we estimate future productivity growth for the other sectors based on their historic TFP growth, and then assume the same potential productivity growth is possible for the water industry.

The final determination did not explicitly set out which of these approaches were the basis for using comparator industry TFP growth as a basis for setting frontier shift possibilities in the water industry. It is unlikely it would have made any difference. But the difference may be important when thinking about how to update the frontier shift estimates for a recessionary period.

Under the former approach, the key question to ask is "to what extent will the water industry change as a consequence of COVID-19 such that the historic data for comparator industries no longer represents a suitable comparator? Whereas under the latter approach, we would want to identify to what extent COVID-19 might affect comparator industries in the future such that we had to adjust how we interpret the historic TFP growth evidence to get forecasts for these sectors, and then we would want to ask ourselves whether the water industry is forecast to be affected by COVID-19 in a similar manner to the comparator industries.

The preceding chapter has looked at the evidence on how TFP growth rates for the comparator sectors varies over the cycle. The evidence from these sectors does not suggest that we need to change the upper and lower bounds for frontier shift we assumed for the water sector in our final assessment published in December 2019, if we base our forecast on how those sectors are forecast to behave during a recession. The evidence on asset betas also suggests that these other comparator sectors are more exposed to systemic risk than the water sector, which might be seen as evidence that there are good reasons not to make inferences for the water sector based on how we expect productivity in these sectors to respond during a recession.

The alternative approach is to ask whether long-run trends observed in comparator sectors are the best basis for forming a view on what changes we should expect the water industry to achieve in the future. Therefore, is there is anything about the challenges facing the water industry in the next five years that have changed sufficiently to mean that evidence gathered from comparator industries on productivity gains in the past is no longer informative?

5.2 What has changed in the water sector?

TFP can be decomposed into

- A scale component
- Catch-up:
  - A technical efficiency change component, where firms move closer to or further away from what's achievable
  - An allocative efficiency component, as firms adopt a more or less efficient mix of inputs.
- A frontier shift

To reach conclusions about what TFP growth might mean for frontier shift, it is also important to control for possible changes in the quality of inputs or quality of outputs.

We consider whether and how COVID-19 might warrant a change in any of these aspects, insofar as it affects the water industry, and what that might mean for the frontier shift that Ofwat might adopt.

5.2.1 Scale effects

Just looking at the effect on industrial demand for water during periods of lockdown, simple calculations based on our three scenarios suggest that demand for water during the health crisis could be materially lower.

Table 5.1: Impact of COVID-19 scenarios on demand (per cent)

		Shorter scenario	Medium scenario	Extended scenario (Year 1)	Extended scenario (Year 2)
Reduction in industrial demand	Water	-6.1	-16.3	-16.3	-6.1
	Wastewater	-6.9	-18.5	-18.5	-6.9
Reduction in overall demand	Water	-3.9	-10.3	-10.3	-3.9
	Wastewater	-5.0	-13.4	-13.4	-5.0

Source: Europe Economics calculations.

Our final assessment in December 2019 assumed that the water industry would continue operating at roughly the same scale of operation. If we instead assume that output in the water industry will fall materially, then Ofwat will need to consider scale effects. However, if Ofwat adjusts its estimates of future demand and connections and changes its forecasts for totex accordingly, there is no need to vary the frontier shift for scale effects, since the effect will be captured elsewhere in the allowed revenue calculations.

Scale effects are conceptually distinct from productivity growth, and our TFP growth estimates have attempted to control for possible scale effects. Ideally, we wanted to find comparator industries where there are constant returns to scale or where the industry's scale of operations

and market structure are little changed (a change in market structure, such as a merger of the two largest firms, may result in scale economies).

Scale effects may justify a change in totex and botex levels, but such changes should occur outside the exercise considering changes in frontier shift. One complication when thinking about how to control for scale effects in a regulatory setting is how quickly the water companies can be expected to respond to changes in scale. Their ability to vary capital, in particular, will be limited in the short run, so standard scale elasticity estimates may not be appropriate. We return to this point when discussing disembodied effects and specifically the possibility of unutilised inputs affecting TFP growth.

5.2.2 Catch-up

By design, Ofwat wanted the frontier shift to reflect what gains were possible over and above any catch-up water companies should have done. The approach to estimating TFP growth in our final assessment in December 2019 had already sought to generate estimates that were not distorted by catch-up effects. Therefore, there is no reason for this consideration to alter the frontier shift sought, although it is possible that Ofwat will conclude that firms require a different length of time to catch-up to the frontier if they are not already there.

5.2.3 Disembodied effects

Evidence from the UK and the US suggests that TFP is procyclical, with various explanations offered for this finding, such as:

- GDP growth and productivity are both driven by technology shocks;
- economies of scale;
- labour and capital hoarding (firms are slow to hire and fire workers, and cannot easily 'fire' capital);
- firms do maintenance work during downturns, work that is needed but does not show up in output measures; and
- employee effort is procyclical (and unobservable).

The implications for water industry frontier shift will depend on which of these explanations is adopted. We discuss the implications for the water sector of each possible explanation in turn below.

The idea that productivity and GDP move in line due to technology shocks might warrant assuming that water industry productivity should have a procyclical pattern. However, this is not certain. It may be that a technology shock benefits certain parts of the economy disproportionately. At the aggregate level, we might observe increased productivity and GDP, but that growth may have come from only a few sectors while most other sectors may have been largely unaffected by the shock. There is also a question as to whether we view COVID-19 as a technology shock (presumably negative). It might be argued that COVID-19 has negatively affected the productivity of the various input factors, such as social distancing rules making labour less productive in certain tasks. Another reason for expecting COVID-19 to feed through to lower water sector productivity on account of a technological shock is through second-order effects from lower research and innovation than in normal times. The reduced innovation may be because the economy-wide incentives to invest in R&D may be lower during a downturn or because the downturn squeezes R&D budgets. COVID-19 has made it less likely that the water

industry will realise the benefits of technology shocks (innovations) than it would during upturns in the economy.

Our analysis already attempts to control for scale effects. We discussed earlier the issue of whether the frontier target should be adjusted to account for possible loss of scale economies in the water sector.

A related point is the possibility that measured productivity will fall because firms have spare capacity due to a reluctance or inability to scale back on inputs during a downturn. In the case of labour, firms have to choose between hoarding labour or incurring hiring and firing costs in response to changing demand. The extent to which this is relevant for the water industry will depend largely on the assumed scale economies in the sector. If there are large economies of scale, then any fall in demand may have few implications for the inputs needed in the sector and there would be no case for water companies' productivity growth to slow on account of idle labour inputs because of short-term frictions to varying the level of inputs. The government's policy of paying 80 per cent of wages for furloughed employees may encourage labour hoarding in other sectors, and could feed through to estimates of economy-wide productivity in the coming years if these employees continue to be recorded as labour inputs. If these arrangements do not affect the water industry to the same extent, then we might expect to see a divergence between economy-wide productivity and the continued scope for improvement in water-sector productivity. However, how to interpret economy-wide productivity data for the period at future determinations is not something that Ofwat needs to resolve now.

Capital is usually assumed to be fixed in the short-run. Some of the productivity and efficiency literature attempts to control for the fact that capital is a quasi-fixed factor of production. For example, Griffith and Van Reenen seek to estimate a "capital input adjusted for capacity" series to use as the measure of capital when estimating productivity.[24] In the absence of such adjustments, one reason measured productivity may decline in recessions is because firms have spare capital. As with labour hoarding, the extent to which this rigidity matters for the water industry will depend on the assumed change in demand and the magnitude of any scale economies. If scale economies are large, then the optimal level of capital may not need to adjust during the downturn even if demand falls notably so there would be no reason for firms to have excess capital.

