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Appendix 7.1

PR19 WHOLESALE REAL PRICE EFFECTS ANALYSIS AND EVIDENCE

September 2018

PR19 WHOLESALE REAL PRICE EFFECTS ANALYSIS AND EVIDENCE

A report for Northumbrian Water

February 2018

Economic Insight Ltd

CONTENTS

1. Executive summary and introduction

This report for Northumbrian Water (Northumbrian) sets out evidence to inform cost escalation factors to apply within the wholesale elements of the company's PR19 Business Plan. Our work includes: (i) forecasting underlying input price inflation by cost category and price control area; and (ii) assessing the scope for 'frontier shift', by price control area and cost type. Our evidence, combined with assumptions regarding the scope for 'catch-up' efficiency savings, can be used to help derive the company's cost baselines. It also acts as supporting evidence for Appointee Table 24a (real price effects).

1.1 Introduction and context

At PR19, companies are required to provide data as to the real price effects (RPEs) for each of the four wholesale price control areas, split by:

- operating expenditure;
- maintaining the long-term capability of the assets infrastructure;
- maintaining the long-term capability of the assets non-infrastructure;
- other capital expenditure ~ infrastructure; and
- other capital expenditure ~ non-infrastructure.

The RPE information requested by Ofwat in relation to the above is set out in Sections B through to E of Appointee Table 24a. Companies are required to provide % RPE values, annually over PR19, in the above cost categories. Ofwat's guidance defines this as follows:

"For wholesale services, the RPE of cost category 'c' in year 't' should be calculated as:

$$RPEc,(\%)=(1plus\ IPIc,t(\%)\ )/(1plus\ CPIH\,t(\%))-1$$

Where IPI (input price inflation) is the absolute-level each cost category (e.g. operating expenditure), has increased in year t relative to the previous regulatory year."[1]

The above might imply that the % values entered in Sections B to E of 24a across the wholesale controls should be consistent with (and derived from) the absolute £ values companies submit in their cost baselines in each price control area. For example, table WS1 requires companies to provide £ cost values for water services, split by business unit (and therefore, price control) for each of the five cost categories referenced above. Therefore, this might further imply that Ofwat expects the corresponding RPE % values in 24a to be calculated from those £ numbers. However, it is important to note that the absolute £s values for companies' costs in their plans will change over time due to changes in outputs (e.g. population growth) and, on the capital side, can vary materially from year-to-year. As such, if the % RPE figures in

[1] *'Delivering Water 2020: Our methodology for the 2019 price review Final guidance on business plan data tables.' Ofwat (December 2017); page 32.*

24a were calculated from absolute cost figures in company plans, this would not provide a measure of prices changes 'controlling for output' (which is contrary to how RPEs are usually measured). Given this, Northumbrian may wish to raise a query with Ofwat as to precisely how the regulator wishes Data Table 24a to be populated – and, relatedly, how it intends to use any information provided.

Notwithstanding the above, to arrive at £ cost baselines for each price control area in the first place, companies need to develop evidence on cost escalation factors, incorporating:

- The **underlying level of gross input price inflation** that arises in each price control area / cost category.

- The level of **efficiency savings** that can be achieved in each price control area / cost category – where these can be further split into:
  - **'catch-up' efficiency** (i.e. the efficiency savings that can be achieved by 'catching up' to the efficiency frontier, however defined); and
  - **'frontier shift' efficiency** (i.e. the productivity gains that even the most efficient firms can achieve).

Relevant to the above, Sections H to K of Appointee Table 24a require companies to separately identify the % efficiency savings assumed in each price control area, by cost category. We would assume that this refers to **total** efficiencies included in the cost baselines (i.e. both catch-up and frontier shift, as above). However, Ofwat's published guidance does not explicitly set this out – and so on this issue, we would also suggest Northumbrian might wish to raise a query with the regulator.

In the above context, Northumbrian asked us to take forward analysis to inform the cost escalation factors that should be included within its wholesale cost baselines. Specifically, the scope of our work includes:

- **Estimating underlying gross input price inflation (pressure), for each wholesale price control area** and by each of the cost categories listed above.

- **Estimating the scope for 'frontier shift' (productivity) efficiency gains** by price control area.

Our work excludes the estimation of 'catch-up' efficiency savings in relation to the wholesale price controls. Therefore, in isolation, our work does not provide all of the information required to derive wholesale cost escalation factors.

Following from the above, it is important to be clear about how our evidence and analysis should be used. Specifically, we recommend the evidence provided in our report is used as follows:

- Our projected underlying inflation forecasts and scope for frontier shift efficiency savings should be combined with evidence regarding the scope for catch-up efficiency savings, to arrive at overall cost escalation factors across the wholesale controls. Northumbrian should then ensure that its submitted cost baselines are consistent with this evidence.

- Following from the above, our underlying inflation forecasts and assessment of frontier shift scope can (again, in combination with assumptions regarding catch-up efficiency) be used as *supporting evidence* to inform the population of the % RPE figures required in Sections B to E of Appointee Table 24a. As noted above, it is unclear as to exactly how Ofwat wishes companies to calculate the figures that must be submitted in Table 24a. As such, we suggest Northumbrian seeks guidance from the regulator, to ensure it uses our forecasts in a manner consistent with the regulator's intent.

- Our projected scope for frontier shift efficiency savings should also be used to inform the population of Sections H to K of Appointee Table 24a. As noted above, we assume Ofwat wishes companies to enter total efficiency % savings. Therefore, assumptions regarding efficiency catch-up would need to be added to our forecast frontier shift numbers (again, subject to clarifying this with Ofwat).

Our report is structured as follows:

- The reminder of this introductory section provides a **summary of our forecasts**, for ease of reference.
- Chapter 2 sets out our detailed forecasts of **underlying input price inflation**, by price control area and cost type.
- Chapter 3 provides our analysis of the scope for **frontier shift efficiency savings.**
- **Supporting technical evidence** is set out in separate appendices.

1.2 Summary of our findings

1.2.1 Underlying gross input price inflation by price control area

We have developed detailed forecasts of the company's underlying input inflation across the wholesale controls. This is based on a range of analytically robust approaches, including the development of econometric forecasts. Importantly, the approach we have used avoids conflating any inefficiency that might be inherent in the company's *actual* costs. To achieve this, we created historical cost indices, using third-party data – and then analysed the relationship between these indices and the UK's wider macroeconomic performance.

Drawing together the various analyses we have developed, the following tables summarise our **central estimates** of input price inflation by wholesale price control area. These can be used (in combination with other evidence, including in relation to the scope for efficiency savings) to arrive at wholesale cost escalation factors to help inform projected baseline costs.

Table 1: Gross input price inflation - wholesale **water resources (central case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	2.03%	2.19%	2.18%	2.26%	2.45%	2.22%
Maintaining the long-term capability of the assets infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Maintaining the long-term capability of the assets non-infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Other capital expenditure ~ infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%
Other capital expenditure ~ non-infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%

Source: Economic Insight analysis

Given the inherent uncertainty of forecasting, we consider it appropriate for Northumbrian to use either the 'annual average' or 'yearly profile' figures, where shown throughout this report.

Table 2: Gross input price inflation - wholesale **water network plus** **(central case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.96%	2.23%	2.20%	2.29%	2.45%	2.23%
Maintaining the long-term capability of the assets infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Maintaining the long-term capability of the assets non-infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Other capital expenditure ~ infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%
Other capital expenditure ~ non-infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%

Source: Economic Insight analysis

Table 3: Gross input price inflation - wholesale **wastewater network plus** **(central case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.93%	2.24%	2.23%	2.36%	2.66%	2.28%
Maintaining the long-term capability of the assets infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Maintaining the long-term capability of the assets non-infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Other capital expenditure ~ infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%
Other capital expenditure ~ non-infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%

Source: Economic Insight analysis

Table 4: Gross input price inflation - wholesale **wastewater bioresources** **(central case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.85%	2.28%	2.22%	2.27%	2.33%	2.19%
Maintaining the long-term capability of the assets infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Maintaining the long-term capability of the assets non-infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Other capital expenditure ~ infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%
Other capital expenditure ~ non-infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%

Source: Economic Insight analysis

1.2.2 Productivity and the scope for frontier shift efficiency savings by price control area

We have reviewed a range of evidence to inform an assessment of the scope for 'frontier shift' efficiency savings over PR19, by price control area. This includes both:

- undertaking an analysis of EU KLEMS data on historical total factor productivity (TFP) by economy sector – where here, we have developed a composite index for historical TFP performance, based on identifying sectors that we consider provide the most appropriate points of comparison; and
- a review of regulatory precedent regarding the scope for frontier shift.

The assessment of the scope for frontier shift by control area is complex. Relatedly, we should like to highlight the following key themes that must be kept in mind when arriving at a suitable set of assumptions:

- **The UK's productivity performance has 'flatlined' since the financial crisis.** Data shows this is now the longest recorded period of zero to falling productivity performance for the economy. This obviously raises the question as to what 'weight' should be placed on more recent data, relative to longer-term data, when developing a view of frontier shift potential over PR19. Accordingly, we have developed scenarios whereby:
  - **Our 'central case' reflects the 16 years to 2015** – thereby placing equal weight on the 8-year period since the financial crisis and the eight preceding years, in which productivity performance was nearer its long-term average. As such, this scenario implicitly assumes some improvement in future productivity performance towards the longer-term average, over the course of PR19. We consider this to be a balanced and neutral interpretation of the data.

  - **Our 'low case' reflects the period from 2008 to 2015** (i.e. the period of low productivity, since the financial crisis). This, therefore, assumes the flatline will broadly continue over PR19. This too is a plausible scenario, in our view, given the uncertainty regarding Brexit and the UK's current weak economic performance.
  - **Our 'high case' is based on the period from 1998-2008** (i.e. the period before the financial crisis). This scenario therefore 'ignores' the long period of low productivity performance in the UK. If one applied this scenario, the implicit assumption is that the UK quickly returns to its higher, long-term, productivity performance. Whilst 'possible', we consider this to be the least likely scenario – and so more weight should be placed on our central and low scenarios.

- Similarly, when reaching a view on forward-looking frontier shift potential, it is important to take care to interpret data and evidence correctly. Here, an important issue is that TFP itself is driven by a number of components, of which frontier shift is only one. In particular, unless the country / industry/ company one is analysing is perfectly competitive, TFP will also embed some degree of catch-up efficiency gain. This is well established in the empirical economics literature. As such, strictly speaking, **our evidence provides an 'upper plausible bound' on the scope for frontier shift.**

Reflecting the above issues, we have provided Northumbrian with a credible range for frontier shift savings, split by control and by opex and capex (in relation to capex, whilst Ofwat's data tables provide further splits by infrastructure and non-infrastructure; and by capex and maintenance, we do not think it is appropriate to attempt to estimate frontier shift separately in these dimensions. As such, our 'capex' figures should be used to inform the company's assumptions across these).

The table overleaf summarises our results for each scenario. Northumbrian should use whichever figures it considers appropriate in light of:

  - ensuring consistency with the rest of its PR19 Plan; and
  - its view as to 'how challenging' it wishes to it be.

Table 5: scope for frontier shift efficiency savings (% pa) by price control area

Price control area	Cost type	Low case	Central case	High case
Wholesale water resources	Opex	-0.04%	0.53%	0.94%
	Capex	-0.31%	0.28%	0.56%
Wholesale water network plus	Opex	0.05%	0.67%	1.05%
	Capex	-0.31%	0.28%	0.56%
Wholesale wastewater network plus	Opex	0.05%	0.67%	1.05%
	Capex	-0.31%	0.28%	0.56%
Wholesale wastewater bioresources	Opex	0.05%	0.67%	1.05%
	Capex	-0.31%	0.28%	0.56%
Retail	Opex	-0.42%	0.42%	1.10%
	Capex	-0.31%	0.28%	0.56%

Source: Economic Insight analysis

2. Forecasts of underlying input price pressure

In this chapter, we set out our forecasts of underlying gross input price pressure for Northumbrian Water over PR19. Forecasts are developed separately by price control area and by cost category, consistent with Ofwat's data requirements. Our approach is based on constructing detailed indices of the company's underlying costs over time, where we then subsequently analyse the historical relationship between the indices and wider economic variables. This avoids inadvertently conflating any inefficiency that may exist in the company's actual historical costs. Our work is further informed by a review of existing third-party forecasts, where appropriate.

In the subsequent subsections of this chapter, we develop forecasts for underlying input price inflation across the wholesale controls. The purpose of this is both to assist the company in: (i) the population of relevant PR19 data tables required by Ofwat; and (ii) the development of its cost baselines – and to provide relevant supporting evidence relating to real price effects.

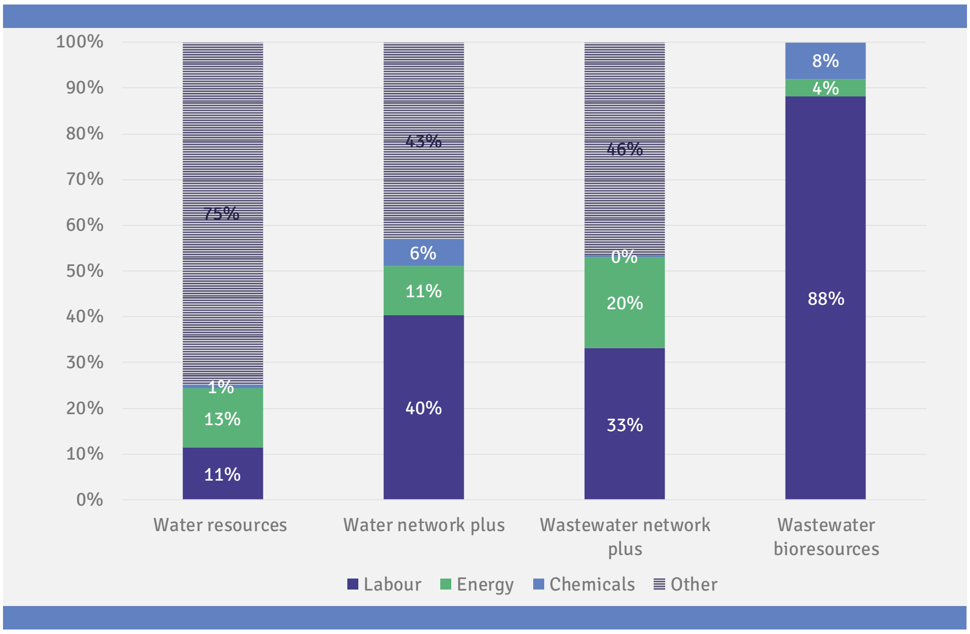
2.1 Northumbrian's cost structure

To develop input price inflation forecasts for total **opex** by price control area, it is first necessary to ascertain the 'mix' of opex by price control area in key cost categories. Accordingly, we split Northumbrian's opex costs into the following categories for the purpose of forecasting inflation:

- labour;
- energy;
- chemicals; and
- other.

Accordingly, Northumbrian provided us with details of the above cost splits, relating to 2016/17 by area. The stacked bar chart below shows our analysis of the resultant makeup of the company's opex, across the wholesale controls.

Figure 1: Split of Northumbrian Water's opex by wholesale price control area, 2016/17 (reconciled to regulatory accounts)[2]



Source: Economic Insight analysis

It should be noted that the 'other' category is significant for three of the price control areas. This is because it includes EA charges and business rates.

2.2 Approach to deriving forecasts by price control area

For developing its Business Plan, Northumbrian needs to reach a view of its underlying inflationary pressure by price control, but also by cost category. Here, relevant categories include:

- opex;
- maintaining the long-term capability of the assets infrastructure;
- maintaining the long-term capability of the assets non-infrastructure;
- other capital expenditure - infrastructure; and
- other capital expenditure - non-infrastructure.

WE HAVE DEVELOPED DETAILED FORECASTS FOR INDIVIDUAL OPEX COST CATEGORIES, WHICH WE THEN WEIGHT BY THE INDIVIDUAL SPLIT OF COSTS ACROSS PRICE CONTROL AREAS TO ARRIVE AT OUR OVERALL FORECASTS.

To develop robust forecasts in the above dimensions, our approach has been as follows:

- For opex, we have developed highly detailed inflation forecasts for each key cost category (i.e. labour, energy and chemicals). Then, for each price control area, we have created an overall opex inflation forecast by 'weighting' the individual forecasts based on the split of inputs used, for each control area (as above).

- In relation to the various categories of capital costs, our approach distinguishes between maintenance and other capital expenditure. We have used publicly available indices for both these elements of capex and have extrapolated forward on that basis, assuming that both maintenance and other capital expenditure is

[2] *To ensure consistency with the company's published regulatory accounts, we used the 'other' category as a balancing item, calculated as 'opex' (as per regulatory accounts) minus the sum of granular opex costs by category (e.g. labour, energy and chemicals) provided by the company.*

the same across all price control areas (and hence have not applied any weighting).