If the COVID-19 crisis leads to a large step reduction in demand that leaves water companies with unutilised capacity, the right way for the regulator to address this is to increase the base allowed revenue per unit of output to reflect the lower level of efficiency achievable when firms are saddled with unutilised capital. This happens automatically under the current regime as the RAB commitment guarantees recovery of historical investment, allowing firms to recover these same costs from the lower level of volume. There is then the separate question about how the targets should evolve year-on-year. The fact that firms have unutilised capacity could even imply scope for faster productivity growth, since they can increase output without having to increase capital inputs (since they can start using their underutilised capacity once more as demand recovers).

The argument that during recession firms will have spare capacity (excess labour and capital) may act as a counter to the suggestion that innovation will fall during recessions. The impediments to innovation are less as firms can free up some resources from productive activities and use the time to engage in training or R&D.

[24] Rachel Griffith and John Van Reenen (2004), "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries", *Review of Economics and Statistics*, Volume 86(4), p.883-895.

The asset beta evidence suggests that the water industry is less cyclical than the general economy, suggesting that there is less of a case for water companies to respond to sudden jumps in demand by deferring maintenance work and 'sweating assets'. Moreover the regulatory settlement is intended to incentivise water companies to undertake efficient levels of maintenance work throughout the business cycle. It is even possible that COVID-19 will create opportunities for water companies to be more efficient in how they schedule and undertake maintenance work. They may be able to schedule certain works for periods when the wider economy is in shutdown, allowing them to agree less onerous requirements with local authorities in terms of the physical space the work is confined to and how long they have to complete the work.

Unobservable employee effort might reflect workers being incentivised by the prospect of larger bonuses during boom times. This is likely to be of less importance in a sector such as the water industry, which is much less cyclical than the general economy. The ability of the water industry to create the right incentives for its workers are unlikely to vary greatly through the business cycle.

Most explanations for procyclical TFP growth would not warrant expecting a similar relationship in the water industry. If we thought the driver for such procyclicality is technology shocks, and that COVID-19 is akin to such a shock (or its effects on innovation will be similar), then there may be a case for reducing the frontier shift expected in the water industry. However, it is likely to be a superior policy for Ofwat to estimate directly any additional costs that the water industry may incur due to the COVID-19 restrictions (e.g. social distancing rules) and include those costs in its allowances. This would allow for a more precise quantification of such impacts than adjusting its frontier shift assumption.

At the macroeconomic level, it is not automatically right to assume that productivity is procyclical, so there is even less reason to assume that all sectors of the economy will have procyclical productivity. In Spain, productivity data is not procyclical, possibly because of greater reliance on temporary employment.[25] At the start of the last century, there were arguments that productivity was countercyclical. More recently, it is possible to find papers arguing that productivity in the US is becoming less procyclical, with explanations such as the reducing importance of traditional manufacturing or greater flexibility in the labour market meaning that problems of 'input' hoarding have become less marked.[26]

5.2.4 Quality of inputs

EU KLEMS controls for changes in the quality of inputs, such as controlling for changes in the composition of the labour forces (in terms of age, gender and education levels). We do not think that there is a compelling reason to expect a notable change in the quality of labour inputs available to the water sector in the next five years.

Most reports to date suggest that the segments of the population most adversely affected by COVID-19 are older people, so the labour force is unlikely to change materially as a consequence.

It is uncertain in what direction any changes in capital input quality might go, even assuming there is a material change that affects the industry during the price-control period. The crisis may

[25] See https://www.caixabankresearch.com/en/why-productivity-growth-declining

[26] See John G. Fernald and J. Christina Wang (2016) "Why Has the Cyclicality of Productivity Changed? What Does It Mean?" *Annual Review of Economics* 2016 8:1, 465-496 https://www.annualreviews.org/doi/10.1146/annurev-economics-080315-015018

lead to technological innovation in capital goods as other sectors create spill-over benefits for the water sector by finding new technologies for doing things given the problems of relying on labour. At the same time, the general reduction in business confidence due to the recession could lead to lower investment in R&D, thus dampening innovation.

5.2.5 Quality of output

Possible measurement issues concerning the quality of output have the potential to complicate how TFP measures should be used when thinking about possible frontier shifts. For example, conclusions that the water sector has had negative TFP growth may reflect a mismeasurement of outputs, rather than an actual fall in productivity. Changes in the quality of output may not be picked up, so while the water industry may be measured as servicing the same number of households and meeting the same level of business demand as 20 years ago, this neglects the fact that the water companies may be doing a lot more to ensure safe water and environmentally friendly production techniques.

When thinking about frontier shift, the productivity gains may show up in the form of less inputs needed for a given level of output, a higher quality of output for a given level of output or some combination of the two. In its December 2019 decision, Ofwat set targets for outcomes and costs that required firms to improve on both counts (fewer costs, better outputs).

The frontier shift assumptions implicitly assumed that the water companies would realise the stretching outcome targets Ofwat was setting. Should Ofwat decide to vary the outcomes firms are expected to realise, then that could warrant a change in the inputs that firms are thought to need to be on the frontier. Under the more severe COVID-19 scenarios, the much lower income of consumers may warrant revisiting decisions on the trade-offs consumers are willing to make between the level of water charges and the realisation of environmental and other targets that might be viewed as improving the quality but not the volume of output of the water industry.

5.3 Can frontier shift be negative?

A regulator should certainly be willing to accept the theoretical possibility of negative frontier shift.

Changing laws or social norms may make certain combinations of inputs less productive than they were in the past. While there may be an abstract argument that, in theory, we could achieve the output levels realised in the past, the frontier could only be reached by breaching the law or social norms. But Ofwat is seeking to identify a frontier that an efficient water company operating within societal norms and laws could be expected to meet. For example, if certain safety procedures (e.g. to prevent the spread of coronavirus) become the norm and adversely affect productivity, Ofwat's targets for frontier shift should reflect this even if it means that it concludes that firms will need more resources in five years' time than they did today to realise the same output.

It is also possible that the nature of inputs changes, such that what was achievable X years ago is no longer achievable today. For example, suppose there have been productivity gains associated with GPS: workers are able to get from one site to another more efficiently. If GPS ceased to function, it may be wrong to assume (at least in the short term) that productivity levels realised in the years prior to GPS becoming widespread are appropriate as map-reading skills in the labour force may not correspond to those present 20 years ago.

While theory suggests that negative frontier shift is possible, we do not think it would be an appropriate assumption for the water sector for AMP7. For the reasons set out above, the water sector is likely to be less affected than other sectors by COVID-19. In particular, we assume that given the key role of the water sector it will continue to be excluded from government lockdown, meaning that its workers will continue to be able to perform their jobs (apart from temporary periods of illness if they succumb to COVID-19). We do not anticipate that a 2m social distancing rule on physical sites will materially affect the ability of workers to perform their jobs, and we do not anticipate that companies should have problems organising remote working for head office staff. Further, under our COVID-19 scenarios these types of restrictions only apply for 3 months (under the "Shorter" scenario) to 18 months (under our "Extended" scenario). Hence, we do not think a negative frontier shift assumption for the water sector is at all plausible.

6 Conclusions

This report has set out to assess the impact of the COVID-19 crisis on RPEs and frontier shift. In particular, it provided our assessment in relation to the following:

- Development of high-level scenarios for the duration and economic impact of the COVID-19 crisis, which then forms the basis for the subsequent assessment of the impact of the COVID-19 crisis on RPEs and frontier shift.
- Qualitative analysis of potential RPEs in each major wholesale cost area (labour, energy, chemicals, and materials, plant and equipment) under each of the COVID-19 scenarios, considering both impacts during the health crisis and after the health crisis has ended.
- Analysis of TFP growth in comparator sectors in past recessionary periods using EU KLEMS data, adjusting for any TFP effects that relate to loss of scale economies due to falling demand.
- Theoretical analysis of how TFP relates to frontier shift in the current context, including whether frontier shift cannot be less than zero on theoretical grounds.

We present the results for each of these points in turn.

6.1 Scenarios for economic impact of COVID-19

Our analysis considered three scenarios for the analysis of the duration and impacts of the COVID-19 crisis. Initially these scenarios have been set out at a high-level including some broad sense-of-scale macroeconomic impacts, while the implications in specific (such as real input prices or productivity) have been considered in later sections of the report.