In order to develop the forecasts for **individual cost components,** our approach has been as follows:

- We have identified the most relevant **historical** inflation data for each of Northumbrian's key cost categories across the different wholesale business areas and have examined this over time (typically ten years).
- Specifically, in relation to the major input costs, such as staff, chemicals and energy, the above step was based on a detailed review of the various elements of each cost category (i.e. staff roles, or chemicals used). We then mapped Northumbrian's mix within each category to credible, independent, historical data at a granular level (e.g. Office for National Statistics (ONS) wage inflation by role, mapped to staff roles within Northumbrian; or the mapping of individual chemicals to broader chemicals commodity data). **This allowed us create, for each cost type, a historical 'index' of underlying inflation,** which allows us to 'strip out' any inefficiency that might be present, were we to base forecasts on the company's actual historical costs.
- As we need to **project** input price pressure over PR19, we then employed three approaches to forecasting input price pressure, namely:
  - **Method 1: economic fundamentals.** This is our preferred methodology, which is based on the analysis of the relationship between input costs (as measured by our bespoke indices) and key economic indicators.
    - Some methods are based on the '**wedge**' between input costs and other inflation indicators, such as the Consumer Prices Index (CPI).
    - Other methods are based on **statistical analysis** of the relationship between input costs and economic variables, such as gross domestic product (GDP) growth.
  - **Method 2: extrapolations.** Here, we extrapolate existing trends in input costs forward. This approach was widely used by companies at PR14. However, in our view less weight will be placed on such approaches at PR19, relative to other, technically superior, methods.[3]
  - **Method 3: independent third-party forecasts.** Where appropriate, we reviewed and drew conclusions from existing forecasts.

We believe that the above represents a thorough and robust approach for deriving forecasts for the underlying inflationary pressure faced by Northumbrian over PR19. The rest of this section sets out our forecasts for each individual cost category in turn.

[3] *See: 'Delivering Water 2020: Our final methodology for the 2019 price review.' Ofwat (December 2017), page 143.*

2.4 Forecasting underlying labour cost inflation

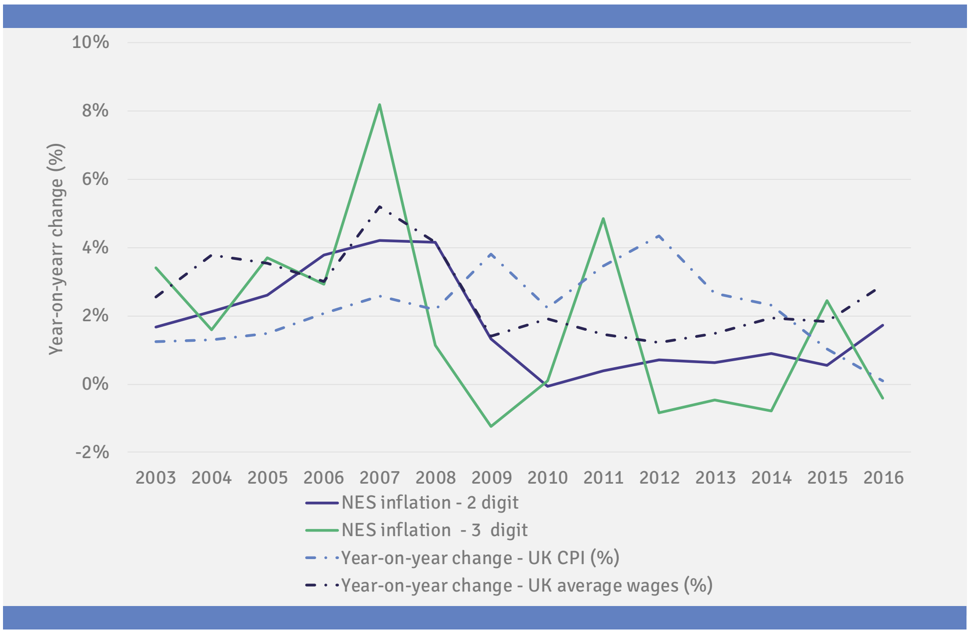
To forecast underlying inflation for labour costs, Northumbrian provided us with a detailed breakdown of its staff costs by function / role across all price control areas. For each function / role, Northumbrian matched the employee data to specific jobs and occupations, as defined using Standard Occupation Classification (SOC) 2011 codes. This data is published by the ONS within its Annual Survey of Hours and Earnings (ASHE). The mappings are shown in Annex B.

The ASHE data contains detailed information on wages by SOC code. So, by having Northumbrian's employee roles matched to SOC codes, we were able to create business area specific indices of underlying wage inflation over time at a highly granular level. Importantly, this avoids any possibility of conflating underlying inflation with any inefficiency that might be present in the company's actual historical staff costs.

In creating the indices, an important consideration is the level of disaggregation applied in matching job roles to SOC codes. Specifically, within the ASHE, SOC codes range from 1 digit (which are general occupation types, but have reliable wage inflation estimates due to a larger sample size) to 4 digit SOC codes (which are very specific, but are subject to greater uncertainty in their estimation, due to small sample size). Thus, there is a trade-off between using codes that are most relevant to Northumbrian's actual roles, and the precision of the estimates of wage inflation for each role. We therefore created wage inflation indices using both 2 and 3 digit SOC codes, which we consider are most likely to strike the appropriate balance between these two considerations.

Following from the above, the next figure shows Northumbrian's labour cost indices (at 2 and 3 digit SOC code levels) for the *company as whole* compared to CPI and overall UK average wage inflation over time as reported by the ONS. To be consistent with the Office of Budget Responsibility (OBR) forecasts (on which we base our projections), UK average wage inflation is calculated from wages and salaries data in the National Accounts; and employee numbers from the Labour Force Survey (LFS).

Figure 2: Historical wage inflation

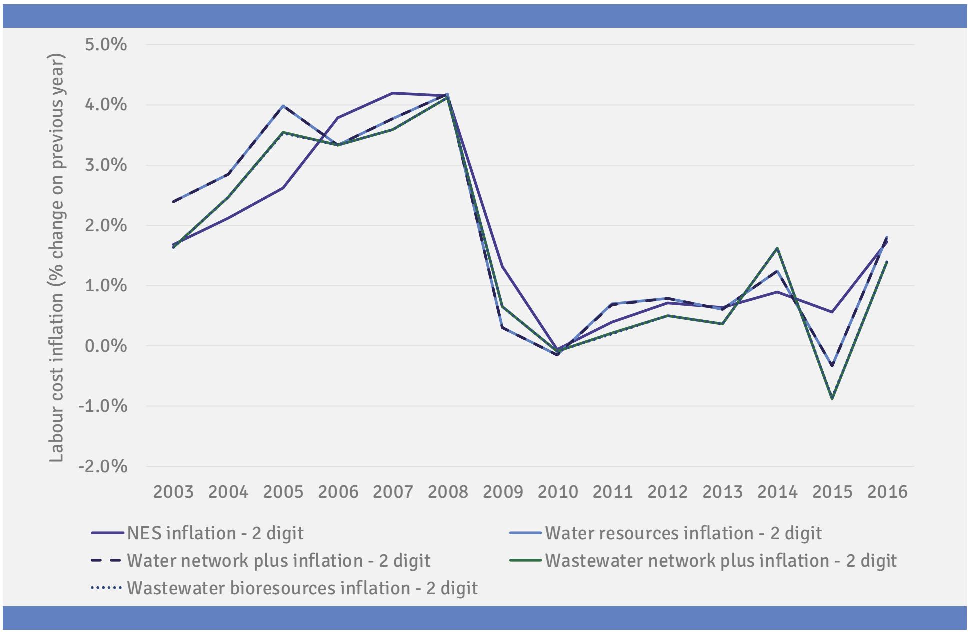


Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

As can be seen from the previous chart, our calculated Northumbrian wage indices imply underlying inflation of 1.8% pa, which is – on average – lower than CPI and overall UK wage inflation.

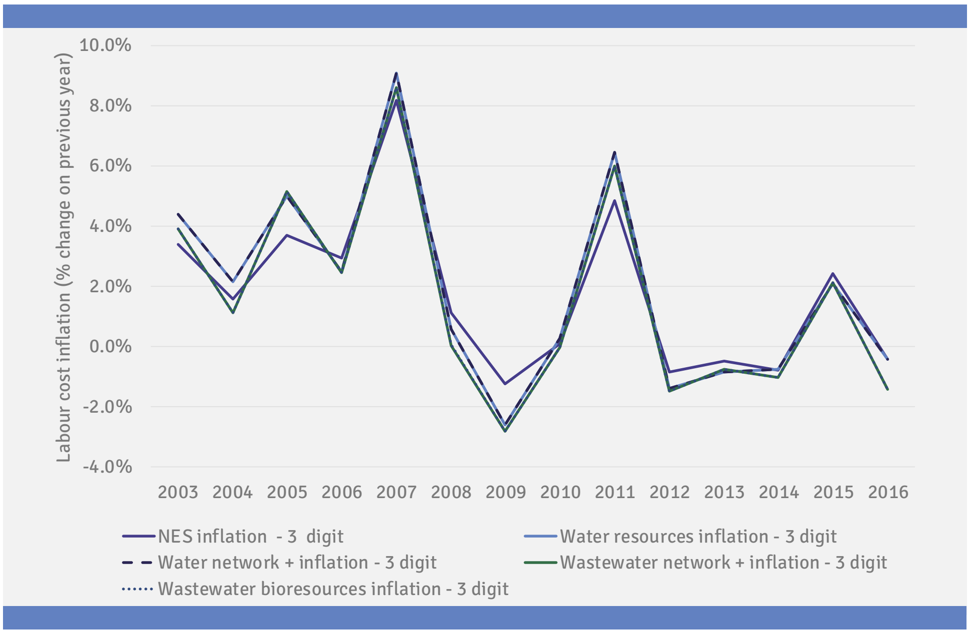
Our Northumbrian labour cost indices for the individual price control areas are set out in the following two figures. We show the indices based on 2 and 3 digit SOC codes separately.

Figure 3: Northumbrian Water labour cost inflation – overall company, water (resources and network plus), and wastewater (network plus and bioresources), **2 digit SOC codes**



Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

Figure 4: Northumbrian Water labour cost inflation – overall company, water (resources and network plus), and wastewater (network plus and bioresources), **3 digit SOC codes**



Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

As can be seen from the graphs, up until 2008, wage inflation tends to be quite high, dropping significantly in the aftermath of the financial crisis.

The following subsections set out our forecasts for Northumbrian's underlying labour cost inflation, using the three forecasting methodologies described previously:

- firstly, we set out estimates derived from **economy-based estimates of wage inflation**, including both the wedge and econometric methodologies;
- secondly, we provide estimates based on an analysis of **past trends** in the wage index;
- thirdly, we discuss **independent third-party** estimates of future UK wage inflation; and
- finally, we summarise the evidence we have analysed and provide our **overall estimates** of underlying labour cost inflation over PR19 by price control area.

2.4.1 Economy-based estimates

As we set out above, our preferred methodology bases wage forecasts on economic fundamentals, rather than extrapolations of historical labour costs. Our approach to generating economy-based estimates of labour cost inflation is based on two key steps:

- First, we used data from the bespoke labour cost indices we created to explore relationships between wider measures of the UK's economic performance. We used two methods for this step:

  (a) we identified the historical '*wedge*' between our indices for Northumbrian's labour cost inflation and more general inflation measures (in particular, UK average wage inflation and CPI); and

(b) we used econometrics to identify a *statistical relationship* between Northumbrian's wage inflation (again, as measured by our index) and GDP growth.

- We then assumed that the identified relationship holds in the future – and developed forecasts for Northumbrian's labour cost inflation on the basis of the OBR's official forecasts for growth and general inflation in the UK economy.

In the following we set out our results.

2.4.1.1 Wedge estimates for labour cost inflation

Here, we calculated the wedge between inflation in our Northumbrian labour cost indices and both: (i) average UK wages; and (ii) CPI inflation. Overall, we consider that deriving forecast using the *wedge to average UK wage inflation* should be preferred over the *wedge to CPI inflation*. This is because we expect there will be more commonality between the drivers of UK wage inflation and Northumbrian labour cost inflation than is the case for CPI. CPI inflation is based on a basket of goods and services; and will be driven by supply and demand *across the economy*. Wage inflation is driven by supply and demand in the *labour market specifically.*

The following table shows the size of these wedges for the whole period for which data is available, from 2003 to 2016. In general, Northumbrian's underlying wage inflation (as measured by our index) is below UK average wage inflation (i.e. the wedges are negative), although the difference is slightly less pronounced based on 2 digit SOC codes, rather than 3 digit ones. Northumbrian's underlying wage inflation also tends to be below CPI, although the wedges are smaller in this case.

Table 6: Historical wedge between Northumbrian Water labour cost indices and: (i) average UK wage inflation; and (ii) CPI

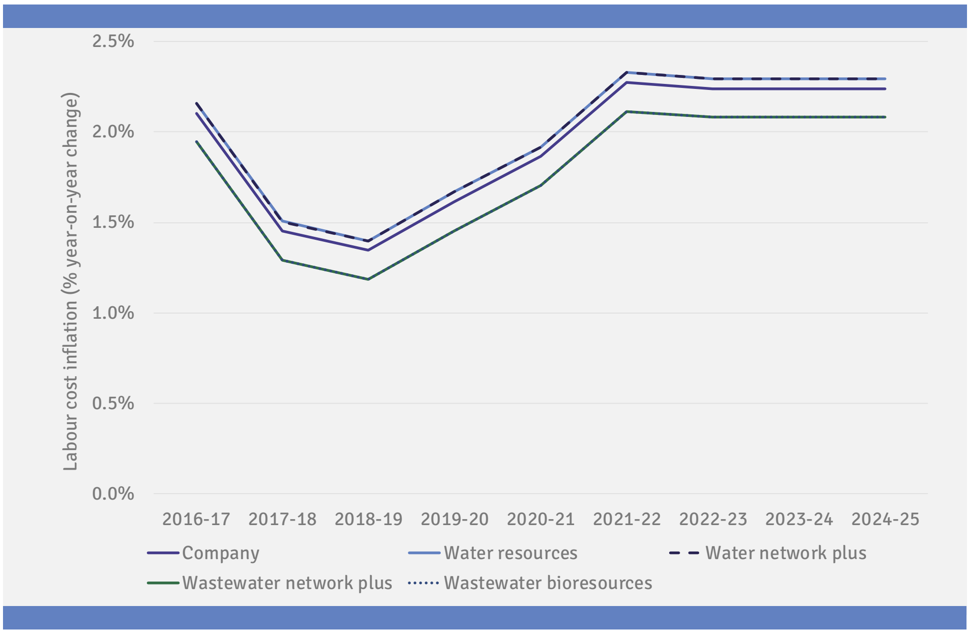
	Company	Water resources	Water network plus	Waste-water network plus	Waste-water bio-resources
Wedge to **average UK wage inflation** – 2 digit	-0.83%	-0.78%	-0.78%	-0.99%	-0.99%
Wedge to **average UK wage inflation** – 3 digit	-0.84%	-0.70%	-0.70%	-1.03%	-1.03%
Wedge to **CPI inflation** – 2 digit	-0.43%	-0.38%	-0.38%	-0.59%	-0.59%
Wedge to **CPI inflation** – 3 digit	-0.44%	-0.30%	-0.30%	-0.64%	-0.64%

Source: Economic Insight analysis

To derive forecast underlying labour input cost inflation for Northumbrian, we combined these 'wedges' with the most recent projections for both wage and CPI growth taken from the OBR. These are available up to the year 2022/23. For years beyond 2023, we assumed that wage and CPI growth continue at the level forecast for 2023.

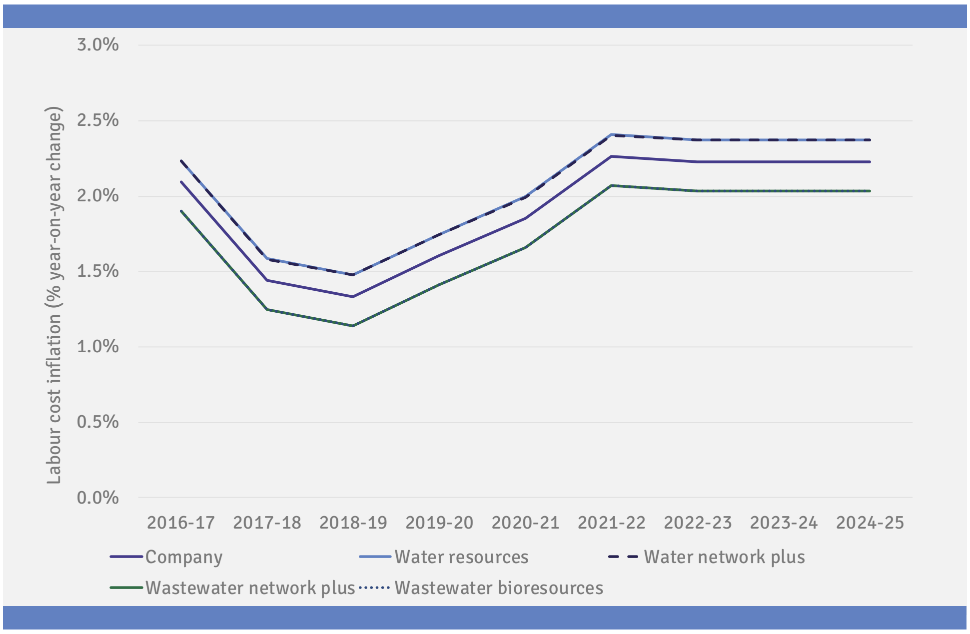
Our overall forecasts using this methodology, with respect to UK wage inflation, are shown in the following figures. Estimates based on 2 digit SOC codes are generally higher than those based on 3-digit SOC codes. Furthermore, estimates based on wage inflation are usually higher than those based on CPI (which are set out in the appendix). This is mostly driven by the fact that the OBR forecasts wage inflation to be materially higher than CPI by the early 2020s (i.e. it forecasts real wage growth).