The three scenarios considered are as follows:

- A "Shorter" scenario assuming that the COVID-19 health crisis ends after 3 months and after 6 months almost all restrictions are lifted. Under this scenario GDP is significantly reduced during the first 3 months of the period, however much of that is caught up once the restrictions are lifted after 6 months. Therefore, the COVID-19 crisis has no enduring economic impacts after 6 months. Under this scenario the effects of Suppression amount to a loss of GDP of around 10 per cent over 3 months.
- An "Extended" scenario in which the restrictions associated with the health crisis last over an 18-month period. This period is sufficiently long to create enduring economic impacts (i.e. economic "scarring") even after 18 months. These effects taper away gradually over time, and the scenario assumes that all "scarring" is gone by the end of the next price control period. A key feature of this scenario is that coronavirus is considered by governments to be too dangerous to allow economic life to carry on as before. Consequently, under this scenario governments apply strict Suppression rules in periods where the spread of the coronavirus means that public health services may become overwhelmed. Drawing on the analysis presented by Imperial College, the scenario assumes that Suppression follows a Sawtooth pattern whereby two months of Suppression are followed by one month of relaxation for the first 9 months, after which the Sawtooth takes the form of one month on, one month off. Further, in the periods of the Sawtooth in which Suppression is relaxed, we assume assets are used more intensively than would have been normal in the past, so as to catch up with lost

output and demand. Under this scenario the aggregate effect on GDP is that it is 5 to 10 per cent lower in the first year, then 3.33 to 6.67 per cent lower during the following six months.

- A "Medium" scenario is assumed to be a shorter and more moderate version of the Extended scenario in which case the health crisis lasts a year and any enduring economic impacts after one year fade away quicker than under the Extended scenario. The Sawtooth under this scenario works in the same way as described above for the Extended scenario (i.e. two months of Suppression followed by one month of relaxation for the first 9 months, after which it takes the form of one month on, one month off, including the assumption that assets are used more intensively during the relaxation months). Similarly, the aggregate effect over the year is that GDP is 5 to 10 per cent down.

6.2 Real price effects under COVID-19 scenarios

We conduced a qualitative analysis to assess the case for a potential RPE under the COVID-19 scenarios. We present the results for each major wholesale cost area in turn.

In the case of labour costs, the crisis is likely to lead to a significant increase in unemployment which puts downward pressure on wage growth. This means that there is a serious possibility of negative real wage growth over AMP7 under the Extended scenario.

For energy costs, the COVID-19 crisis has already led to plummeting oil prices which is likely to feed through into other energy prices as well. This appears to reflect existing issues in world oil markets (including the failure of Russia and Saudi Arabia to reduce oil output) along with plummeting demand caused by COVID-19.

At the same time demand for electricity during the crisis is likely to fall due to industries shutting down. The supply of electricity is unlikely to be affected given that energy is a priority sector that the government will want to ensure keeps running. These factors, along with lower input fuel costs (e.g. lower gas prices driven by lower oil prices), are likely to lead to industrial electricity prices falling during the crisis.

The above factors imply either a negative RPE if combined with the existing assumption for base energy costs, or a reduced base energy cost. If addressed in the latter way, it is possible that energy prices could recover during the period, thus implying a potentially positive RPE from a lower base energy cost.

However, there is great uncertainty over future energy prices so the argument for indexation or a true-up mechanism may be stronger. In particular, there is now a case for placing more weight on the historical periods we identified in which electricity price volatility was greater.

In the case of chemical costs, and materials, plant and equipment costs the net effect of the COVID-19 crisis on these input prices is indeterminate under all three scenarios. This is because these sectors are likely to be facing both reduced demand and restrictions in supply over AMP7.

6.3 TFP growth in past recessionary periods

We looked at TFP growth in four past recessionary periods covered by the EU KLEMS dataset: the 1973-1974 recession, the 1980-1981 recession, the 1990-1991 recession and the 2008-2009 recession. Our analysis examined TFP growth over a 5-year period from the start of each recession as the outbreak of the COVID-19 pandemic and the measures introduced by

governments to mitigate the health impacts of the crisis began around the start of the next 5-year price control period for the water sector in the UK.

The TFP growth rates suggest that for 3 of the 4 recessionary periods considered (with the exception of the 1973-74 recession) productivity growth typically slows down (and on a number of occasions goes negative) in the recession years, followed by a bounce back in the years immediately following the recession.

Although average TFP growth for the comparator sectors shows substantial variation across the 4 recessions, the average across recessions is 0.6 per cent (including when scale effects are adjusted for). Therefore we do not find strong evidence to change the lower bound of our recommended range which was also 0.6 per cent. Similarly, we do not find strong evidence to change our recommended upper bound of 1.2 per cent either. This is because when focusing on the TFP growth performance of the stronger performing comparator sectors a figure of 1.2 is supported by 2 of the 4 recessions considered, with a third recession supporting a figure of up to 1.1 per cent.

Further, our analysis of asset betas for the comparator and water sectors suggest that all our comparators are much more exposed to business cycle than the water sector. Consequently, any reduction in productivity growth of comparators over recessionary periods is likely to overstate the impact on the frontier shift the water sector may be expected to achieve.

In addition, analysis of the EU KLEMS dataset shows that water sector TFP growth is decoupled from the wider economy, given that in 3 out of the 4 recessionary periods analysed our comparator sectors typically experienced a slowdown during the recessions followed by a bounce-back in the immediate aftermath of the recession while opposite movements in water sector TFP were observed. Further, in the last recession (2008-09) a Water UK report shows significant continued TFP growth in the water sector despite the fact that productivity was falling across the economy.

Thus, we do not find strong evidence to change our proposed range for frontier shift wholesale totex of 0.6 to 1.2 per cent.

Further, as summarised in the section below, TFP can be affected by factors such as capacity utilisation. Therefore, even if TFP growth rate is lower in a recessionary period, it needs to be carefully considered whether this lower TFP growth rate directly translates to a lower frontier shift figure in the specific context of the water sector.

6.4 Read-across from TFP to frontier shift in current context

Finally, we also conducted a theoretical analysis of how TFP relates to frontier shift in the current COVID-19 context.

Our analysis explored the question of whether there is anything about the challenges facing the water industry in the next five years that have changed sufficiently to mean that evidence gathered from comparator industries on productivity gains in the past is no longer informative.

To this end – drawing on first principles – we decomposed TFP growth into the following components and explored the implications of the COVID-19 crisis for each of these elements:

- A scale component – Simple calculations based on our three scenarios suggest that industrial and overall demand for water during the crisis could be materially lower. Therefore, scale

effects may justify a change in base totex and botex, but such changes should occur outside the exercise considering changes in frontier shift.

- Catch up (consisting of a technical efficiency change component and an allocative efficiency component) – Our approach to estimating TFP growth in our final assessment already sought to generate estimates that were not distorted by catch-up effects.
- Frontier shift – Evidence generally supports the finding of procyclical TFP growth, but most explanations for this finding would not warrant expecting a similar relationship in the water industry. To the extent that the driver for such procyclicality is technology shocks, and the measures taken to control COVID-19 are akin to such a shock, then there may be a case for temporarily reducing the frontier shift expected in the water industry during the period of the health crisis, although a better, alternative approach would be for Ofwat / the CMA to consider separately whether companies will incur any additional costs during the period of the health crisis.

Finally, while theory suggests that negative frontier shift is possible, we do not think it would be an appropriate assumption for the water sector for AMP7. For the reasons set out in this report, the water sector is likely to be less affected than other sectors by the COVID-19 crisis. For instance, our analysis assumes that the water sector would be excluded from lockdown under all scenarios given its key role.