Figure 5: Forecast labour cost inflation – based on wage inflation wedge, **2 digit SOC**



Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

Figure 6: Forecast labour cost inflation – based on wage inflation wedge, **3 digit SOC**



Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

As can be seen, forecasts based on the 'wedge' with national wage growth are reasonably consistent across the 2 and 3 digit SOC code indices.

2.4.1.2 Econometric estimates

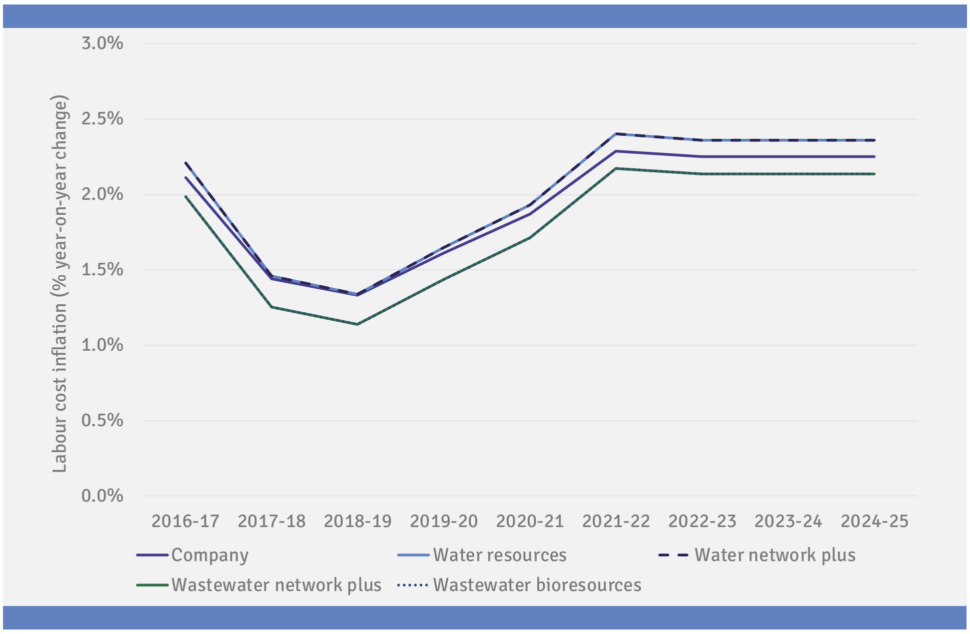
We used econometric analysis to investigate the statistical relationship between our Northumbrian labour cost indices and: (i) UK GDP; and (ii) average UK wages. Variables such as GDP and wages are generally *non-stationary*, meaning that simple regressions of wage levels on GDP can lead to spurious findings of relationships. We addressed this non-stationarity in two ways:

- First, we developed regressions of the *percentage changes* in Northumbrian's labour cost indices on changes in nominal GDP / average UK wages.
- Second, we regressed levels of Northumbrian's labour cost indices on the level of nominal GDP / average UK wages (both expressed as an index) *and lagged values of Northumbrian's labour cost indices.*

Our overall preference is for the former method, as this allows for easier comparisons to be made between the R^2 of the regressions – since the presence of lagged values of the labour cost index in the levels regression results in high R^2 values across the board. We also found that, in practice, the models for nominal GDP in *levels* performed poorly overall.

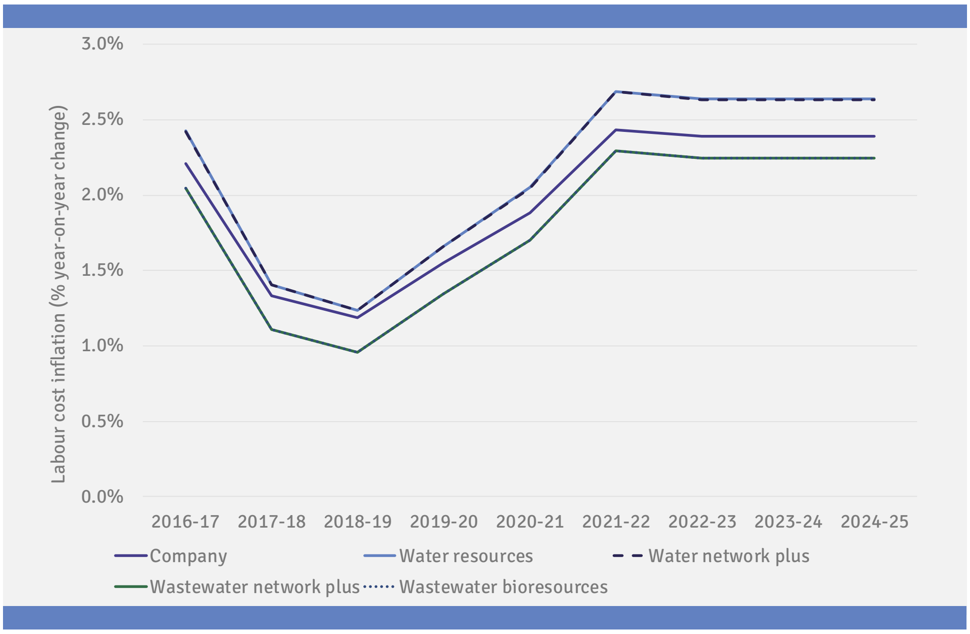
The following figures show projected labour cost inflation based on the regression in percentage changes.

Figure 7: Forecast labour cost inflation – based on average UK wage (percentage changes), **2 digit SOC**



Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

Figure 8: Forecast labour cost inflation – based on average UK wage (percentage changes), **3 digit SOC**



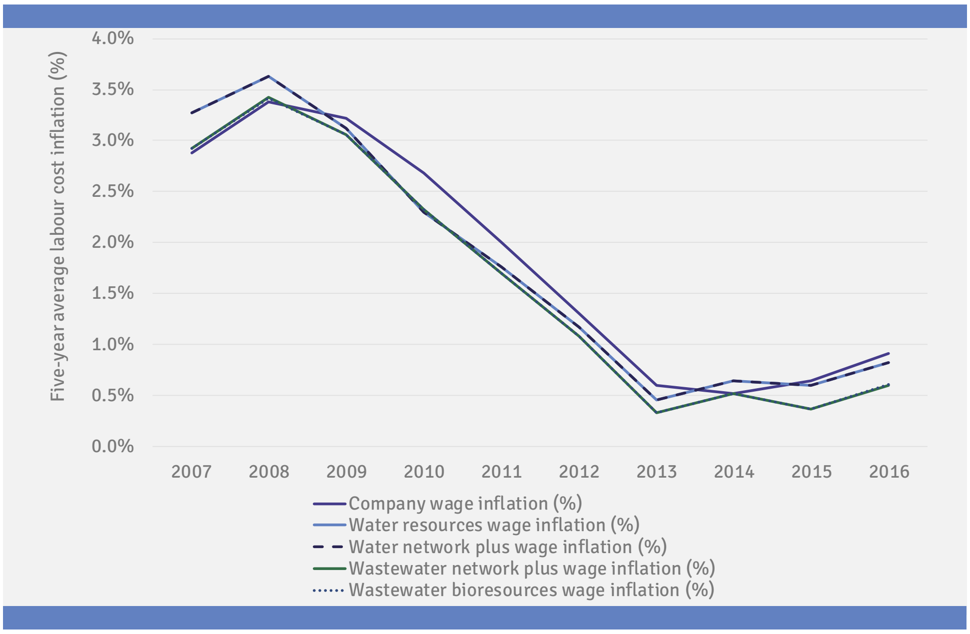
Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

2.4.2 Extrapolating existing trends

The second methodology for forecasting wage inflation for PR19 across the wholesale controls is to extrapolate forward existing trends in our Northumbrian labour cost indices. We place less weight on this approach than on approaches based on economic fundamentals. This is because, clearly, a limitation of an extrapolation is that the implied forecast is *simply a continuation of the past*. Consequently, this method implies relatively low future labour cost inflation. In practice, and as explained elsewhere, it is well established that labour market performance and inflation are, in fact, closely linked to the wider macroeconomic environment. In this case, therefore, extrapolations ignore the OBR's projections for the UK's economic performance.

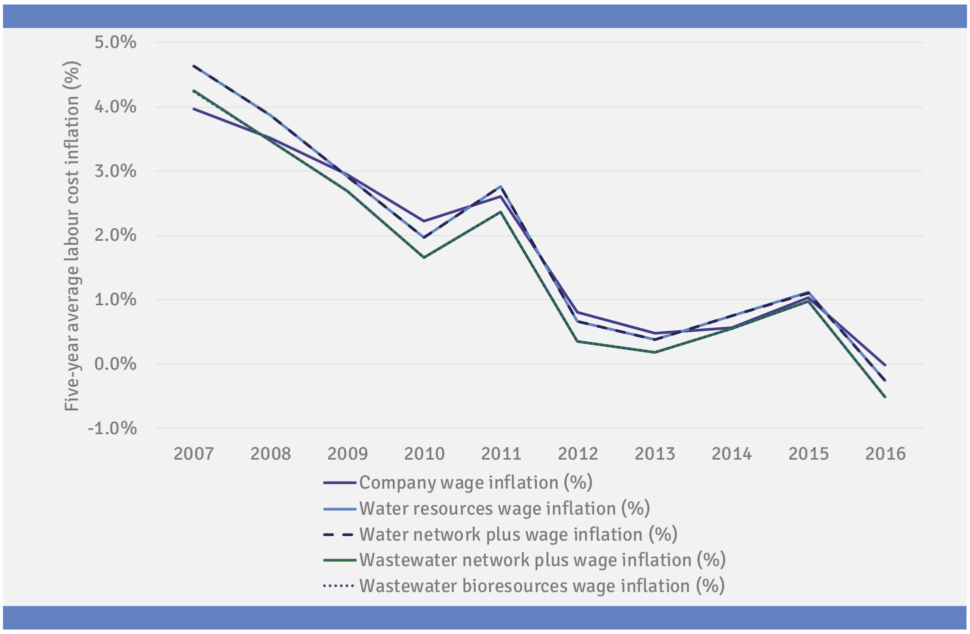
The following figures show five-year rolling averages of the Northumbrian Water wage inflation indices at both the 2 and 3 digit SOC code levels. Both show a prominent downward trend, combined with a levelling off and a slight increase around 2013/14. We note that these trends mirror the performance of the economy over the relevant time-period.

Figure 9: Northumbrian Water wage inflation index – water and wastewater, 5 year rolling average, **2 digit** SOC code



Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

Figure 10: Northumbrian Water wage inflation index – water and wastewater, 5 year rolling average, **3 digit** SOC code



Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

In addition to calculating five-year averages for inflation, we have also examined average inflation over the whole period for which data are available (2003 to 2016). This is shown in the following table.

Table 7: Long-term trends in Northumbrian Water labour cost index inflation (% pa)

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Whole period – 2 digit	1.77%	1.82%	1.82%	1.61%	1.61%
Whole period – 3 digit	1.76%	1.90%	1.90%	1.56%	1.56%
Last 5 years – 2 digit	0.91%	0.82%	0.82%	0.60%	0.60%
Last 5 years – 3 digit	-0.02%	-0.26%	-0.26%	-0.51%	-0.51%

Source: Economic Insight analysis of ONS ASHE and Northumbrian Water data

As noted previously, a drawback of all extrapolations is that they ignore the expected impact of changes to the UK's broader economic performance over time. Most specifically in this case, they ignore the OBR's expected upturn in UK wage growth between now and 2023. This limitation is more pronounced in relation to shorter-term data, which is likely to be less representative of future economic conditions. Consequently, if one were to use an extrapolation approach, we would advocate placing more weight on data using the whole time-period.

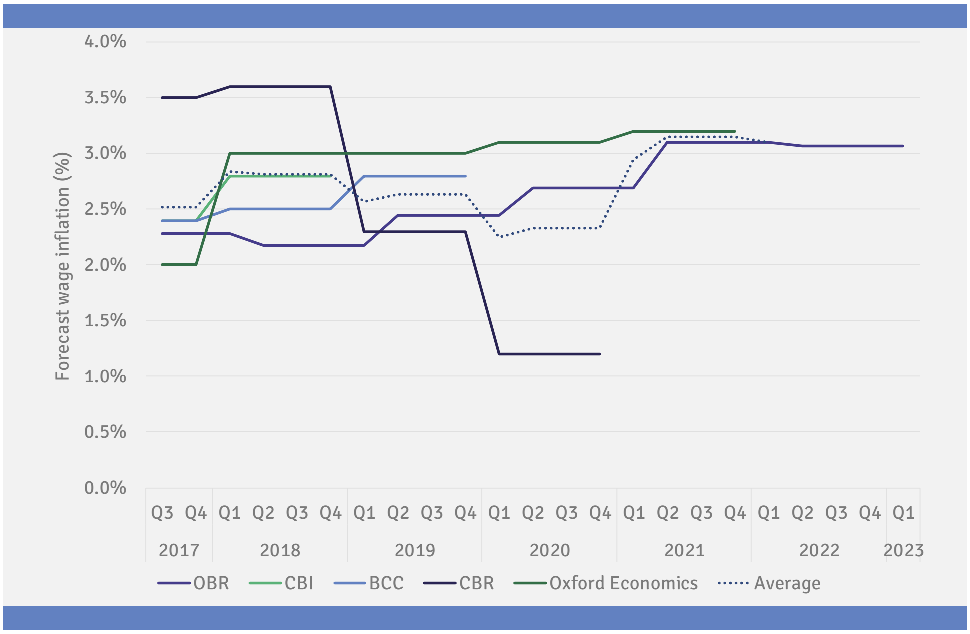
2.4.3 Independent wage growth forecasts

Finally, we examined a range of independent forecasts of future wage growth in the UK – from Government bodies and other forecasters, namely: the OBR; the Confederation of British Industry (CBI); the British Chamber of Commerce (BCC); the Centre for Business Research (CBR); and Oxford Economics. These are shown in the subsequent figure. We highlight the following:

- None of the forecasts provides projections for the whole of 2020 to 2025 period; and only the OBR's and Oxford Economics' forecasts extend beyond 2020.
- Forecasts for 2018/19 are in the range of 2.2% to 3.6% per annum. Most forecasts are relatively stable, although the CBR's suggests a material fall in wages between 2018 and 2019.
- There are differences in forecasted wage growth in 2020. Whereas the OBR's and Oxford Economics' forecasts are in the range of 2.7% to 3.1% per annum, CBR forecasts wage growth to be 1.2%.
- Across all of the independent forecasts we have reviewed, the average expected UK wage inflation rate is estimated to be in the range of 2.4% to 2.9% per annum (note, as above, this refers to the period up to 2020 as only the OBR and Oxford Economics provide longer-term forecasts).

WE PLACE MOST WEIGHT ON THE OBR'S FORECASTS, DUE TO BOTH ITS 'OFFICIAL STATUS' AND THE FACT THAT IS ONE OF THE FEW FORECASTS THAT EXTEND BEYOND 2020.

Figure 11: Forecast UK wage inflation



Source: OBR, CBI, BCC, CBR and Oxford Economics

While these results are inherently uncertain, we place most weight on the OBR's forecasts, which are used for official purposes. Moreover, they are towards the 'middle' of the range of available nearer-term forecasts.

2.4.4 Summary and overall labour cost inflation for PR19

As set out above, we have used a range of methods to forecast Northumbrian's underlying labour cost inflation, across the wholesale price control areas, for PR19.

Overall, for projecting labour cost inflation for the company as a whole, and the wholesale water and wastewater parts of the business, we place most weight on the projections that use **econometrics, based on percentage changes in average UK wages.** This is for the following reasons:

- They are based on economic fundamentals, and so should be internally consistent with other wider macroeconomic assumptions that are inherent in the PR19 Plan.
- Their statistical nature means that we can objectively judge how well the models perform against historical data.
- They give 'stable' results. Specifically, they give very similar projections based on both 2 and 3 digit SOC code labour cost indices. In addition, they give similar projections to the estimates based on the 'wedge' against UK wage growth.