6.5 Summary of conclusions

In summary, our overall conclusions are:

- Under the "Medium" and "Extended" scenarios, there is a case for revisiting Ofwat's previous assumptions on RPEs for real wages and energy prices. Real wages are likely to grow more slowly than Ofwat has assumed, with stagnant or negative real wage growth over AMP7 being a possibility under the "Extended" scenario. Energy prices are also likely to be lower, albeit with the future path of energy prices subject to greater uncertainty. (The reduction in energy prices could be captured through a lower base energy cost allowance rather than a negative RPE.)
- We are maintaining our frontier shift range of 0.6 to 1.2, as the evidence from past recessions as well as theoretical considerations suggest that the water sector is shielded from the negative productivity impacts likely to be observed elsewhere in the economy.

Appendices

Europe Economics

Appendix 1: EU KLEMS GVA Data

Appendix 1 presents the TFP growth values in terms of gross value added for the 4 recessionary periods considered in Chapter 4. Further, the final section presents the TFP growth values for the 2008-2009 recession when further intangible assets are included within capital assets, using the analytical database published as part of the 2019 EU KLEMS dataset.

Similarly to the tables included in Chapter 4, the first five columns of each table report year by year TFP growth for 5 years from the start of the recession while the last three columns show the averages calculated for the recessionary period, for the post-recession period, and for the full 5-year period from the start of the recession, respectively. Corresponding figures for "Total industries" (when using the NACE 1 dataset) and "Market economy" (when using the NACE 2 dataset) and values for the Electricity, gas and water supply sector (separately in the case of the NACE 2 dataset) are also reported.

The TFP growth figures reported in the tables below are consistent with the general trend typically observed across recessions (with the exception of the 1973-74 recession) whereby productivity growth slows down in the recession years, followed by a bounce back in the years immediately following the recession.

As explained in our final assessment[27], we believe that TFP growth measured in gross output terms is a more accurate measure of frontier shift if applied to botex or totex (which includes spending on intermediate inputs), nevertheless some lesser weight should also be placed on TFP growth in value added terms. Since TFP growth estimates in value added terms are by definition higher in magnitude than the corresponding TFP gross output measure, by placing some weight on the former we move towards the upper end of the range for TFP growth in gross output terms.

The 1973-74 recession

In Table 0.1 we present the TFP growth values in gross value added terms using the EU KLEMS database which uses NACE 1 sector definitions for the 1973-74 recession.

[27] Europe Economics (2019): "Real Price Effects and Frontier Shift – Final Assessment and Response to Company Representations", 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

Table 0.1: TFP growth in value added for 1973-1974 recession, unadjusted for scale effects (NACE 1, per cent)

Industry Comparators	1973	1974	1975	1976	1977	Average for recessionary period (1973-1974)	Average for post-recession period (1975-1977)	Average for full 5-year period (1973-1977)
Chemicals and chemical products	12.5	-2.2	-3.9	10.0	1.6	5.2	2.6	3.6
Construction	-4.3	-10.0	-1.9	-0.3	1.8	-7.1	-0.2	-3.0
Machinery, nec	4.7	1.1	4.9	-2.8	-1.6	2.9	0.2	1.3
Total manufacturing	6.1	-6.1	-2.3	2.9	1.2	0.0	0.6	0.4
Transport and storage	7.2	-3.2	-1.2	0.8	2.2	2.0	0.6	1.2
Average for comparators	**5.3**	**-4.1**	**-0.9**	**2.1**	**1.0**	**0.6**	**0.7**	**0.7**
Total industries (for purpose of comparison)	1.3	-6.8	-1.0	0.2	0.2	-2.8	-0.2	-1.2
Electricity, gas and water supply	6.5	-2.5	3.0	1.6	4.6	2.0	3.1	2.6

Source: Europe Economics' analysis of EU KLEMS data.

In Table 0.2 we present the TFP growth values in gross value added terms adjusted for scale effects.

Table 0.2: TFP growth in value added for 1973-1974 recession, adjusted for scale effects (NACE 1, per cent)

Industry Comparators	1973	1974	1975	1976	1977	Average for recessionary period (1973-1974)	Average for post-recession period (1975-1977)	Average for full 5-year period (1973-1977)
Chemicals and chemical products	12.5	-2.0	-4.1	10.1	1.8	5.2	2.6	3.7
Construction	No comparable scale elasticities available							
Machinery, nec	4.6	1.0	5.0	-2.8	-1.7	2.8	0.2	1.2
Total manufacturing	6.3	-5.8	-2.6	2.8	1.3	0.3	0.5	0.4
Transport and storage	7.3	-2.9	-1.1	0.8	2.3	2.2	0.6	1.3
Average for comparators	**7.7**	**-2.4**	**-0.7**	**2.7**	**0.9**	**2.6**	**1.0**	**1.6**
Total industries (for purpose of comparison)	No comparable scale elasticities available							
Electricity, gas and water supply	No comparable scale elasticities available							

Source: Europe Economics' analysis of EU KLEMS data.

The 1980-81 recession

In Table 0.3 we present the TFP growth values in gross value added terms using the EU KLEMS database which uses NACE 1 sector definitions for the 1980-81 recession.

Table 0.3: TFP growth in value added for 1980-1981 recession, unadjusted for scale effects (NACE 1, per cent)

Industry Comparators	1980	1981	1982	1983	1984	Average for recessionary period (1980-1981)	Average for post-recession period (1982-1984)	Average for full 5-year period (1980-1984)
Chemicals and chemical products	-7.1	4.8	7.0	12.5	7.8	-1.1	9.1	5.0
Construction	-4.8	-3.4	11.3	6.8	2.1	-4.1	6.8	2.4
Machinery, nec	-5.2	-3.8	8.7	1.7	2.3	-4.5	4.2	0.7
Total manufacturing	-6.6	1.4	5.5	7.1	4.5	-2.6	5.7	2.4
Transport and storage	-6.3	4.8	2.1	6.5	1.3	-0.8	3.3	1.7
Average for comparators	**-6.0**	**0.8**	**6.9**	**6.9**	**3.6**	**-2.6**	**5.8**	**2.4**
Total industries (for purpose of comparison)	-4.1	0.5	2.8	3.0	-0.3	-1.8	1.8	0.4
Electricity, gas and water supply	0.6	5.3	1.4	3.3	-16.2	3.0	-3.8	-1.1

Source: Europe Economics' analysis of EU KLEMS data.

In Table 0.4 we present the TFP growth values in gross value added terms adjusted for scale effects.

Table 0.4: TFP growth in value added for 1980-1981 recession, adjusted for scale effects (NACE 1, per cent)

Industry Comparators	1980	1981	1982	1983	1984	Average for recessionary period (1980-1981)	Average for post-recession period (1982-1984)	Average for full 5-year period (1980-1984)
Chemicals and chemical products	-7.2	4.4	6.6	12.1	7.8	-1.4	8.8	4.7
Construction	No comparable scale elasticities available							
Machinery, nec	-5.2	-3.7	8.8	1.8	2.3	-4.4	4.3	0.8
Total manufacturing	-6.8	0.9	5.1	6.8	4.4	-2.9	5.4	2.1
Transport and storage	-6.2	4.6	2.1	7.3	2.2	-0.8	3.9	2.0
Average for comparators	**-6.3**	**1.5**	**5.7**	**7.0**	**4.2**	**-2.4**	**5.6**	**2.4**
Total industries (for purpose of comparison)	No comparable scale elasticities available							
Electricity, gas and water supply	No comparable scale elasticities available							

Source: Europe Economics' analysis of EU KLEMS data.

The 1990-91 recession

In Table 0.5 we present the TFP growth values in gross value added terms using the EU KLEMS database which uses NACE 1 sector definitions for the 1990-91 recession.