Bringing these considerations together, our overall recommended forecasts are shown in the following table. Reflecting the inherent uncertainty of such analysis, a high, central, and low forecast is provided for each control area. All figures are based on the 2 digit SOC code approach, which on balance we consider to be superior.

Table 8: Our overall Northumbrian Water labour cost inflation forecasts, 2020-25, **2 digit** SOC codes

Price control area	Scenario	2020 / 21	2021 / 22	2022 / 23	2023 / 24	2024 / 25	Avg
Company	High (independent third-party forecasts)	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
	Central (econometrics based on wages % changes)	1.87%	2.29%	2.25%	2.25%	2.25%	2.18%
	Low (wedge to UK wages)	1.86%	2.28%	2.24%	2.24%	2.24%	2.17%
Water resources	High (independent third-party forecasts)	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
	Central (econometrics based on wages % changes)	1.93%	2.40%	2.36%	2.36%	2.36%	2.28%
	Low (wedge to UK wages)	1.92%	2.33%	2.29%	2.29%	2.29%	2.23%
Water network plus	High (independent third-party forecasts)	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
	Central (econometrics based on wages % changes)	1.93%	2.40%	2.36%	2.36%	2.36%	2.28%
	Low (wedge to UK wages)	1.92%	2.33%	2.29%	2.29%	2.29%	2.23%
Wastewater network plus	High (independent third-party forecasts)	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
	Central (econometrics based on wages % changes)	1.72%	2.17%	2.14%	2.14%	2.14%	2.06%
	Low (wedge to UK wages)	1.70%	2.12%	2.08%	2.08%	2.08%	2.01%
Wastewater bioresources	High (independent third-party forecasts)	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
	Central (econometrics based on wages % changes)	1.72%	2.17%	2.14%	2.14%	2.14%	2.06%
	Low (wedge to UK wages)	1.70%	2.12%	2.08%	2.08%	2.08%	2.01%

Source: Economic Insight analysis

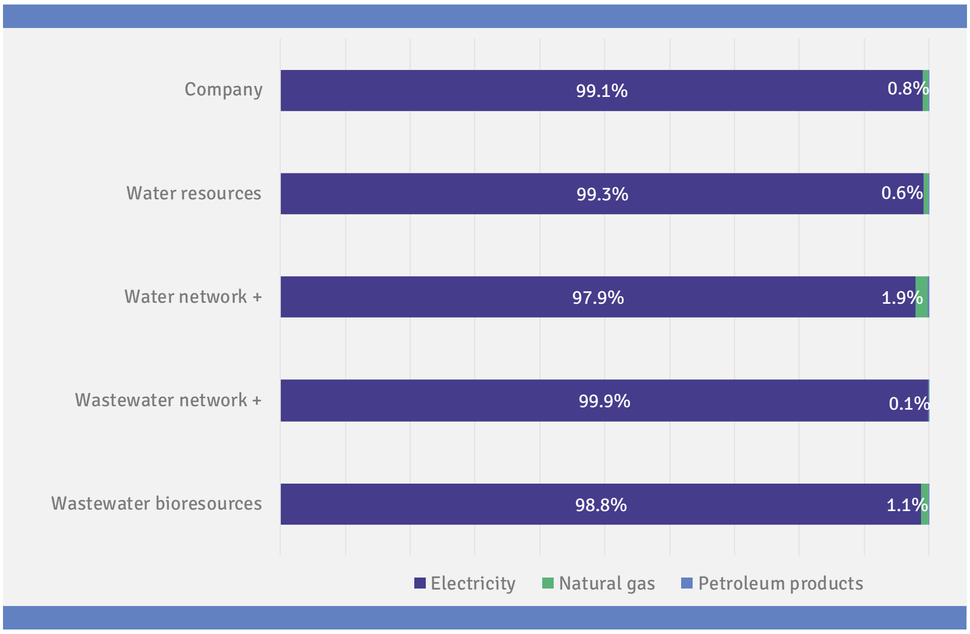
2.5 Energy input price pressure

2.5.1 Overview of types of energy costs incurred by Northumbrian

Utility companies – including water companies – are amongst the highest users of energy in the UK. As such, changes in energy costs can have an important impact on their overall underlying inflationary pressure.

As shown below, data provided to us by Northumbrian indicates that its energy costs primarily consist of electricity.

Figure 12: Northumbrian Water's energy purchases, 2016/17



Source: Northumbrian Water data

2.5.2 Economy-based estimates

As per our approach to forecasting underlying labour cost inflation, we begin with an 'economy-based' approach for projecting energy input price inflation. This involved the following steps:

- We first developed an index of Northumbrian's energy costs, based on energy / fuel price indices for the UK industrial sector, as published by the Department for Business, Energy & Industrial Strategy (BEIS).
- We then collected historical data on relevant drivers of energy costs, such as GDP, which were publicly available from the ONS.
- We then projected forward the relationship identified above. As before, we explored both 'wedge' and 'econometric' approaches (although in this case, our econometric models were not sufficiently robust to use).

2.5.2.1 Developing the index of energy costs

We use economy-wide historical data on price inflation for energy costs, relevant to the main energy types used by Northumbrian, to generate our indices for Northumbrian's historical energy cost inflation. As set out previously, the use of economy-wide data, rather than actual energy cost data for Northumbrian, avoids the risk of our forecasts 'baking in' historical inefficiency. We generate separate indices for all relevant wholesale price control areas.

To generate the indices, we matched Northumbrian's historical energy purchases to energy / fuel price indices for the industrial sector, as published by BEIS. Having collected data for individual types of energy, we then used purchase amounts (in £) for each business area to calculate a weighted average inflation for: Northumbrian as a whole; water resources; water network plus; wastewater network plus; and wastewater bioresources, separately. The weights we used for each energy / fuel type are summarised in the following table.

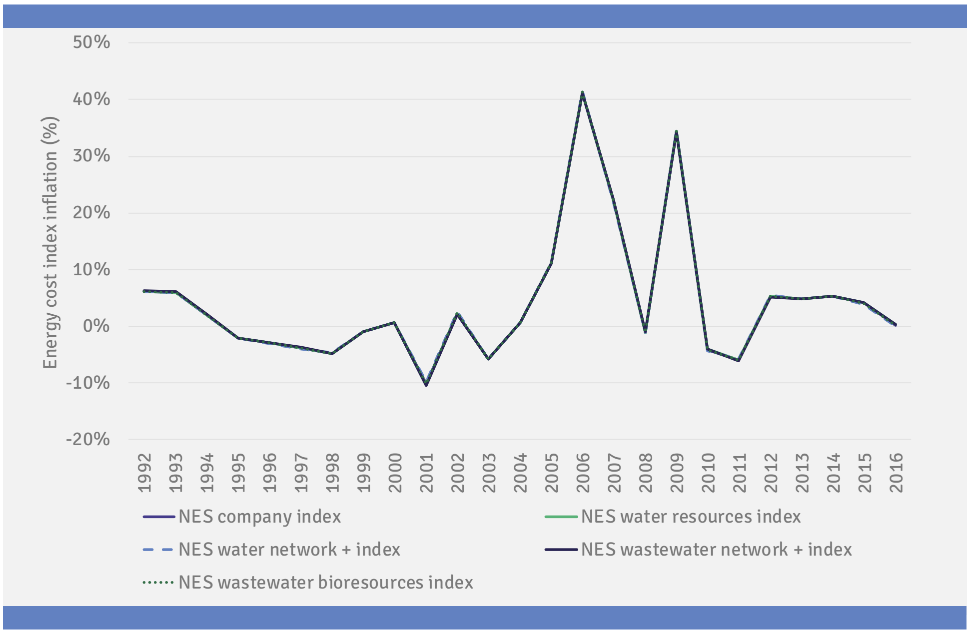
Table 9: Northumbrian Water weights

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Electricity	99.1%	99.3%	97.9%	99.9%	98.8%
Gas	0.8%	0.6%	1.9%	0.1%	1.1%
Heavy fuel oil	0.1%	0.1%	0.2%	0.0%	0.0%

Source: Economic Insight analysis

The resulting indices are shown in the following figure.

Figure 13: Northumbrian Water energy cost inflation indices



Source: Economic Insight analysis

As set out in the previous table, the 'mix' of energy costs by price control area is nearly identical for Northumbrian. As such, in the above chart, the historical index of energy inflation is effectively 'the same' for each control area. In addition, the chart shows that underlying energy inflation has fluctuated considerably over time. In particular, we note the market spikes around the time of the financial crisis.

2.5.2.2 Wedge estimates

To derive forecasts, we next calculated the wedge between inflation in our Northumbrian energy cost indices by control area and both: (i) nominal GDP inflation; and (ii) CPI inflation. Overall, we consider that deriving forecast using the *wedge to nominal GDP inflation* should be preferred over the *wedge to CPI inflation*. This is because we expect that there will be more commonality between the drivers of nominal GDP and Northumbrian Water energy cost inflation, than is the case for CPI.

The following table shows the size of these wedges for the whole period for which data is available, from 1992 to 2016. In general, Northumbrian's underlying energy cost inflation (as measured by our index) is very similar to the trend in GDP (i.e. the wedges are close to zero). In contrast, Northumbrian's underlying energy cost inflation also tends to be above CPI.

Table 10: Historical wedge between Northumbrian Water energy cost indices and: (i) nominal GDP inflation; and (ii) CPI inflation

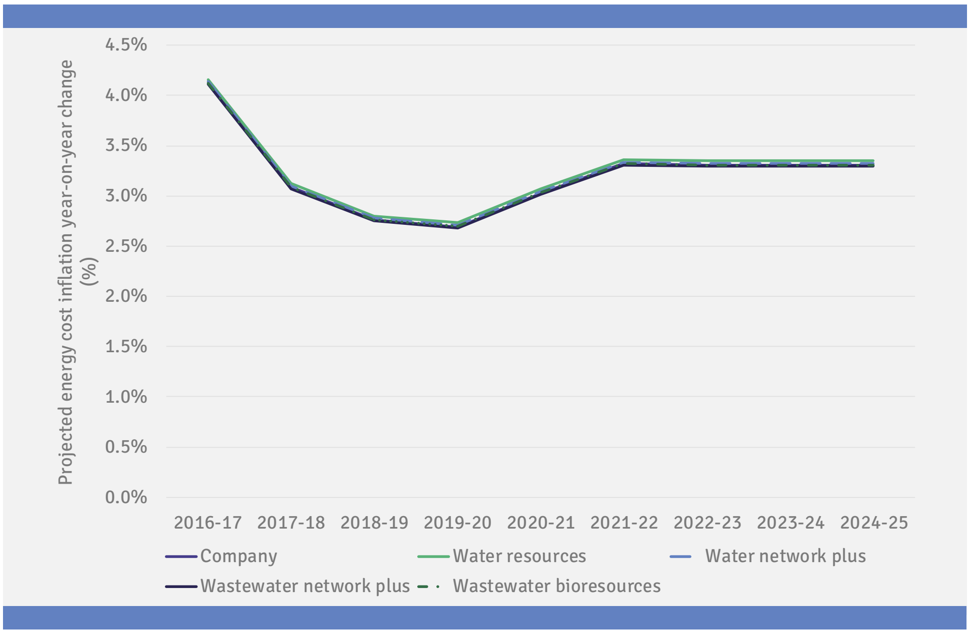
	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Wedge to **nominal GDP inflation**	-0.04%	-0.04%	-0.02%	-0.05%	-0.04%
Wedge to **CPI inflation**	1.88%	1.87%	1.89%	1.86%	1.88%

Source: Economic Insight analysis

To obtain forecasts from the above, we combined these 'wedges' with the most recent projections for both nominal GDP and CPI growth, taken from the OBR. These are available up to the year 2022/23. For years beyond 2023, we assumed that nominal GDP and CPI growth continue at the level forecast for 2023.

Our overall forecasts using this methodology, with respect to nominal GDP inflation are shown in the following figure. As can be seen, energy cost inflation is generally consistent across business areas. This is due to a large proportion of energy costs being driven by electricity prices across all wholesale areas.

Figure 14: Forecast energy cost inflation – based on nominal GDP wedge



Source: Economic Insight analysis of ONS and Northumbrian Water data

2.5.3 Independent forecasts

BEIS publishes a range of forecasts relating to: UK energy demand and supply; energy prices; as well as projections of carbon dioxide and other greenhouse gas emissions.[4]

For each, BEIS' central projection is referred to as the 'reference case', which embeds its best views in relation to drivers including:

- energy usage patterns;
- fossil fuel prices;
- GDP; and
- Population growth.

BEIS uses statistical techniques to arrive at its projections, based on trends and relationships identified from historical data, adjusting them to take account of implemented, adopted and agreed Government energy policies. Besides the reference scenario, BEIS also sets out projections for the following:

- low and high fossil fuel prices; and
- low and high economic growth.

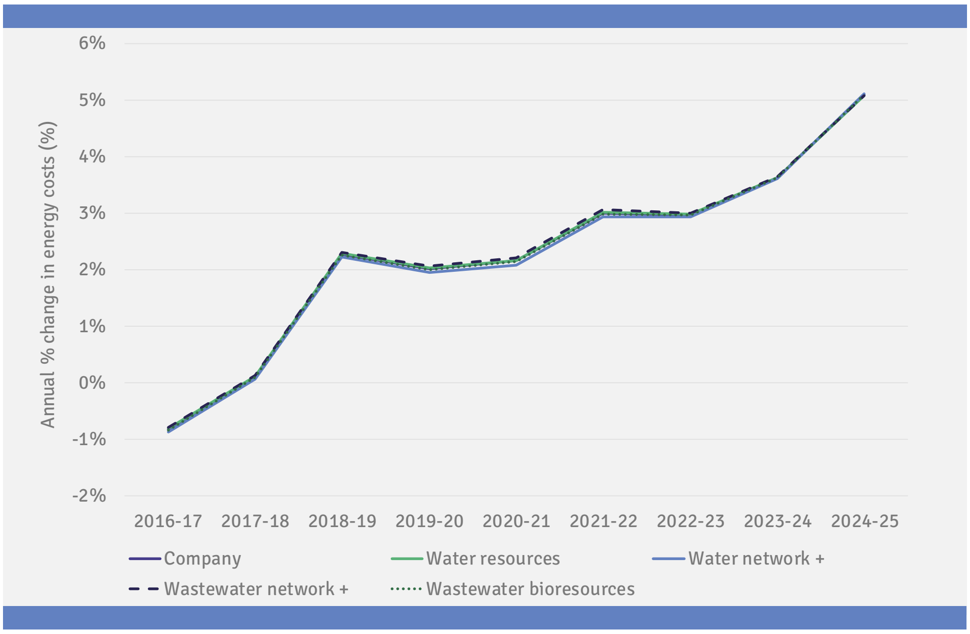
We consider BEIS's projections to be a credible source of information. Consequently, we have also derived forecasts by applying Northumbrian's energy input weights (set out above) directly to the 8-year rolling average of BEIS projections for energy prices for industrial customers for:

- electricity (p/kWh);
- natural gas (p/kWh); and
- gas oil (p/kWh).

We applied these to BEIS's various different scenarios: (i) reference; (ii) low fuel prices; (iii) high fuel prices; (iv) low growth; and (v) high growth. Our overall forecasts using this methodology for the reference scenario are shown in the following figure. As can be seen, energy cost inflation is generally consistent across all business areas.

[4] *'Updated energy and emissions projections 2017.' Department for Business, Energy & Industrial Strategy (January 2018).*

Figure 15: Forecast energy cost inflation – based on BEIS reference case



Source: Economic Insight analysis of BEIS and Northumbrian Water data

2.5.4 Extrapolating existing trends

Our final approach to forecasting energy inflation was one of extrapolation. Accordingly, the following table shows energy cost inflation for all of Northumbrian's energy cost indices, over a range of timeframes. We also present the rolling five-year averages of the Northumbrian-specific energy price indices.