Table 0.5: TFP growth in value added for 1990-1991 recession, unadjusted for scale effects (NACE 1, per cent)

Industry Comparators	1990	1991	1992	1993	1994	Average for recessionary period (1990-1991)	Average for post-recession period (1992-1994)	Average for full 5-year period (1990-1994)
Chemicals and chemical products	0.7	10.1	6.0	3.8	8.4	5.4	6.1	5.8
Construction	1.8	-0.1	7.1	1.6	1.2	0.9	3.3	2.3
Machinery, nec	0.7	-2.8	1.5	5.8	5.7	-1.0	4.4	2.2
Total manufacturing	1.3	2.3	3.6	3.1	2.7	1.8	3.1	2.6
Transport and storage	1.1	-1.3	-1.0	0.7	5.5	-0.1	1.7	1.0
Average for comparators	**1.2**	**1.7**	**3.4**	**3.0**	**4.7**	**1.4**	**3.7**	**2.8**
Total industries (for purpose of comparison)	-0.3	1.4	1.7	2.4	1.0	0.6	1.7	1.3
Electricity, gas and water supply	1.8	3.3	-1.0	1.6	-0.4	2.5	0.1	1.0

Source: Europe Economics' analysis of EU KLEMS data.

In Table 0.6 we present the TFP growth values in gross value added terms adjusted for scale effects.

Table 0.6: TFP growth in value added for 1990-1991 recession, adjusted for scale effects (NACE 1, per cent)

Industry Comparators	1990	1991	1992	1993	1994	Average for recessionary period (1990-1991)	Average for post-recession period (1992-1994)	Average for full 5-year period (1990-1994)
Chemicals and chemical products	0.7	9.8	5.8	3.7	8.3	5.3	5.9	5.7
Construction	No comparable scale elasticities available							
Machinery, nec	0.7	-2.7	1.6	5.9	5.7	-1.0	4.4	2.3
Total manufacturing	1.2	1.8	3.3	3.0	2.8	1.5	3.0	2.4
Transport and storage	1.1	-1.3	-0.7	1.0	5.8	-0.1	2.0	1.2
Average for comparators	**0.9**	**1.9**	**2.5**	**3.4**	**5.6**	**1.4**	**3.8**	**2.9**
Total industries (for purpose of comparison)	No comparable scale elasticities available							
Electricity, gas and water supply	No comparable scale elasticities available							

Source: Europe Economics' analysis of EU KLEMS data.

The 2008-09 recession

In Table 0.7 we present the TFP growth values in gross value added terms using the EU KLEMS database which uses NACE 2 sector definitions for the 2008-09 recession.

Table 0.7: TFP growth in value added for 2008-2009 recession, unadjusted for scale effects (NACE 2, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for full 5-year period (2008-2012)
Chemicals and chemical products incl. pharmaceuticals	7.9	2.0	-0.5	-5.2	-7.1	4.9	-4.3	-0.6
Chemicals and chemical products excl. pharmaceuticals	7.4	-11.0	6.2	6.5	-5.8	-1.8	2.3	0.6
Construction	-2.2	-11.1	13.1	3.1	-7.0	-6.7	3.1	-0.8
Machinery and equipment n.e.c.	4.7	-16.8	17.0	3.2	-0.5	-6.0	6.6	1.5
Other manufacturing; repair and installation of machinery and equipment	-2.0	-1.5	9.7	6.3	-12.4	-1.8	1.2	0.0
Professional, scientific, technical, administrative and support service activities	1.0	-6.0	5.8	2.7	1.6	-2.5	3.4	1.0
Total manufacturing	2.6	-4.3	6.0	2.4	-1.8	-0.9	2.2	1.0
Transport and storage	-2.1	-14.3	3.6	3.0	-2.6	-8.2	1.3	-2.5
Average for comparators (using Chemicals and chemical products incl. pharmaceuticals)	**1.4**	**-7.4**	**7.8**	**2.2**	**-4.3**	**-3.0**	**1.9**	**-0.1**
Average for comparators (using Chemicals and chemical products excl. pharmaceuticals)	**1.3**	**-9.3**	**8.8**	**3.9**	**-4.1**	**-4.0**	**2.9**	**0.1**
Market economy (for purpose of comparison)	-0.2	-5.5	2.3	0.4	-0.9	-2.8	0.6	-0.3
Electricity, gas, steam and air conditioning supply	-4.8	-12.0	-2.9	-12.4	-5.7	-8.4	-7.0	-7.5
Water supply; sewerage; waste management and remediation activities	-2.2	-16.1	-2.0	-0.2	-1.6	-9.2	-1.3	-4.4

Source: Europe Economics' analysis of EU KLEMS data.

In Table 0.8 we present the TFP growth values in gross value added terms adjusted for scale effects.

Table 0.8: TFP growth in value added for 2008-2009 recession, adjusted for scale effects (NACE 2, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for full 5-year period (2008-2012)
Chemicals and chemical products incl. pharmaceuticals	7.1	1.4	-0.9	-5.4	-7.0	4.3	-4.4	-1.0
Chemicals and chemical products excl. pharmaceuticals	6.7	-11.5	5.6	6.3	-5.7	-2.4	2.1	0.3
Construction	No comparable scale elasticities available							
Machinery and equipment n.e.c.	4.7	-16.7	17.0	3.1	-0.5	-6.0	6.5	1.5
Other manufacturing; repair and installation of machinery and equipment	-2.1	-1.6	9.5	6.2	-12.2	-1.9	1.1	-0.1
Professional, scientific, technical, administrative and support service activities	No comparable scale elasticities available							
Total manufacturing	2.3	-4.7	5.9	2.4	-1.7	-1.2	2.2	0.8
Transport and storage	-2.0	-14.1	3.6	3.0	-2.6	-8.0	1.4	-2.4
Average for comparators (using Chemicals and chemical products incl. pharmaceuticals)	**2.0**	**-7.1**	**7.0**	**1.9**	**-4.8**	**-2.6**	**1.4**	**-0.2**
Average for comparators (using Chemicals and chemical products excl. pharmaceuticals)	**1.9**	**-9.7**	**8.3**	**4.2**	**-4.6**	**-3.9**	**2.7**	**0.0**
Market economy (for purpose of comparison)	No comparable scale elasticities available							
Electricity, gas, steam and air conditioning supply	No comparable scale elasticities available							
Water supply; sewerage; waste management and remediation activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of EU KLEMS data.

The 2008-09 recession with intangibles

In Table 0.9 we present the TFP growth values in gross value added terms for the 2008-09 recession when further intangible assets are included within capital assets, using the analytical database published as part of the 2019 EU KLEMS dataset (which uses NACE 2 sector definitions).

Table 0.9: TFP growth in value added for 2008-2009 recession including intangibles, unadjusted for scale effects (NACE 2, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for full 5-year period (2008-2012)
Chemicals and chemical products incl. pharmaceuticals	7.7	1.7	-0.2	-5.4	-7.2	4.7	-4.3	-0.7
Chemicals and chemical products excl. pharmaceuticals	7.3	-10.8	6.3	6.2	-6.3	-1.8	2.1	0.5
Construction	-2.0	-11.2	12.9	3.1	-6.6	-6.6	3.2	-0.7
Machinery and equipment n.e.c.	4.7	-16.5	16.6	3.2	-0.5	-5.9	6.4	1.5
Other manufacturing; repair and installation of machinery and equipment	-1.9	-1.6	9.6	6.2	-12.4	-1.8	1.1	0.0
Professional, scientific, technical, administrative and support service activities	1.0	-6.5	5.5	2.5	1.2	-2.8	3.1	0.7
Total manufacturing	2.6	-4.3	5.9	2.3	-1.7	-0.8	2.2	1.0
Transport and storage	-2.0	-14.3	3.7	3.0	-2.4	-8.1	1.4	-2.4
Average for comparators (using Chemicals and chemical products incl. pharmaceuticals)	**1.4**	**-7.5**	**7.7**	**2.1**	**-4.2**	**-3.0**	**1.9**	**-0.1**
Average for comparators (using Chemicals and chemical products excl. pharmaceuticals)	**1.4**	**-9.3**	**8.7**	**3.8**	**-4.1**	**-4.0**	**2.8**	**0.1**
Market economy (for purpose of comparison)	-0.2	-5.7	2.4	0.4	-1.0	-2.9	0.6	-0.8
Electricity, gas, steam and air conditioning supply	-4.4	-12.2	-2.4	-11.9	-5.4	-8.3	-6.6	-7.3
Water supply; sewerage; waste management and remediation activities	-2.2	-15.8	-2.0	-0.3	-1.5	-9.0	-1.3	-4.4

Source: Europe Economics' analysis of EU KLEMS data.

In Table 0.10 we present the TFP growth values in gross value added terms adjusted for scale effects.

Table 0.10: TFP growth in value added for 2008-2009 recession including intangibles, adjusted for scale effects (NACE 2, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for full 5-year period (2008-2012)
Chemicals and chemical products incl. pharmaceuticals	6.9	1.3	-0.7	-5.5	-7.1	4.1	-4.4	-1.0
Chemicals and chemical products excl. pharmaceuticals	6.5	-11.2	5.7	6.0	-6.2	-2.4	1.8	0.2
Construction	No comparable scale elasticities available							
Machinery and equipment n.e.c.	4.8	-16.4	16.7	3.1	-0.5	-5.8	6.4	1.5
Other manufacturing; repair and installation of machinery and equipment	-2.0	-1.8	9.4	6.1	-12.2	-1.9	1.1	-0.1
Professional, scientific, technical, administrative and support service activities	No comparable scale elasticities available							
Total manufacturing	2.3	-4.7	5.8	2.3	-1.7	-1.2	2.2	0.8
Transport and storage	-1.9	-14.1	3.7	3.0	-2.3	-8.0	1.5	-2.3
Average for comparators (using Chemicals and chemical products incl. pharmaceuticals)	**2.0**	**-7.1**	**7.0**	**1.8**	**-4.8**	**-2.6**	**1.3**	**-0.2**
Average for comparators (using Chemicals and chemical products excl. pharmaceuticals)	**1.9**	**-9.6**	**8.3**	**4.1**	**-4.6**	**-3.9**	**2.6**	**0.0**
Market economy (for purpose of comparison)	No comparable scale elasticities available							
Electricity, gas, steam and air conditioning supply	No comparable scale elasticities available							
Water supply; sewerage; waste management and remediation activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of EU KLEMS data.

Appendix 2: ONS MFP Data

In this Appendix we present TFP growth averages using the MFP estimates produced by the ONS for the available sectors that are the closest to our comparators from the EU KLEMS dataset. The MFP dataset is currently classed by the ONS as experimental statistics meaning that the estimates are yet to be fully developed.

The Appendix reports MFP growth values both in terms of the Gross Output and the Gross Value Added measure. MFP growth to gross output terms is converted using the GVA / GO ratios from the EU KLEMS dataset.[28]

The 1973-74 recession

In Table 0.11 and Table 0.12 we present the MFP growth values in gross output terms using the ONS MFP dataset for the 1973-74 recession, unadjusted and adjusted for scale effects, respectively.

Table 0.11: MFP growth in gross output for 1973-1974 recession, unadjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1973	1974	1975	1976	1977	Average for recessionary period (1973-1974)	Average for post-recession period (1975-1977)	Average for 5-year period (1973-1977)
Manufacturing	2.2	0.0	-0.3	0.8	0.2	1.1	0.2	0.6
Construction	-1.7	-2.7	-0.9	-0.1	0.5	-2.2	-0.2	-1.0
Transportation and Storage	5.8	-0.5	-0.4	2.1	2.0	2.7	1.2	1.8
Professional, Scientific and Technical Activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average for comparators	**1.6**	**-0.8**	**-0.4**	**0.7**	**0.7**	**0.4**	**0.3**	**0.3**
Total Market Sector (for purpose of comparison)	1.8	-1.3	-0.4	0.8	0.3	0.3	0.2	0.2
Electricity, Gas, Steam and Air Conditioning Supply	4.4	0.7	1.2	0.2	1.8	2.6	1.1	1.7
Water Supply; Sewerage, Waste Management and Remediation Activities	4.4	-3.8	-2.3	0.9	0.0	0.3	-0.5	-0.2

Source: Europe Economics' analysis of ONS data.

[28] As the latest (2019) EU KLEMS dataset only includes data up until 2016, we used the ratio calculated for 2016 for the additional two years available in the ONS MFP dataset (i.e. 2017 and 2018).

Table 0.12: MFP growth in gross output for 1973-1974 recession, adjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1973	1974	1975	1976	1977	Average for recessionary period (1973-1974)	Average for post-recession period (1975-1977)	Average for 5-year period (1973-1977)
Manufacturing	2.2	-0.1	-0.3	0.8	0.1	1.1	0.2	0.6
Construction	No comparable scale elasticities available							
Transportation and Storage	5.8	-0.4	-0.4	2.1	2.0	2.7	1.2	1.8
Professional, Scientific and Technical Activities	No comparable scale elasticities available							
Average for comparators	**4.0**	**-0.2**	**-0.3**	**1.4**	**1.1**	**1.9**	**0.7**	**1.2**
Total Market Sector (for purpose of comparison)	No comparable scale elasticities available							
Electricity, Gas, Steam and Air Conditioning Supply	No comparable scale elasticities available							
Water Supply; Sewerage, Waste Management and Remediation Activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of ONS data.

In Table 0.13 and Table 0.14 we present the MFP growth values in gross value added terms using the ONS MFP dataset for the 1973-74 recession, unadjusted and adjusted for scale effects, respectively.

Table 0.13: MFP growth in value added for 1973-1974 recession, unadjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1973	1974	1975	1976	1977	Average for recessionary period (1973-1974)	Average for post-recession period (1975-1977)	Average for 5-year period (1973-1977)
Manufacturing	7.0	-0.1	-1.0	3.0	0.6	3.4	0.9	1.9
Construction	-3.4	-5.7	-2.1	-0.2	1.0	-4.5	-0.5	-2.1
Transportation and Storage	10.2	-0.9	-0.8	4.2	4.0	4.7	2.5	3.3
Professional, Scientific and Technical Activities	6.8	-3.2	-3.0	1.0	-2.8	1.8	-1.6	-0.2
Average for comparators	**5.1**	**-2.5**	**-1.7**	**2.0**	**0.7**	**1.3**	**0.3**	**0.7**
Total Market Sector (for purpose of comparison)	4.2	-3.3	-1.0	2.0	0.7	0.5	0.5	0.5
Electricity, Gas, Steam and Air Conditioning Supply	8.7	1.5	2.8	0.3	3.8	5.1	2.3	3.4
Water Supply; Sewerage, Waste Management and Remediation Activities	8.6	-8.1	-5.3	1.9	0.1	0.2	-1.1	-0.6

Source: Europe Economics' analysis of ONS data.

Table 0.14: MFP growth in value added for 1973-1974 recession, adjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1973	1974	1975	1976	1977	Average for recessionary period (1973-1974)	Average for post-recession period (1975-1977)	Average for 5-year period (1973-1977)
Manufacturing	7.0	-0.1	-1.0	3.0	0.6	3.4	0.8	1.9
Construction	No comparable scale elasticities available							
Transportation and Storage	10.2	-0.8	-0.8	4.2	4.0	4.7	2.5	3.4
Professional, Scientific and Technical Activities	No comparable scale elasticities available							
Average for comparators	**8.6**	**-0.5**	**-0.9**	**3.6**	**2.3**	**4.1**	**1.7**	**2.6**
Total Market Sector (for purpose of comparison)	No comparable scale elasticities available							
Electricity, Gas, Steam and Air Conditioning Supply	No comparable scale elasticities available							
Water Supply; Sewerage, Waste Management and Remediation Activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of ONS data.

Overall the averages calculated for the recessionary period are higher than those reported for the post-recessionary period in most of our comparator sectors (notably with the exception of the Construction sector) in terms of both measures, suggesting lower productivity growth in the years immediately following the 1973-74 recession. At the same time, water sector productivity growth was also higher in the recessionary period than post-recession, in line with the MFP movements reported for most of the comparator sectors.

The 1980-81 recession

In Table 0.15 and Table 0.16 we present the MFP growth values in gross output terms using the ONS MFP dataset for the 1980-81 recession, unadjusted and adjusted for scale effects, respectively.