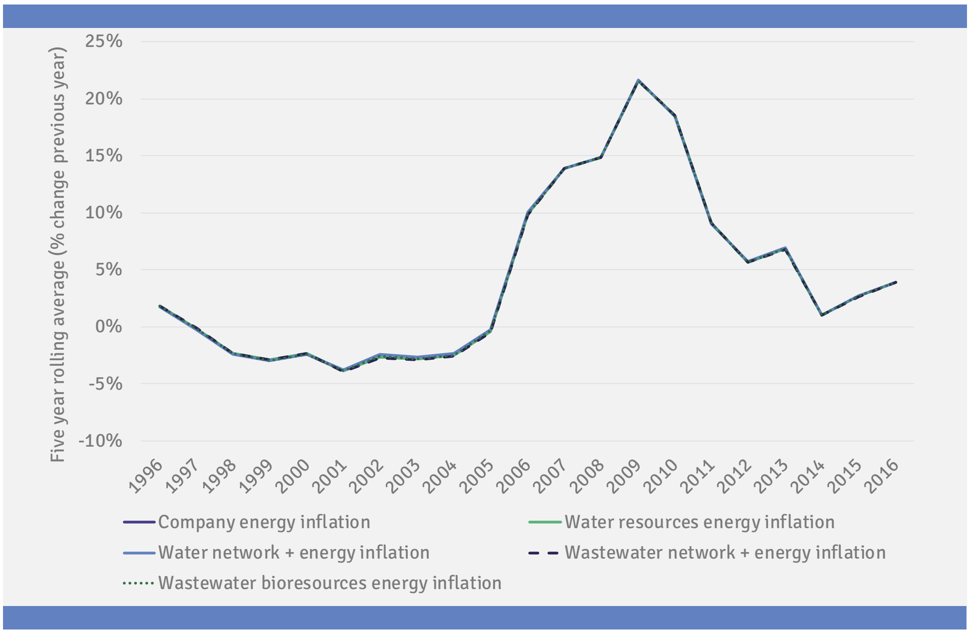
As described elsewhere, a limitation with extrapolations is that they will not account for expected changes in cost drivers – or the broader economy.

Table 11: Northumbrian Water energy price indices, average annual inflation

Time period	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Last year	0.21%	0.23%	0.05%	0.33%	0.19%
Last 5 years	3.92%	3.92%	3.90%	3.94%	3.92%
1992-2016	4.18%	4.18%	4.20%	4.17%	4.18%

Source: Economic Insight analysis

Figure 16: Northumbrian Water energy cost inflation, 5 year rolling averages



Source: Economic Insight analysis

2.5.5 Summary of overall energy cost inflation

Overall, we believe that our forecasts based on the BEIS's projections (which themselves are derived from detailed statistical analysis) are the most plausible. Accordingly, our 'central case' reflects BEIS's 'low growth' figures; and our 'high case' reflects the BEIS 'reference case' scenario. This reflects the fact that the OBR has recently significantly downgraded its projections for the UK's economic performance. Accordingly, our view is that the 'low growth' scenario modelled by BEIS is now more likely – and therefore a credible central case – for Northumbrian to draw on. Finally, BEIS's 'low prices' scenario is used in our 'low case'.

Table 12: Our overall Northumbrian Water energy cost inflation forecasts, 2020-25

Price control area / year		2020 / 21	2021 / 22	2022 / 23	2023 / 24	2024 / 25	Avg
Company	High (BEIS reference case)	2.16%	3.01%	2.98%	3.63%	5.09%	3.38%
	Central (BEIS low growth)	2.11%	2.92%	2.91%	3.54%	5.04%	3.30%
	Low (BEIS low prices)	1.46%	2.40%	2.25%	3.19%	4.83%	2.83%
Water resources	High (BEIS reference case)	2.17%	3.02%	2.99%	3.64%	5.09%	3.38%
	Central (BEIS low growth)	2.12%	2.93%	2.92%	3.54%	5.03%	3.31%
	Low (BEIS low prices)	1.48%	2.41%	2.26%	3.20%	4.83%	2.84%
Water network plus	High (BEIS reference case)	2.08%	2.93%	2.94%	3.62%	5.11%	3.34%
	Central (BEIS low growth)	2.04%	2.84%	2.87%	3.53%	5.05%	3.27%
	Low (BEIS low prices)	1.37%	2.30%	2.19%	3.16%	4.84%	2.77%
Waste-water network plus	High (BEIS reference case)	2.21%	3.06%	3.01%	3.64%	5.08%	3.40%
	Central (BEIS low growth)	2.17%	2.97%	2.94%	3.55%	5.03%	3.33%
	Low (BEIS low prices)	1.53%	2.47%	2.30%	3.22%	4.83%	2.87%
Waste-water bio-resources	High (BEIS reference case)	2.14%	2.99%	2.97%	3.63%	5.10%	3.37%
	Central (BEIS low growth)	2.10%	2.90%	2.90%	3.54%	5.04%	3.30%
	Low (BEIS low prices)	1.44%	2.38%	2.24%	3.19%	4.84%	2.82%

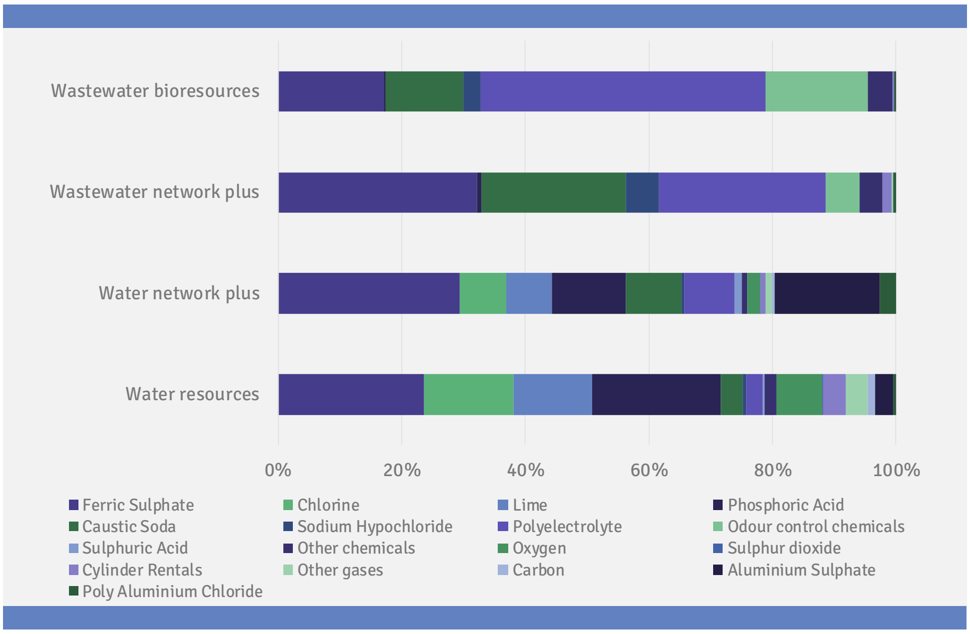
Source: Economic Insight analysis

2.6 Chemicals inflation forecasting

2.6.1 Northumbrian Water's mix of chemical costs

Our forecasting approach starts from understanding the 'mix' of chemicals procured by Northumbrian, by price control area. As such, the following chart shows the configuration of chemicals used by Northumbrian as of 2016/17.

Figure 17: Northumbrian Water's chemical purchases, across all price business areas (% of total chemical purchases in each business area)



Source: Northumbrian Water

2.6.2 Evidence on key drivers of chemical costs

In practice, chemical costs are affected by various underlying variables. We have reviewed evidence from the academic literature regarding this – which suggests the most important drivers are likely to include:

- **Crude oil** is used in the production of a number of chemicals – and is a key driver of chemical prices. A number of academic papers have analysed this impact. For example, Babula and Somwaru (1992) examined the dynamic effects on agricultural chemicals (and fertiliser) prices of a crude oil price shock. They used monthly data from 1962 to 1990 to construct a vector autoregression (VAR) model of crude oil, industrial chemicals and fertiliser prices. They find that a quarter of an increase in crude oil prices would be passed through to chemical prices.[5]

- **Exchange rates** are widely acknowledged as a driver of commodity prices. For example, Harri et al. (2009) examine the links between exchange rates and several commodities, including agricultural products that use chemicals as inputs.

[5] *'Dynamic Impacts of a Shock in Crude Oil Price on Agricultural Chemical and Fertilizer Prices.' R. A. Babula and A. Somwaru, Agribusiness, Vol. 8 No. 3, 243-252 (1992).*

They find that exchange rates play an important role in the determining of prices for all of the commodities they examined.[6] Similarly, Chen et al. (2009) use exchange rates to forecast commodity prices. They find that such forecasts are robust against a ranch of alternative benchmarks (including random walk and autoregressive models).[7]

- There are strong theoretical reasons to expect **economic growth** to have a positive relationship with chemicals and other commodity prices. As economic activity, measured in GDP increases, is likely to put pressure on existing supplies. While this will generate a supply-side response, any lag in new suppliers coming on-stream will result in price increases. This relationship has been detailed for other commodities, including food.[8] Interestingly, a related literature examines causality in the *opposite direction*, from commodity prices to economic growth.[9] We think there are good reasons to test whether the relationship between chemical prices and growth is *higher* for the components of GDP that are most intensive in their use of chemicals; in particular, **construction.**

The key point to take from this is that *forecasting chemical cost inflation over time is challenging, due to the many factors that drive prices.* As we set out below, our econometric analysis combines oil price inflation, economic growth, and then adjusts this for expected changes in exchange rates.

2.6.3 Economy-based estimates

As explained above, we think that economy-based methods for forecasting (whereby we identify relationships between the inflation measure of interest and other macroeconomic factors) have merit. As such, we explored this approach in relation to chemicals input price inflation – as follows:

- We developed indices of Northumbrian's chemical commodity costs, based on detailed US data on price inflation for individual chemical types. We did this by price control area. As explained before, the use of wider economy data (in this case, chemicals commodity prices, rather than actual Northumbrian chemical cost data, avoids inadvertently conflating inefficiency in our forecasts).

- We then collected the historical data on the key underlying drivers of chemical cost inflation, as suggested by economic theory and our review of the available literature.

- We used these data to estimate regressions, examining the statistical relationship between the chemical cost indices and underlying drivers. We then selected the most robust regression(s) to use in our forecasts.

- We collected forecast data for the underlying chemical cost drivers, and then used these to generate forecasts of future chemical cost inflation to 2025.

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6 *'The Relationship between Oil, Exchange Rates and Commodity Prices.' (2009).*

7 *'Can Exchange Raters Forecast Commodity Prices?' Y.-C. Chen, K. Rogoff and B. Rossi, NBER Working Paper No. 13901 (2009).*

8 *'Global agricultural supply and demand: factors contributing to the recent increase in food commodity prices.' R. Trostle, United States Department of Agriculture (May 2008).*

9 *'Commodity prices and growth in Africa.' A. Deaton, Journal of Economic Perspectives, Vol. 13 No. 3 (1999).*

- As our analysis was based on US data, we then adjusted for forecast movements in the £ / $ exchange rate.

2.6.3.1 Developing indices of chemical commodity costs

To generate the indices, Northumbrian matched its historical chemical purchases to chemical groups in the US Producer Price Index, published by the US Bureau of Labor Statistics. This allows our chemical indices to be constructed on a much more granular basis than would be possible if we were to use price inflation data from the ONS. Further, as chemicals are commodities (traded globally), there are strong arguments for using US, rather than UK, data. This has implications for how we adjust for exchange rate movements, which we set out in more detail below.

Having collected detailed price data for individual chemicals, we then used purchase amounts (in £s) for each price control area (whole company, water and wastewater) to calculate weighted average inflation for Northumbrian. The weights that we used for each chemical type are summarised in the following table.

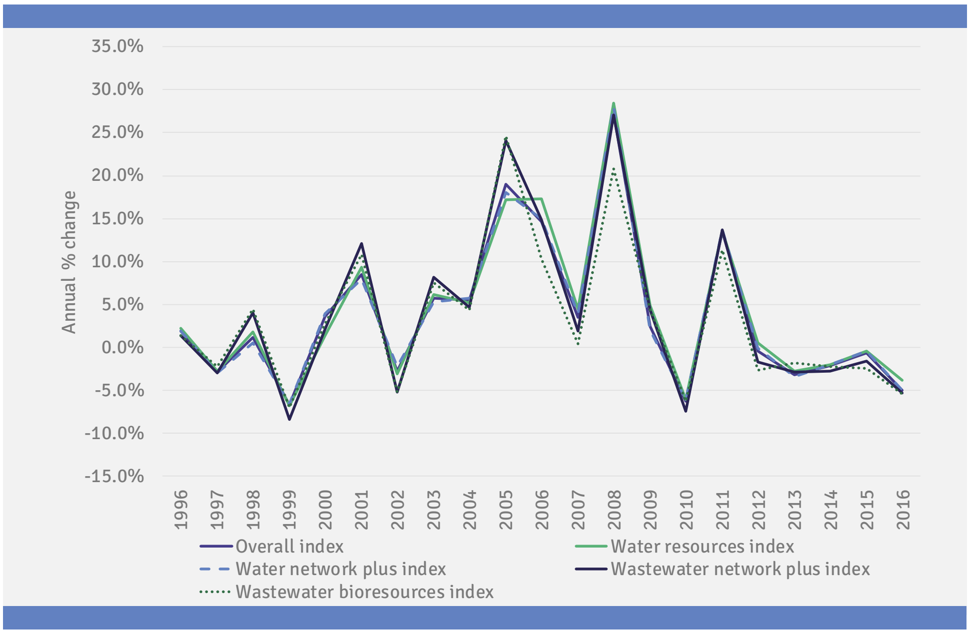
Table 13: Northumbrian Water chemicals matched to US Producer Price Index and weightings

NES chemical purchases	Relevant US Producer Price Index equivalent	Company	Water resources	Water network plus	Waste-water network plus	Waste-water bio-resources
Ferric Sulphate	Inorganic chemicals, other than alkalies and chlorine	28.3%	24.6%	29.6%	32.6%	17.2%
Chlorine	Alkalies and chlorine, including natural sodium carbonate and sulfate	19.6%	19.2%	17.2%	34.8%	31.9%
Lime	Lime	6.6%	13.2%	7.4%	0.0%	0.0%
Phosphoric Acid	Basic inorganic chemicals	10.8%	21.7%	12.1%	0.6%	0.3%
Polyelectrolyte	Water-treating compounds	12.6%	2.8%	8.2%	27.5%	46.4%
Sulphuric Acid	Sulfuric acid	1.0%	0.3%	1.3%	0.0%	0.0%
Other chemicals	Chemicals and allied products	1.3%	2.0%	0.8%	3.7%	3.9%
Oxygen	Oxygen	2.1%	7.7%	2.1%	0.0%	0.0%
Sulphur dioxide	Industrial gases	1.1%	3.6%	1.2%	0.3%	0.1%
Carbon	Carbon black	0.4%	1.2%	0.4%	0.0%	0.0%
Aluminium Sulphate	Aluminum compounds	16.1%	3.6%	19.7%	0.5%	0.2%

Source: Economic Insight analysis

The resulting indices are shown in the following figure; and cover the timeframe 1996 to 2016.

Figure 18: Chemical cost inflation indices



Source: Economic Insights analysis of US Producer Price Index

2.6.3.2 Collecting historical data on chemical cost drivers

Having generated time series data for our chemicals inflation indices, we then gathered historical data on the drivers of chemical costs. As set out above, our review of the literature suggested that oil prices, GDP growth, and potentially construction activity, were most likely to drive chemical cost inflation.

- Data on **nominal GDP growth** was sourced from the International Monetary Fund (IMF). We collected these data for the US, the UK and the world (although our analysis focused on US data).
- Data on historical **oil prices** (in $ per barrel) was taken from the World Bank.
- We used OECD data to construct a time series for **construction activity**, again for the US and the UK.

2.6.3.3 Estimating regressions

WE ADDRESSED CONCERNS OVER NON-STATIONARITY BY CONDUCTING REGRESSIONS IN PERCENTAGE CHANGES AND BY USING LAGS OF THE DEPENDENT VARIABLE.

Having compiled time series data on both chemical cost indices for Northumbrian, and the underlying cost drivers, our next step was to estimate regressions of the relationship between them. We examined regressions on all three potential explanatory variables, together and individually, alongside regressions of the combinations of GDP and oil prices; and oil prices and construction activity. We also included lags of the variables, and examined the impact of different timeframes for the robustness of the regressions.

We note that economic variables including prices and GDP are generally *non-stationary* - and tend to trend upwards over time. Unless care is taken, statistical analysis of non-stationary variables can suggest spurious relationships. Consistent with our approach to labour inflation, to address this we ran regressions in *percentage changes,* alongside regressions in *levels* that included *lags of the dependent variable*.

Again, as noted previously, we consider that the former method is preferable, as it allows for easier comparisons to be made across the regressions' R^2 (as regressions in levels including lags have very high values across the board). We found that the best fitting model was for the period since 2001, and included GDP lagged by one year, oil prices and oil prices lagged by one year, alongside a year dummy for 2008.

2.6.3.4 Collecting forecast data for underlying cost drivers

To translate our estimates of the historical relationships between the chemical cost indices and GDP into **forecasts** to 2025, we collected third-party forecast information on the underlying cost drivers.

- Future nominal GDP forecasts were taken from the IMF, and were fully consistent with the historical data from the same source. These forecasts were available until 2022. For 2023 to 2025, we assumed that growth continues at its 2022 level.

- Oil price forecasts were taken from the World Bank, and were also fully consistent with the historical data from the same source. These forecasts were available for every year to 2025.

- We generated our own forecasts for construction. We calculated the long-term average (consistent with the estimation window of our regressions) of the ratio of construction to GDP growth, and then applied this long-term average to the IMF's GDP forecasts.

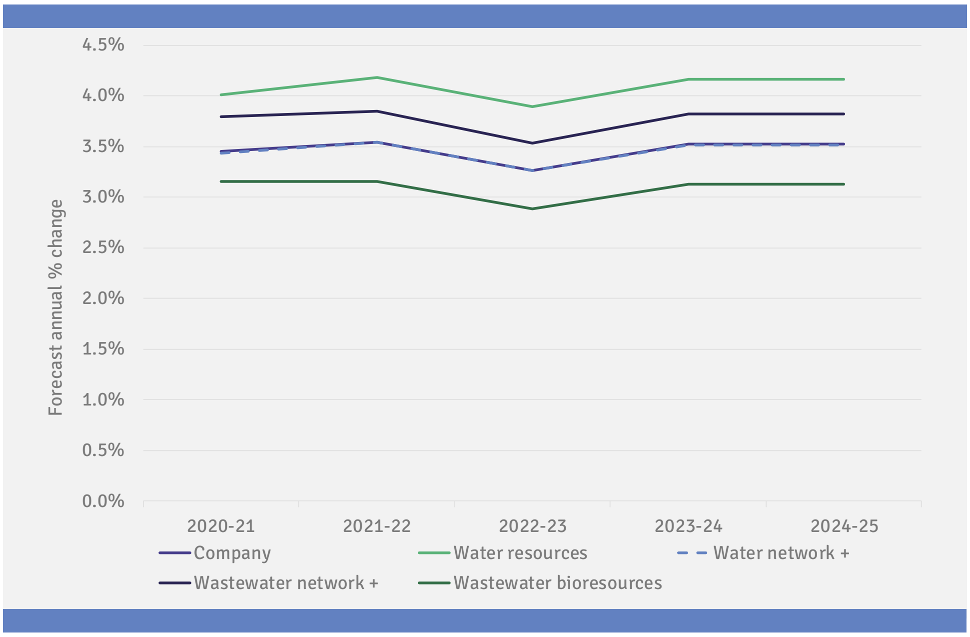
2.6.3.5 Adjusting for exchange rates

As a final step, since our forecasts were based on US data, we adjusted them for anticipated changes in £/$ exchange rates. We used forecasts from BNP Paribas for years to 2018, and then projected the 2018 level forward to 2025. This is broadly consistent with the OBR's forecasts for the Sterling effective (trade-weighted) exchange rate index, which is flat from 2018.

2.6.3.6 Econometric forecasts

We found that the preferred econometric model for chemical cost inflation was one in percentage changes that included: a one year lag of GDP; current oil price inflation; and a one year lag of oil price inflation, alongside a year dummy for 2008. The following figure sets out our associated forecasts based on this. There is an initial 'spike' in the period 2017/18, followed by gradually declining inflation out to 2025. This is primarily driven by high forecast outturn oil price inflation for 2017 and 2018, of 23.8% and 5.7% respectively. Due to the lag structure of the model, this drops out of the forecast over time.

Figure 19: Forecasts for Northumbrian Water chemical cost inflation – based on econometrics



Source: Economic Insight analysis

2.6.4 Extrapolating existing trends

Our second methodology was to extrapolate forward existing trends in the Northumbrian Water chemical cost indices. As was the case for our labour cost inflation analysis, we place less weight on this approach than on the evidence based on economic fundamentals. The extrapolation approach constructs forecasts by assuming that future inflation is simply a continuation of the recent past. While this may be appropriate in some circumstances – particularly when underlying cost drivers are expected to be stable over time – an extrapolation approach is clearly inappropriate where cost drivers are expected to change in the future (noting that, in the case of chemicals, there is expected to be a large rise in the price of crude around 2017/18).

The following table presents average chemical cost inflation for the three indices, over a range of timeframes. We have also presented rolling five-year averages of the price indices in figure that follows (see overleaf).

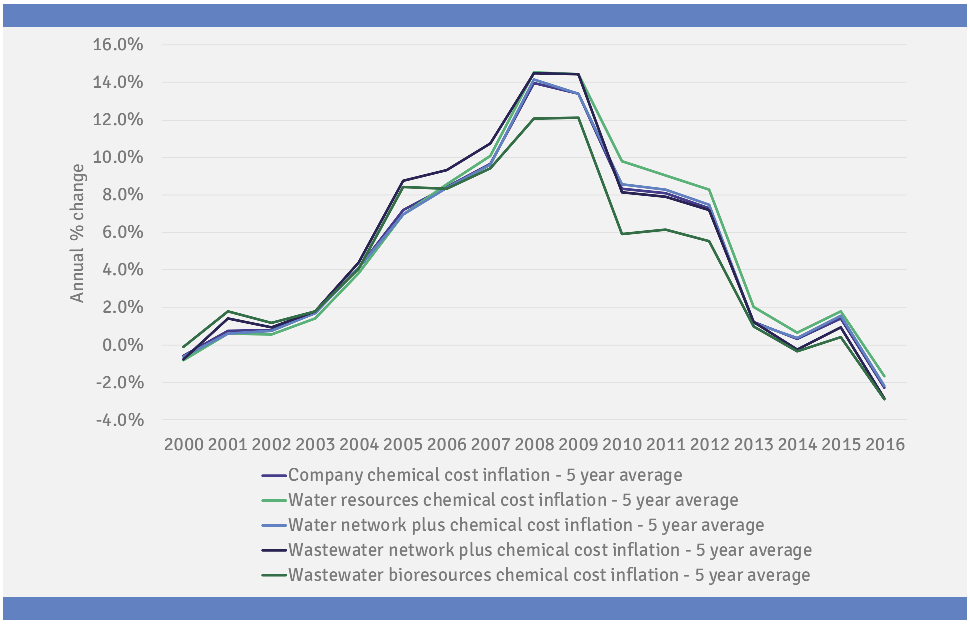
When using an extrapolation approach, we think it most appropriate to focus on the period from 2001 to now (i.e. the period denoted ‘consistent with econometrics’ in the following table) implying chemical cost inflation of between 4.29% pa to 5.57% pa.

Table 14: Northumbrian Water chemical price indices, average annual inflation

Time period	Company	Water resources	Water network plus	Wastewater network plus	Waste-water bio-resources
Last year	-5.00%	-3.84%	-5.00%	-5.28%	-5.41%
Last 5 years	-2.26%	-2.19%	-2.19%	-2.84%	-2.91%
1996-2016	3.66%	4.05%	3.68%	3.83%	3.24%
Consistent with econometrics	4.99%	5.57%	5.02%	5.26%	4.29%

Source: Economic Insight analysis

Figure 20: Northumbrian Water chemical cost inflation, 5 year rolling averages



Source: Economic Insight analysis

2.6.5 Independent third-party forecasts

INDEPENDENT FORECASTS SUGGEST CHEMICAL COST INFLATION IN THE RANGE OF 2% TO 3% PA, FOR THE PERIOD 2020-2025.

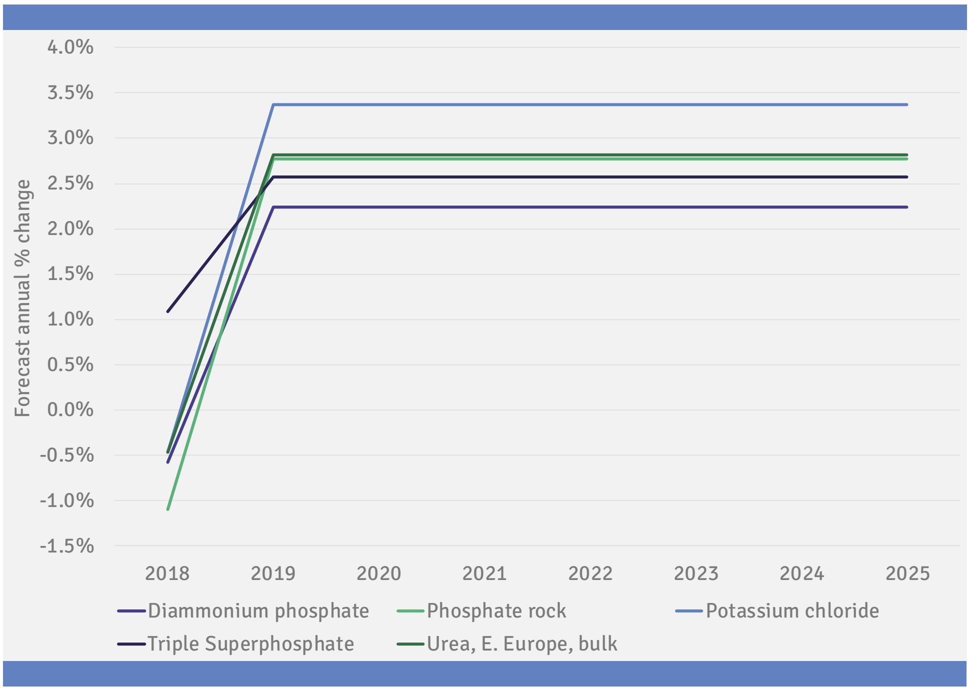
We examined independent forecasts of chemical cost inflation. Unfortunately, few forecasts are available specifically for the chemicals that Northumbrian uses, although some are available from the World Bank for a subset of Northumbrian's chemical needs. We also draw on the First Economics report from August 2013, which provides chemical cost forecasts for the water industry, based on ONS data.[10]

Forecasts from the World Bank are shown in the figure below, and are broadly in the region of 2% to 3% over 2020 to 2025. This compares with First Economics' forecasts

[10] 'Water Industry Input Price Inflation and Frontier Productivity Growth.' *First Economics (2013).*

of 5% chemical cost inflation for the period from 2015 to 2020 (based on an extrapolation approach, using broad chemical categories from ONS data). As we describe above, a problem with independent forecasts is that they do not reflect the mix of chemicals that Northumbrian Water actually uses. They do, however, provide a useful benchmark for expected chemical price inflation in general, over the relevant time-period. Overall, these forecasts suggest chemical cost inflation in the range of 1-3.5% pa.

Figure 21: World Bank chemical cost forecasts – adjusted for exchange rate movements



Source: World Bank

2.6.6 Summary and overall chemical cost inflation forecasts

We have presented a range of forecasts for Northumbrian's chemical cost inflation over the period 2020-25. The following table draws these together to provide: high, central and low, forecasts – based on the following:

- **high** estimates are derived from the trend analysis (using a time-period consistent with the econometrics approach);
- **central** estimates are derived from the econometrics approach, based on % changes for the period since 2001, where variables included are: GDP lagged by one year; oil prices; and oil prices lagged by one year; alongside a year dummy for 2008; and
- **low** estimates are derived from independent third-party forecasts.

Table 15: Our overall Northumbrian Water chemical cost inflation forecasts, 2020-25

		2020 / 21	2021 / 22	2022 / 23	2023 / 24	2024 / 25	Avg
Company	High (trend)	4.99%	4.99%	4.99%	4.99%	4.99%	4.99%
	Central (econometrics)	3.45%	3.54%	3.27%	3.52%	3.52%	3.46%
	Low (independent third-party)	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%
Water resources	High (trend)	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%
	Central (econometrics)	4.01%	4.18%	3.89%	4.16%	4.16%	4.08%
	Low (independent third-party)	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%
Water network plus	High (trend)	5.02%	5.02%	5.02%	5.02%	5.02%	5.02%
	Central (econometrics)	3.43%	3.54%	3.26%	3.52%	3.52%	3.45%
	Low (independent third-party)	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%
Wastewater network plus	High (trend)	5.26%	5.26%	5.26%	5.26%	5.26%	5.26%
	Central (econometrics)	3.79%	3.84%	3.53%	3.82%	3.82%	3.76%
	Low (independent third-party)	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%
Wastewater bioresources	High (trend)	4.29%	4.29%	4.29%	4.29%	4.29%	4.29%
	Central (econometrics)	3.15%	3.15%	2.88%	3.13%	3.13%	3.09%
	Low (independent third-party)	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%

Source: Economic Insight analysis

2.7 'Other' input price pressure

As demonstrated in Figure 1, there are 'other' (opex-related) input costs within all of Northumbrian's business areas.

These tend to be quite significant in some areas, specifically in water resources, where they are mostly driven by EA charges; and in water and wastewater network plus, where they are mostly driven by business rates.

We have assumed that they will move in line with CPI inflation for the following reasons:

- The UK government will peg business rates to CPI from April 2018.[11]
- Previously, regulators and the Competition Commission, have assumed that EA charges would rise in line with RPI. As most regulators are moving towards CPI, we believe that it would be a reasonable assumption that they will rise in line with CPI over PR19.
- Moreover, in the latest EA charge proposals, the charges themselves will be allowed to rise at CPI.[12]

As mentioned previously, the OBR provides forecast CPI up to 2022/23. For the remaining years to 2024/25, we have simply assumed that CPI would rise at the same level as in the previous years.

The following table illustrates our CPI inflation assumption for the remaining 'other' category of opex-related input costs.

Table 16: CPI inflation forecast

	2020/21	2021/22	2022/23	2023/24	2024/25	Average
CPI	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%

Source: OBR up to 2022/23

[11] *'Budget 2017: Business rates to be pegged to CPI from 2018.' BBC (23 November 2017), http://www.bbc.co.uk/news/business-42085005*

[12] *'Environment Agency Charge proposals from 2018.' Environment Agency (2017), page 13. https://consult.environment-agency.gov.uk/engagement/environmentagency-charging-proposals-fromapril2018/supporting_documents/Environment%20Agency%20Charge%20Proposals%20Consultation%20Document.pdf*

2.9 Forecasting underlying inflation for capital costs

The previous subsections set out forecasts for individual elements of opex. In addition to this, and as described in the introductory chapter, Ofwat requires companies to provide inflation forecasts relating to capital costs. Specifically, including the categories of: maintenance / capex; infrastructure and non-infrastructure.

To explore this, we used data from the Resource Cost Indices, which are published by the Building Cost Information Services (BCIS) of RICS (this data was formerly provided by the Department for Business, Innovation and Skills). These indices measure the notional trend of input costs to contractors; and primarily relate to construction work. Categories of work within the data are: building of non-housing; house building; road construction; and general infrastructure. [13]

Across the above categories, separate indices are published at a detailed level, including:

- building work;
- mechanical work (heating and ventilating);
- electrical work;
- labour and plant; and
- materials.

Having reviewed the BCIS data carefully, with reference to the categories required for PR19, we consider the most relevant indices to be:

- Resource Cost Index of Maintenance of Building Non-Housing (NOMACOS): which we use for **capital maintenance** inflation forecasting.

- Resource Cost Index of Building Non-Housing (NOCOS): which we use for **capex** inflation forecasting.

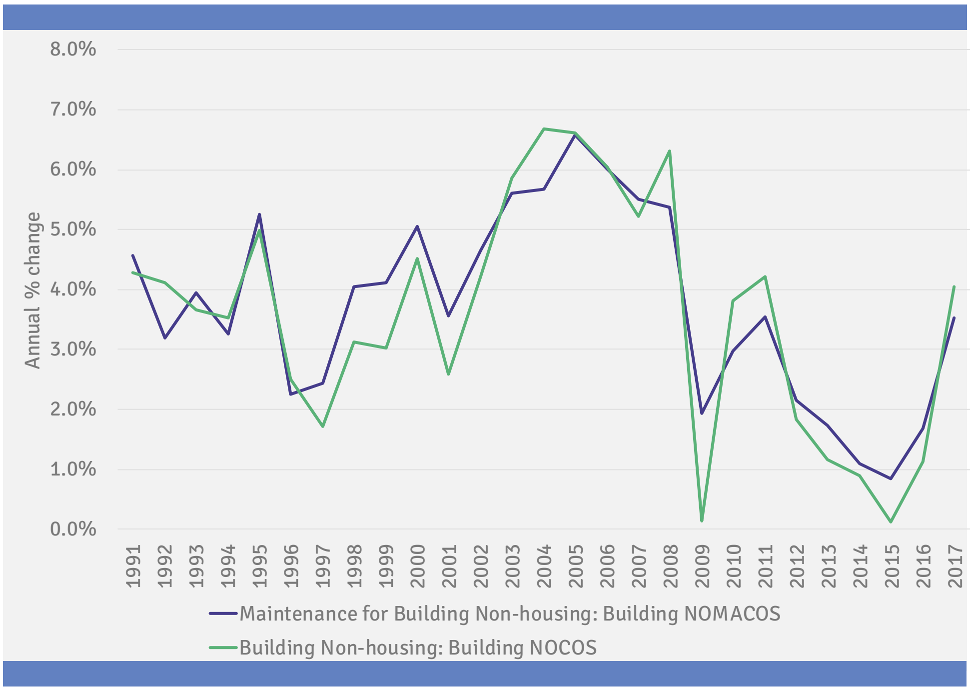
We do not think that the BCIS data allows for any further, more granular, disaggregation of capital cost inflation. Specifically, we have not sought to also differentiate between:

- infrastructure and non-infrastructure related capital cost inflation; or
- the various price control areas for PR19.

Following from the above, the figure overleaf shows how the cost indices for maintenance for building (capital maintenance) and building (capex) have moved over time.