Table 0.15: MFP growth in gross output for 1980-1981 recession, unadjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1980	1981	1982	1983	1984	Average for recessionary period (1980-1981)	Average for post-recession period (1982-1984)	Average for 5-year period (1980-1984)
Manufacturing	-1.3	0.2	1.6	2.1	1.3	-0.6	1.7	0.8
Construction	-2.1	-2.0	4.3	2.7	0.7	-2.1	2.6	0.7
Transportation and Storage	-1.5	2.4	1.2	4.3	0.2	0.4	1.9	1.3
Professional, Scientific and Technical Activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average for comparators	**-1.2**	**0.1**	**1.8**	**2.3**	**0.6**	**-0.5**	**1.5**	**0.7**
Total Market Sector (for purpose of comparison)	-1.2	0.4	1.9	2.4	0.1	-0.4	1.5	0.7
Electricity, Gas, Steam and Air Conditioning Supply	0.7	2.3	0.1	1.5	-8.4	1.5	-2.3	-0.8
Water Supply; Sewerage, Waste Management and Remediation Activities	-5.1	-0.7	-1.3	-1.6	-2.8	-2.9	-1.9	-2.3

Source: Europe Economics' analysis of ONS data.

Table 0.16: MFP growth in gross output for 1980-1981 recession, adjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1980	1981	1982	1983	1984	Average for recessionary period (1980-1981)	Average for post-recession period (1982-1984)	Average for 5-year period (1980-1984)
Manufacturing	-1.4	0.2	1.7	2.1	1.3	-0.6	1.7	0.8
Construction	No comparable scale elasticities available							
Transportation and Storage	-1.5	2.4	1.1	4.2	0.2	0.4	1.8	1.3
Professional, Scientific and Technical Activities	No comparable scale elasticities available							
Average for comparators	**-1.4**	**1.3**	**1.4**	**3.1**	**0.7**	**-0.1**	**1.8**	**1.0**
Total Market Sector (for purpose of comparison)	No comparable scale elasticities available							
Electricity, Gas, Steam and Air Conditioning Supply	No comparable scale elasticities available							
Water Supply; Sewerage, Waste Management and Remediation Activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of ONS data.

In Table 0.17 and Table 0.18 we present the MFP growth values in gross value added terms using the ONS MFP dataset for the 1980-81 recession, unadjusted and adjusted for scale effects, respectively.

Table 0.17: MFP growth in value added for 1980-1981 recession, unadjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1980	1981	1982	1983	1984	Average for recessionary period (1980-1981)	Average for post-recession period (1982-1984)	Average for 5-year period (1980-1984)
Manufacturing	-4.4	0.6	5.1	6.4	3.9	-1.9	5.1	2.3
Construction	-4.8	-4.7	10.2	6.3	1.8	-4.7	6.1	1.8
Transportation and Storage	-2.9	4.5	2.2	8.0	0.3	0.8	3.5	2.4
Professional, Scientific and Technical Activities	-2.7	-0.7	5.3	7.0	-1.3	-1.7	3.6	1.5
Average for comparators	**-3.7**	**-0.1**	**5.7**	**6.9**	**1.2**	**-1.9**	**4.6**	**2.0**
Total Market Sector (for purpose of comparison)	-2.7	1.0	4.2	5.1	0.2	-0.8	3.2	1.6
Electricity, Gas, Steam and Air Conditioning Supply	1.8	6.3	0.4	3.5	-20.9	4.1	-5.7	-1.8
Water Supply; Sewerage, Waste Management and Remediation Activities	-13.3	-1.9	-3.3	-3.8	-6.9	-7.6	-4.7	-5.9

Source: Europe Economics' analysis of ONS data.

Table 0.18: MFP growth in value added for 1980-1981 recession, unadjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1980	1981	1982	1983	1984	Average for recessionary period (1980-1981)	Average for post-recession period (1982-1984)	Average for 5-year period (1980-1984)
Manufacturing	-4.4	0.6	5.1	6.4	3.9	-1.9	5.1	2.3
Construction	No comparable scale elasticities available							
Transportation and Storage	-2.9	4.5	2.1	8.0	0.3	0.8	3.5	2.4
Professional, Scientific and Technical Activities	No comparable scale elasticities available							
Average for comparators	**-3.7**	**2.6**	**3.6**	**7.2**	**2.1**	**-0.5**	**4.3**	**2.4**
Total Market Sector (for purpose of comparison)	No comparable scale elasticities available							
Electricity, Gas, Steam and Air Conditioning Supply	No comparable scale elasticities available							
Water Supply; Sewerage, Waste Management and Remediation Activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of ONS data.

Overall the averages calculated for the recessionary period are significantly lower (and go negative in a number of cases) than those reported for the post-recessionary period in the majority of the comparator sectors, both in terms of gross output and gross value added, suggesting a bounce-back in the post-recession period. At the same time, the ONS MFP results also suggest that water sector productivity growth was lower in the recessionary period than post-recession, in line with the MFP movements reported for most of the comparator sectors. Therefore, the decoupling of the water sector from the wider economy observed from past EU KLEMS evidence is not present in the ONS MFP dataset.

The 1990-91 recession

In Table 0.19 and Table 0.20 we present the MFP growth values in gross output terms using the ONS MFP dataset for the 1990-91 recession, unadjusted and adjusted for scale effects, respectively.

Table 0.19: MFP growth in gross output for 1990-1991 recession, unadjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1990	1991	1992	1993	1994	Average for recessionary period (1990-1991)	Average for post-recession period (1992-1994)	Average for 5-year period (1990-1994)
Manufacturing	0.5	0.4	1.0	1.3	1.2	0.5	1.1	0.9
Construction	-0.6	-1.4	0.5	-0.6	-1.5	-1.0	-0.5	-0.7
Transportation and Storage	-0.5	0.0	0.4	1.8	1.9	-0.3	1.3	0.7
Professional, Scientific and Technical Activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average for comparators	**-0.2**	**-0.3**	**0.5**	**0.6**	**0.4**	**-0.2**	**0.5**	**0.2**
Total Market Sector (for purpose of comparison)	-0.4	-0.3	0.1	1.4	0.6	-0.4	0.7	0.3
Electricity, Gas, Steam and Air Conditioning Supply	0.9	1.6	0.0	1.6	-0.8	1.3	0.3	0.7
Water Supply; Sewerage, Waste Management and Remediation Activities	-0.5	-1.7	-1.3	-0.1	-0.3	-1.1	-0.6	-0.8

Source: Europe Economics' analysis of ONS data.

Table 0.20: MFP growth in gross output for 1990-1991 recession, adjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1990	1991	1992	1993	1994	Average for recessionary period (1990-1991)	Average for post-recession period (1992-1994)	Average for 5-year period (1990-1994)
Manufacturing	0.5	0.4	0.9	1.3	1.2	0.5	1.1	0.9
Construction	No comparable scale elasticities available							
Transportation and Storage	-0.4	0.0	0.4	1.8	2.0	-0.3	1.4	0.7
Professional, Scientific and Technical Activities	No comparable scale elasticities available							
Average for comparators	**0.0**	**0.2**	**0.7**	**1.5**	**1.6**	**0.1**	**1.2**	**0.8**
Total Market Sector (for purpose of comparison)	No comparable scale elasticities available							
Electricity, Gas, Steam and Air Conditioning Supply	No comparable scale elasticities available							
Water Supply; Sewerage, Waste Management and Remediation Activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of ONS data.

In Table 0.21 and Table 0.22 we present the MFP growth values in gross value added terms using the ONS MFP dataset for the 1990-91 recession, unadjusted and adjusted for scale effects, respectively.