[13] *'Resource Cost Indices (formerly BIS).' BCIS (May 2016).*

Figure 22: Historical inflation of maintenance and building cost indices, 1991-2016



Source: BCIS Online

As can be seen, the impact of the financial crisis on non-house building construction and maintenance inflation was severe. Indeed, it has not yet returned to pre-crisis levels.

In the following we set out how we used these indices to create gross input price pressure forecasts for capital costs.

2.9.1 Economy-based estimates

In terms of economy-based estimates, the econometric models we estimated based on the relationships between the capital cost indices and GDP were not robust. As such, we focus on the 'wedge' methodology here.

We calculated the wedge between the capital cost indices set out above and both (i) nominal GDP inflation; and (ii) CPIH inflation. Here, we consider that deriving the forecast using the *wedge to nominal GDP inflation* should be preferred over the *wedge to CPIH inflation*.

The following table shows the size of the wedges for the whole period for which data is available, from 1991 to 2016. In general, capital cost inflation is below nominal GDP inflation (i.e. the wedges are negative), whereas it tends to be above CPIH inflation.

Table 17: Historical wedge between capital cost indices and: (i) nominal GDP inflation; and (ii) CPI inflation

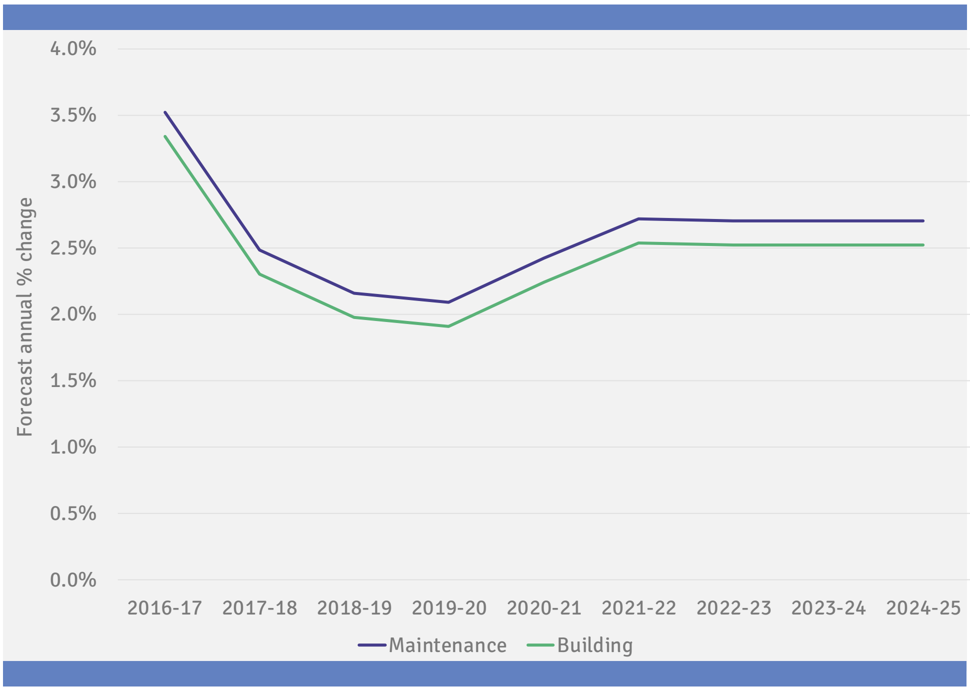
	Capital maintenance (maintenance of Building Non-Housing)	Capex (building Non-Housing)
Wedge to **nominal GDP inflation**	-0.64%	-0.82%
Wedge to **CPIH inflation**	0.38%	0.18%

Source: Economic Insight analysis

We combined these 'wedges' with the most recent projections for both nominal GDP and CPI growth, taken from the OBR. These are available up to the year 2022/23. Consistent with our approach elsewhere, for years beyond 2023 we assumed that nominal GDP and CPI growth continue at the level forecast for 2023. Moreover, to derive the CPIH forecast, we applied the historic wedge between CPI and CPIH to the OBR's forecasts.

Our forecasts based on this methodology are illustrated in the following figure, with respect to nominal GDP inflation. As can be seen, capital cost inflation is initially forecast to decline slightly – reflecting the downturn in economic activity – followed by a period of slight growth; and then plateauing.

Figure 23: Forecast capital cost inflation – based on nominal GDP wedge



Source: Economic Insight analysis

2.9.2 Extrapolating existing trends

We also examined forecast inflation based on an extrapolation of existing trends in capital cost inflation. As mentioned elsewhere, one of the major limitations of extrapolations is that they will not account for expected changes in cost drivers, or the broader economy.

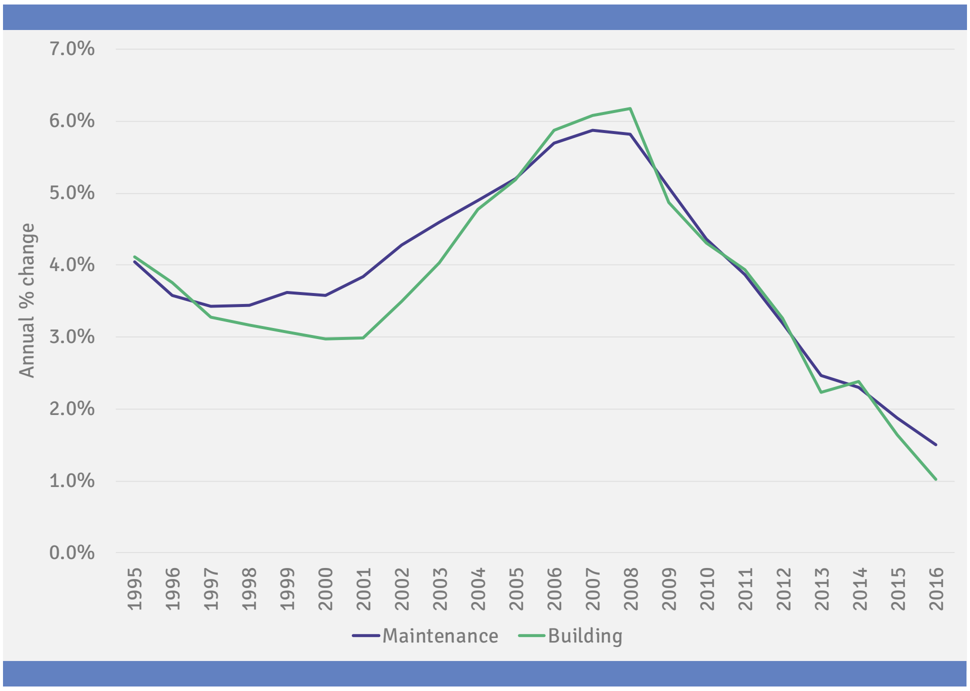
The following table shows capital cost inflation for Northumbrian between 1991 and 2016. We also present five-year rolling averages of the capital cost indices.

Table 18: Capital cost indices, average annual inflation

	Capital maintenance (maintenance of Building Non-Housing)	Capex (building Non-Housing)
1991 - 2016	3.73%	3.55%

Source: Economic Insight analysis

Figure 24: Capital cost inflation, 5 year rolling averages



Source: Economic Insight analysis of BCIS data

2.9.3 Summary of overall capital cost inflation

The following table draws together the above estimates to provide high, central and low forecasts, based on the following:

- **high** estimates are derived from the whole period extrapolated trend;
- **central** estimates are derived from the wedge to GDP approach; and
- **low** estimates are derived from the wedge to CPIH approach.

Table 19: Our overall Northumbrian Water capital cost inflation forecasts, 2020-25

		2020 / 21	2021 / 22	2022 / 23	2023 / 24	2024 / 25	Average
Maintenance	High (trend)	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
	Central (wedge to GDP)	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
	Low (wedge to CPIH)	2.22%	2.21%	2.21%	2.21%	2.21%	2.21%
Capex	High (trend)	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%
	Central (wedge to GDP)	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%
	Low (wedge to CPIH)	2.02%	2.01%	2.01%	2.01%	2.01%	2.01%

Source: Economic Insight analysis

2.10 Summary of our projected gross input price pressure

Drawing the various forecasts set out in the preceding sections together, the following tables summarise our projections for gross underlying input price pressure by wholesale price control area. In each case, a central, high and low forecast is provided.

2.10.1 Water resources

Table 20: Gross input price inflation - wholesale **water resources** **(central case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	2.03%	2.19%	2.18%	2.26%	2.45%	2.22%
Maintaining the long-term capability of the assets infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Maintaining the long-term capability of the assets non-infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Other capital expenditure ~ infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%
Other capital expenditure ~ non-infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%

Source: Economic Insight analysis

Table 21: Gross input price inflation - wholesale **water resources** **(high case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	2.13%	2.29%	2.28%	2.36%	2.55%	2.32%
Maintaining the long-term capability of the assets infrastructure	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
Maintaining the long-term capability of the assets non-infrastructure	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
Other capital expenditure ~ infrastructure	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%
Other capital expenditure ~ non-infrastructure	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%

Source: Economic Insight analysis

Table 22: Gross input price inflation - wholesale **water resources** **(low case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.93%	2.10%	2.07%	2.20%	2.41%	2.14%
Maintaining the long-term capability of the assets infrastructure	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
Maintaining the long-term capability of the assets non-infrastructure	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
Other capital expenditure ~ infrastructure	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%
Other capital expenditure ~ non-infrastructure	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%

Source: Economic Insight analysis

2.10.2 Water network plus

Table 23: Gross input price inflation - wholesale **water network plus (central case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.96%	2.23%	2.20%	2.29%	2.45%	2.23%
Maintaining the long-term capability of the assets infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Maintaining the long-term capability of the assets non-infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Other capital expenditure ~ infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%
Other capital expenditure ~ non-infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%

Source: Economic Insight analysis

Table 24: Gross input price inflation - wholesale **water network plus (high case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	2.43%	2.69%	2.67%	2.74%	2.90%	2.69%
Maintaining the long-term capability of the assets infrastructure	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
Maintaining the long-term capability of the assets non-infrastructure	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
Other capital expenditure ~ infrastructure	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%
Other capital expenditure ~ non-infrastructure	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%

Source: Economic Insight analysis

Table 25: Gross input price inflation - wholesale **water network plus** **(low case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.87%	2.13%	2.10%	2.20%	2.38%	2.14%
Maintaining the long-term capability of the assets infrastructure	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
Maintaining the long-term capability of the assets non-infrastructure	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
Other capital expenditure ~ infrastructure	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%
Other capital expenditure ~ non-infrastructure	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%

Source: Economic Insight analysis

2.10.3 Wastewater network plus

Table 26: Gross input price inflation - wholesale **wastewater network plus (central case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.93%	2.24%	2.23%	2.36%	2.66%	2.28%
Maintaining the long-term capability of the assets infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Maintaining the long-term capability of the assets non-infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Other capital expenditure ~ infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%
Other capital expenditure ~ non-infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%

Source: Economic Insight analysis

Table 27: Gross input price inflation - wholesale **wastewater network plus (high case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	2.27%	2.57%	2.56%	2.69%	2.98%	2.62%
Maintaining the long-term capability of the assets infrastructure	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
Maintaining the long-term capability of the assets non-infrastructure	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
Other capital expenditure ~ infrastructure	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%
Other capital expenditure ~ non-infrastructure	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%

Source: Economic Insight analysis

Table 28: Gross input price inflation - wholesale **wastewater network plus** **(low case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.79%	2.12%	2.08%	2.27%	2.60%	2.17%
Maintaining the long-term capability of the assets infrastructure	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
Maintaining the long-term capability of the assets non-infrastructure	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
Other capital expenditure ~ infrastructure	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%
Other capital expenditure ~ non-infrastructure	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%

Source: Economic Insight analysis

2.10.4 Wastewater bioresources

Table 29: Gross input price inflation - wholesale **wastewater bioresources (central case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.85%	2.28%	2.22%	2.27%	2.33%	2.19%
Maintaining the long-term capability of the assets infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Maintaining the long-term capability of the assets non-infrastructure	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Other capital expenditure ~ infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%
Other capital expenditure ~ non-infrastructure	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%

Source: Economic Insight analysis

Table 30: Gross input price inflation - wholesale **wastewater bioresources (high case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	2.80%	3.20%	3.16%	3.19%	3.25%	3.12%
Maintaining the long-term capability of the assets infrastructure	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
Maintaining the long-term capability of the assets non-infrastructure	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
Other capital expenditure ~ infrastructure	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%
Other capital expenditure ~ non-infrastructure	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%

Source: Economic Insight analysis

Table 31: Gross input price inflation - wholesale **wastewater bioresources** **(low case)**

Year / cost category	2020-21	2021-22	2022-23	2023-24	2024-25	Average
Operating expenditure	1.78%	2.18%	2.14%	2.18%	2.24%	2.10%
Maintaining the long-term capability of the assets infrastructure	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
Maintaining the long-term capability of the assets non-infrastructure	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
Other capital expenditure ~ infrastructure	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%
Other capital expenditure ~ non-infrastructure	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%

Source: Economic Insight analysis

3. Frontier shift

In this chapter, we provide an assessment of the scope for frontier shift efficiency savings, by price control area (i.e. efficiency savings that can be made, over and above catch-up efficiency). This is primarily based on a composite index comparator analysis, using EU KLEMS data. We also provide a review of regulatory precedent on frontier shift as a further source of evidence – which we use as a 'cross check'.

The key findings with regards to frontier shift are as follows.

- Based on our composite index analysis, we find that the scope for opex frontier shift savings for Northumbrian is between C. 0.0% and 1.1% pa. For capex, we find the range to be between -0.3% (i.e. negative) and 0.6%.
- The overall scope for frontier shift savings over PR19 primarily depends on the 'time-period' from which evidence is drawn. In particular, it turns on whether one considers the objective to be to ensure that the forecasts are most consistent with the 5 years of PR19, or should be more reflective of longer-term productivity. This consideration is particularly pertinent, due to the UK's weak productivity performance in recent years.
- Objectively, we consider that more weight should be put on the low and central case scenarios we have developed, than on the 'high' scenario. This is because the high scenario is based on 'omitting' the last decade of low productivity performance for the UK – and so implicitly assumes a fast reversion to the UK's (higher) longer-term productivity performance. We consider this to be unlikely.
- We note that care must be taken, both when analysing productivity data and when reviewing existing studies and regulatory precedent on this issue. This is because TFP is composed of a number of factors, of which frontier shift is only one.

3.1 Understanding frontier shift – concepts of productivity

Within business plans at PR19, companies need to make assumptions regarding the direction and magnitude of key cost drivers. One of these includes the scope to make ongoing efficiency savings. In turn, the scope to make efficiency savings can be thought of as having two main components:

- **catch-up efficiency** (i.e. the efficiency 'gap' between an individual company within the industry and the efficiency frontier); and
- **frontier shift** (the efficiency savings that even a perfectly efficient firm could make – due to assumed productivity gains).

It is the latter of these (frontier shift) that is the focus of this chapter.

Following from the above, it is important to be clear about the various different concepts of productivity; and how they do, or do not, relate to frontier shift.

There are a number of measures of total productivity, but a commonly used concept is that of total factor productivity (TFP). TFP provides a measure of the total change in output that is not explained by a change in inputs (labour and capital). As such, TFP allows one to compare the efficiency of how firms, industries or countries deploy inputs in a multi-factor environment. TFP is typically measured by the Solow residual, as follows:

$$gY - \alpha * gK - (1 - \alpha) * gL$$

Where:

- gY is the growth rate of aggregate output;
- gK is the growth rate of aggregate capital;
- gL is the growth rate of aggregate labour; and
- α is the capital share.