Table 0.21: MFP growth in value added for 1990-1991 recession, unadjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1990	1991	1992	1993	1994	Average for recessionary period (1990-1991)	Average for post-recession period (1992-1994)	Average for 5-year period (1990-1994)
Manufacturing	1.4	1.2	2.6	3.6	3.2	1.3	3.1	2.4
Construction	-1.6	-3.6	1.3	-1.6	-4.1	-2.6	-1.5	-1.9
Transportation and Storage	-0.9	-0.1	0.8	3.5	3.8	-0.5	2.7	1.4
Professional, Scientific and Technical Activities	-3.0	-1.0	-8.6	-0.2	1.6	-2.0	-2.4	-2.2
Average for comparators	**-1.0**	**-0.9**	**-1.0**	**1.3**	**1.2**	**-1.0**	**0.5**	**-0.1**
Total Market Sector (for purpose of comparison)	-0.8	-0.7	0.3	2.7	1.3	-0.8	1.4	0.6
Electricity, Gas, Steam and Air Conditioning Supply	3.0	5.3	-0.1	4.3	-2.0	4.1	0.7	2.1
Water Supply; Sewerage, Waste Management and Remediation Activities	-1.7	-5.8	-3.6	-0.3	-0.8	-3.7	-1.6	-2.4

Source: Europe Economics' analysis of ONS data.

Table 0.22: MFP growth in value added for 1990-1991 recession, adjusted for scale effects (ONS MFP, per cent)

Industry Comparators	1990	1991	1992	1993	1994	Average for recessionary period (1990-1991)	Average for post-recession period (1992-1994)	Average for 5-year period (1990-1994)
Manufacturing	1.3	1.2	2.6	3.6	3.2	1.3	3.1	2.4
Construction	No comparable scale elasticities available							
Transportation and Storage	-0.9	-0.1	0.8	3.5	3.9	-0.5	2.7	1.5
Professional, Scientific and Technical Activities	No comparable scale elasticities available							
Average for comparators	**0.2**	**0.5**	**1.7**	**3.6**	**3.6**	**0.4**	**2.9**	**1.9**
Total Market Sector (for purpose of comparison)	No comparable scale elasticities available							
Electricity, Gas, Steam and Air Conditioning Supply	No comparable scale elasticities available							
Water Supply; Sewerage, Waste Management and Remediation Activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of ONS data.

Overall the averages calculated for the recessionary period are significantly lower (and often go negative, especially in the case of the gross value added measure) than those reported for the post-recessionary period in the majority of the comparator sectors, both in terms of gross output and gross value added, suggesting a bounce-back in the post-recession period. At the same time, the ONS MFP results also suggest that water sector productivity growth was lower in the recessionary period than post-recession, in line with the MFP movements reported for most of the comparator sectors. Therefore, the decoupling of the water sector from the wider economy observed from past EU KLEMS evidence is not present in the ONS MFP dataset.

The 2008-09 recession

In Table 0.23 and Table 0.24 we present the MFP growth values in gross output terms using the ONS MFP dataset for the 1990-91 recession, unadjusted and adjusted for scale effects, respectively.

Table 0.23: MFP growth in gross output for 2008-2009 recession, unadjusted for scale effects (ONS MFP, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for 5-year period (2008-2012)
Manufacturing	-0.2	-0.7	1.6	1.1	-0.6	-0.5	0.7	0.2
Construction	-1.3	-4.8	4.7	1.2	-3.6	-3.0	0.8	-0.7
Transportation and Storage	-2.0	-5.2	0.5	2.0	-1.4	-3.6	0.4	-1.2
Professional, Scientific and Technical Activities	0.8	-3.5	0.3	1.1	-0.6	-1.4	0.3	-0.4
Average for comparators	**-0.7**	**-3.5**	**1.8**	**1.4**	**-1.6**	**-2.1**	**0.5**	**-0.5**
Total Market Sector (for purpose of comparison)	-0.7	-2.1	0.7	0.4	-0.3	-1.4	0.3	-0.4
Electricity, Gas, Steam and Air Conditioning Supply	-1.8	-0.8	-0.4	-1.6	-0.3	-1.3	-0.8	-1.0
Water Supply; Sewerage, Waste Management and Remediation Activities	-2.7	-5.6	-1.4	1.9	-0.6	-4.1	0.0	-1.7

Source: Europe Economics' analysis of ONS data.

Table 0.24: MFP growth in gross output for 2008-2009 recession, adjusted for scale effects (ONS MFP, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for 5-year period (2008-2012)
Manufacturing	-0.2	-0.7	1.7	1.1	-0.6	-0.5	0.7	0.3
Construction	No comparable scale elasticities available							
Transportation and Storage	-2.0	-5.2	0.6	2.1	-1.4	-3.6	0.4	-1.2
Professional, Scientific and Technical Activities	No comparable scale elasticities available							
Average for comparators	**-1.1**	**-2.9**	**1.1**	**1.6**	**-1.0**	**-2.0**	**0.6**	**-0.5**
Total Market Sector (for purpose of comparison)	No comparable scale elasticities available							
Electricity, Gas, Steam and Air Conditioning Supply	No comparable scale elasticities available							
Water Supply; Sewerage, Waste Management and Remediation Activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of ONS data.

In Table 0.25 and Table 0.26 we present the MFP growth values in gross value added terms using the ONS MFP dataset for the 1990-91 recession, unadjusted and adjusted for scale effects, respectively.

Table 0.25: MFP growth in gross value added for 2008-2009 recession, unadjusted for scale effects (ONS MFP, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for 5-year period (2008-2012)
Manufacturing	-0.7	-2.2	4.9	3.5	-1.8	-1.4	2.2	0.7
Construction	-3.1	-12.1	11.9	3.0	-8.9	-7.6	2.0	-1.8
Transportation and Storage	-4.7	-11.8	1.1	4.5	-3.3	-8.3	0.8	-2.9
Professional, Scientific and Technical Activities	1.4	-6.1	0.6	2.0	-1.1	-2.4	0.5	-0.6
Average for comparators	**-1.8**	**-8.1**	**4.6**	**3.2**	**-3.8**	**-4.9**	**1.4**	**-1.2**
Total Market Sector (for purpose of comparison)	-1.4	-4.5	1.6	0.8	-0.7	-2.9	0.6	-0.8
Electricity, Gas, Steam and Air Conditioning Supply	-9.7	-2.9	-2.5	-10.8	-1.7	-6.3	-5.0	-5.5
Water Supply; Sewerage, Waste Management and Remediation Activities	-5.2	-11.5	-2.7	3.7	-1.2	-8.4	-0.1	-3.4

Source: Europe Economics' analysis of ONS data.

Table 0.26: MFP growth in gross value added for 2008-2009 recession, adjusted for scale effects (ONS MFP, per cent)

Industry Comparators	2008	2009	2010	2011	2012	Average for recessionary period (2008-2009)	Average for post-recession period (2010-2012)	Average for 5-year period (2008-2012)
Manufacturing	-0.7	-2.2	5.0	3.5	-1.8	-1.4	2.2	0.7
Construction	No comparable scale elasticities available							
Transportation and Storage	-4.7	-11.8	1.2	4.5	-3.3	-8.3	0.8	-2.8
Professional, Scientific and Technical Activities	No comparable scale elasticities available							
Average for comparators	**-2.7**	**-7.0**	**3.1**	**4.0**	**-2.6**	**-4.8**	**1.5**	**-1.0**
Total Market Sector (for purpose of comparison)	No comparable scale elasticities available							
Electricity, Gas, Steam and Air Conditioning Supply	No comparable scale elasticities available							
Water Supply; Sewerage, Waste Management and Remediation Activities	No comparable scale elasticities available							

Source: Europe Economics' analysis of ONS data.

Overall the averages calculated for the recessionary period are significantly lower (and in fact go negative for all of the comparator sectors) than those reported for the post-recessionary period, both in terms of gross output and gross value added, suggesting a bounce-back in the post-

recession period. At the same time, the ONS MFP results also suggest that water sector productivity growth was lower in the recessionary period than post-recession, in line with the MFP movements reported for most of the comparator sectors. Therefore, the MFP growth rates reported for the water sector do not support any decoupling from the wider economy, coinciding with the finding suggested by past EU KLEMS evidence for the 2008-09 recession.