In the context of our work, the critical point to understand is that observed **changes in TFP in a country, industry or company, may be driven by a range of factors – and thus 'frontier shift' will only be <u>one element</u> that makes up total observable TFP.** This point is well established in both the theoretical and empirical literature. Selected examples are as follows:

Griffith et al (2006) write: *"Intuitively, there is productivity dispersion within [an] industry because establishments differ in their underlying potential to innovate and it takes time to converge towards the constantly advancing frontier. In steady-state, the frontier will be whichever establishment in the industry has highest capability to innovate. All other establishments will lie an equilibrium distance behind the frontier, such that expected productivity growth as a result of both innovation and catch-up equals expected productivity growth as a result of innovation in the frontier."*[14]

This point is also made by Li and Waddams Price (2011), who develop an empirical analysis that decomposes TFP in mobile telecoms into its constituent parts, separating out the effects of catch-up from other drivers, such as innovation (i.e. frontier shifting technical efficiency) and competition.[15]

'Most of the analytical work underlying the duality between production and cost frontiers assumes perfectly competitive markets, which is rarely the norm among regulated industries.' – Coelli (2003)

Coelli et al (2003) note that [an analysis of TFP in the context of economic regulation is] *"quite problematic conceptually, as most of the analytical work underlying the duality between production and cost frontiers assumes perfectly competitive markets, which is rarely the norm among regulated industries."*[16]

Similarly, the above issues are also recognised within historical regulatory determinations and submissions. For example, as noted by CEPA:

"In the economy as a whole, or where there is assumed to be a reasonable amount of competition, if the sample of firms is both (i) large and (ii) random, it seems reasonable to expect that the efficiency improvement [TFP] should be largely driven by frontier shift. In these circumstances, an equal number of firms ought to be moving closer to the frontier as those that are moving away from it, on average. By contrast, if the sample contains a significant proportion of companies that are commonly recognised to be

[14] *'Technological Catch-up and the Role of Multinationals.' Rachel Griffith, Stephen Redding, and Helen Simpson; Princeton (2006).*

[15] *'Effect of regulatory reform on the efficiency of mobile telecommunications.' Yan Li & Catherine Waddams Price. Centre for Competition Policy and Norwich Business School, University of East Anglia (2011).*

[16] *'A Primer on Efficiency Measurement for Utilities and Transport Regulators.' Coelli, Tim; Estache, Antonio; Perelman, Sergio Trujillo, Lourdes; World Bank (2013).*

experiencing catch-up, through the effect of privatisation or comparative competition, then it is appropriate to make an adjustment to the TFP figure to recognise that not all of the efficiency improvement is likely to relate to frontier shift."[17]

The above issues have implications that should be considered when assessing the scope for 'frontier shift' in practice. Here, methodological approaches include the following:

- **Infer frontier efficiency scope from an analysis of TFP trends in other sectors / countries** (say, using a composite index, as we subsequently explain). Here, one is implicitly making the assumption that the comparators are competitive. As in practice, no comparators will be perfectly competitive, this approach will never give a 'pure' measure of the scope for frontier shift (and, indeed, will typically overstate it). However, so long as the comparators in any composite index are carefully selected, the presence of 'catch-up' inefficiency is often assumed away as a simplifying assumption.

- **Adjusted TFP comparators to decompose productivity into 'catch-up' and 'frontier' components.** This represents an augmented version of the above approach, whereby assumptions are overlaid in order to adjust the comparators to 'strip out' the catch-up element of efficiency savings.

- **Statistical analysis to explicitly decompose TFP into its constituent parts.** Methods including stochastic frontier analysis (SFA) and data envelope analysis (DEA) can be used to 'split' TFP into its various parts, so as to identify the 'frontier' element.

- **Analysis of historical productivity delivered within the industry of interest.** In principle, one could identify the scope for future frontier shift by examining historical trends in productivity within the industry of interest (in this case, the water sector). However, as above, if the sector is not considered to be competitive, this approach again raises the challenge as to how the overall observed TFP can be decomposed into its constituent parts. As noted above, the regulated monopoly status of the wholesale elements of the water value chain implies that historical TFP information, in isolation, is unlikely to be a reliable indicator of future frontier shift potential.

This has two important implications for any analysis used to inform frontier shift potential. Firstly, across all methods, it is important that care is taken to interpret the underlying evidence appropriately, so as not to erroneously conflate factors unrelated to frontier shift. Secondly, when using comparative approaches in particular, the choice of benchmark is likely to matter.

When comparative information is used, further important considerations include:

- **The similarity of the mix of labour and capital.** Because capital substitution can impact TFP, comparators are likely to be more valid where the underlying mix of inputs (which is sometimes **proxied by activities** undertaken) is similar. Where differences arise, adjusted TFPs can be calculated – typically either: (i) to allow for capital substitution; or (ii) to assume 'constant capital'.

[17] *'Office of Rail Regulation (ORR) Scope for Improvement in the Efficiency of Network Rail's Expenditure on Support and Operations: Supplementary analysis of Productivity and Unit Cost Change.' CEPA (2012).*

- **Economies of scale.** In principle, observed changes in TFP over time within an industry may, in part, be due to the realisation of scale economies, as output grows. As such, comparators are likely to be more valid where expected economies of scale are similar. In some cases, there is precedent for making adjustments, to control for differences in scale. This is typically as follows:

Volume-adjusted TFP = Unadjusted TFP - (1 – E) × (change in outputs over the period)

In practice, the data required to make adjustments for either labour and capital mix; and / or economies of scale, is often absent. Therefore, instead these issues are often 'taken into account' in the selection of comparators within a composite index.

3.2 Key context: the UK's productivity performance – time periods and business cycles

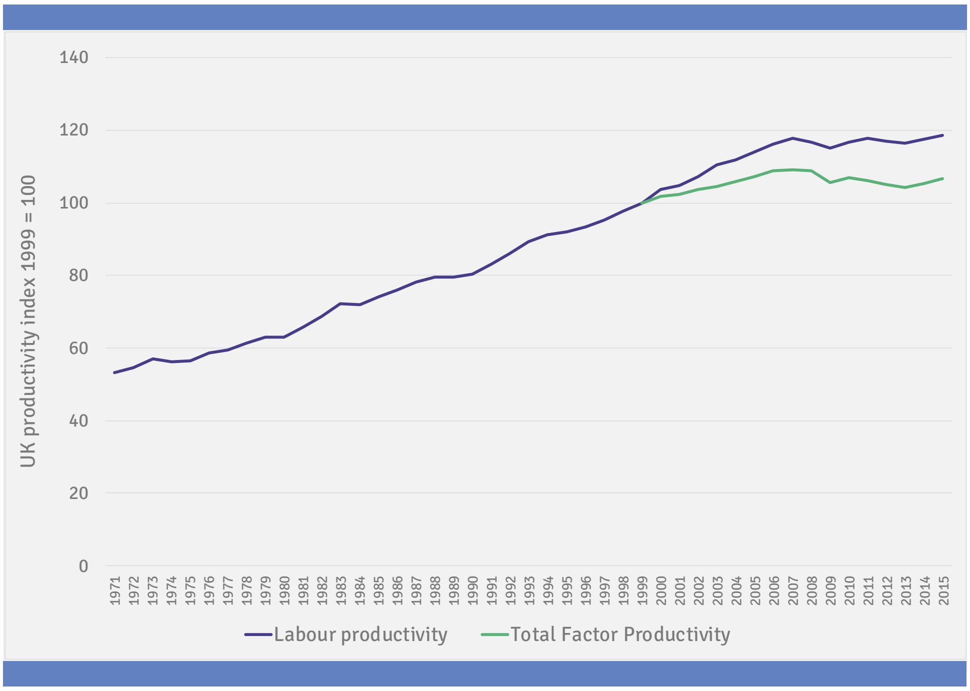
In reaching a view on the potential scope for frontier shift gains in the water industry, it is important to understand the broader context of historical productivity performance in the UK.

3.2.1 The UK's broader productivity position

The following figure shows both the UK's TFP and labour productivity (measured in output per hour worked) over time. A longer time series is available for the latter, which extends back to 1971. This shows that, in the decade prior to the 2008/09 financial crisis and recession, labour productivity was growing in line with its long-term average, of around 2% pa. However, since then, productivity has flatlined, or slightly fallen. Specifically:

- Labour productivity has averaged just 0.1% pa since 2008.
- TFP has averaged -0.3% pa since 2008.

Figure 25: UK productivity levels – annual index



Source: ONS and EU KLEMS

The fact that productivity has not increased for a period of time (or slightly fallen) is not particularly unusual. Indeed, the chart shows that it has fallen or flattened in the past. What is unusual, however, is the duration of the 'flat line', which is longer than any other period previously experienced, including the heavy recessions of the late 1980s and early 1990s.

The UK's weak productivity performance since 2008 is well documented – and has become a key policy issue in the recent past – as highlighted in the following:

'The main reason for lowering our GDP forecast since March is a significant downward revision to potential productivity growth, reflecting a reassessment of the post-crisis weakness and the hypotheses to explain it.' – The OBR

- In November 2017, the OBR downgraded its GDP forecasts for the UK. This, in turn, was driven by the authority reaching a more pessimistic view regarding the outlook for productivity. *"The main reason for lowering our GDP forecast since March is a significant downward revision to potential productivity growth, reflecting a reassessment of the post-crisis weakness and the hypotheses to explain it."*[18]

- The IFS notes: *"Productivity growth has been weak in almost all sectors of the [UK] economy, and negative in some. The lack of productivity growth in the finance sector has been important, but cannot explain the majority of the recent weakness."*[19]

- A 2012 paper from the Department for Business, Innovation and Skills finds that *"[t]hanks to rapid productivity growth since the 1980s, the UK has been closing the productivity gap with its major competitors, however since the 2000s the rate of progress has slowed. This is reflected in measures of both labour productivity and Total Factor Productivity (TFP). In general, the productivity gap is driven by poor productivity across most sectors, rather than the UK having an unfavourable sector mix, if anything, the UK's sector mix has served to reduce the productivity gap."*[20]

- The Financial Times' survey of economists in January 2018 reported that: *"more than half of all respondents said there was unlikely to be any pick-up in productivity this year."*[21]

- As Harari (2017) notes: *"the flat level of productivity since the recession is particularly notable given the growth seen in previous decades".*[22]

3.2.2 Business cycles

Following from the above, **business cycles** (alternating periods of recession and recovery) are part of all economies. They are usually measured in terms of the downward and upward movements of GDP around its long-term growth trend. In simple terms, the length of a business cycle is the time-period between a peak and a trough in GDP.

Accordingly, the following chart (see overleaf) shows the annual percentage change in real GDP in the UK since 1949, relative to its long-term trend.

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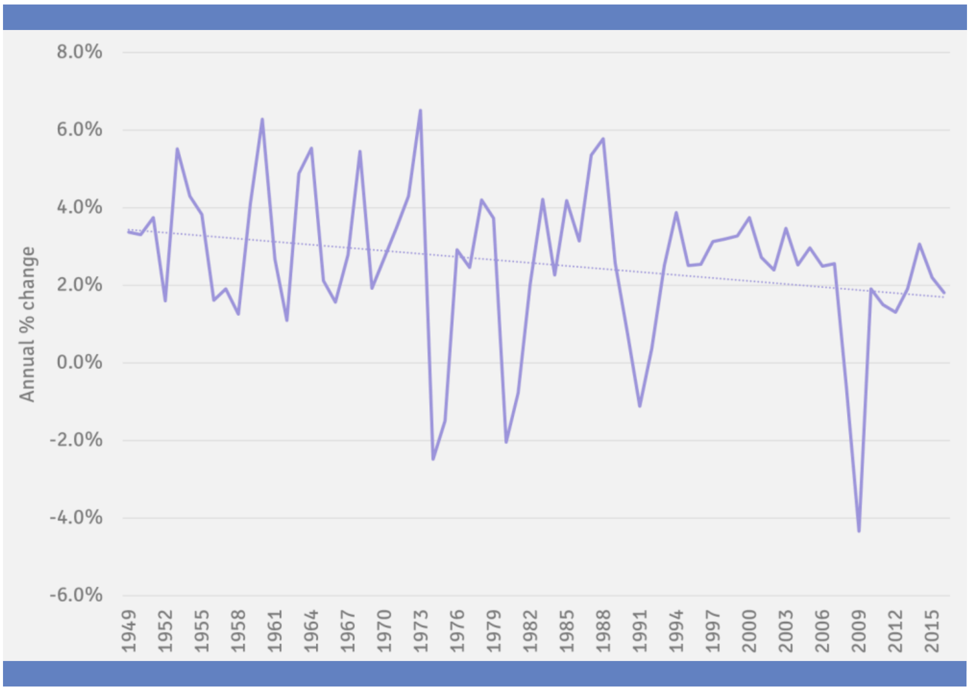
[18] *'Economic and fiscal outlook – November 2017 .' OBR (2017).*
[19] *https://www.ifs.org.uk/publications/7821*
[20] *'Benchmarking UK Competitiveness in the Global Economy.' BIS Economic Paper No. 19 (October 2012).*
[21] *'UK productivity performance will be sluggish, say economists.' The FT, January 1st 2018.*
[22] *'Productivity in the UK.' Daniel Harari. House of Commons Library (20 September 2017).*

Figure 26: Real GDP, UK, annual % change including long-run trend (1949 – 2016)



Source: ONS

The above chart clearly identifies 'peaks' and 'troughs' around the long-term average GDP growth rate – consistent with economic performance in the UK being cyclical. Indeed, various studies have identified distinct 'cycles' within the UK economy. For example, the Economic Cycle Research Institute (ECRI) has published the peak and trough dates for business cycles across 21 different countries, including the UK, since the 1970s. These are reported in the following table.

Table 32: ECRI UK business cycle peak and trough dates, 1948 - 2016

Business Cycle	Peak or trough	Dates
1974 – 1975	Peak	September 1974
	Trough	August 1975
1979 - 1981	Peak	June 1979
	Trough	May 1981
1990 - 1992	Peak	May 1990
	Trough	March 1992
2008 - 2010	Peak	May 2008
	Trough	January 2010

Source: 'Business Cycle Peak and Trough Dates, 21 Countries, 1948-2016.' ECRI (March 2017).

3.2.3 Implications for analysis of frontier shift

The cyclical nature of the UK's economy – coupled with its flatlining productivity performance since the financial crisis – has important implications for any analysis used to set expected 'frontier shift' efficiency in future. In our view, the key considerations are as follows:

- Firstly, to the extent that expected frontier shift must draw on historical data, **the time-period over which any such analysis is undertaken will clearly materially impact the conclusions one reaches.**

- Secondly, **determining 'which' time-period is appropriate thus turns on the purpose for which any forecast frontier shift analysis is being used.** Most obviously:

  - If the primary purpose is to inform frontier shift potential over the relative near-term (e.g. say the 5-year period of a price control) then one should most likely attach more weight to the recent past.
  - If, on the other hand, one wanted a view of longer-term frontier shift potential, so in turn, one should use longer-term historical data to inform that analysis.

3.3 EU KLEMS composite index analysis

In this section, we set out an analysis of TFP, as reported in the EU KLEMS data (a commonly used source by regulators in setting price determinations). Here, our methodology is as follows:

- **We identify sectors within EU KLEMS that we consider to be 'comparable'** to the relevant price control areas (reflecting our views on 'input mix' and 'activities' in particular).

- **We then develop a composite TFP index** for each price control area, based on weighting the individual comparators.

- **Finally, we estimate the scope for future frontier shift for each control area,** based on the historical trends implied by our indices. Here, and with reference to the previous discussion of business cycles, a range of time periods are tested.

3.3.1 The EU KLEMS data

The EU KLEMS is the most comprehensive data source relating to TFP estimates. It includes measures of TFP growth at both an overall economy level, as well as disaggregated down to individual sectors or industries by country (including within the UK). The most recent 2017 EU KLEMS databases retains the standard EU KLEMS structure of previous rounds. However, the number of years for which growth accounting data is available is slightly reduced. For example, whereas the 2011 EU KLEMS release allowed one to calculate TFP growth since the 1970s, the current release only goes back to 1998 for the UK.

The EU KLEMS database contains information on 34 industries and eight more aggregate categories. These are set out in the following table.

Table 33: EU KLEMS industries, based on NACE Rev.2 / ISIC Rev.4

No	Description	Code
Agg	**Total industries** (all industries excluding T and U)	**TOT**
Agg	**Market economy** (all industries excluding L, O, P, Q, T and U)	**MARKT**
1	Agriculture, forestry and fishing	A
2	Mining and quarrying	B
Agg	**Total manufacturing**	**C**
3	Food products, beverages and tobacco	10-12
4	Textiles, wearing apparel, leather and related products	13-15
5	Wood and paper products, printing and reproduction of recorded media	16-18
6	Coke and refined petroleum products	19
7	Chemicals and chemical products	20-21
8	Rubber and plastics product, other non-metallic mineral products	22-23
9	Basic metals and fabricated metal products, except machinery and equipment	24-25
10	Electrical and optical equipment	26-27
11	Machinery and equipment n.e.c.	28
12	Transport equipment	29-30
13	Other manufacturing; repair and installation of machinery and equipment	31-33
14	Electricity, gas and water supply	D-E
15	Construction	F
Agg	**Wholesale and retail trade; repair of motor vehicles and motorcycles**	**G**
16	Wholesale and retail trade and repair of motor vehicles and motorcycles	45
17	Wholesale trade, except of motor vehicles and motorcycles	46
18	Retail trade, except of motor vehicles and motorcycles	47
Agg	**Transportation and storage**	**H**
19	Transport and storage	49-52

No	Description	Code
20	Postal and courier activities	53
21	Accommodation and food service activities	I
Agg	**Information and communication**	**J**
22	Publishing, audio-visual and broadcasting activities	58-60
23	Telecommunications	61
24	IT and other information services	62-63
25	Financial and insurance activities	K
26	Real estate activities	L
27	Professional, scientific, technical, administrative and support service activities	M-N
Agg	**Community social and personal services** (O-U excluding T and U)	**O-U**
28	Public administration and defence; compulsory social security	O
29	Education	P
30	Health and social work	Q
Agg	**Arts, entertainment, recreation and other service activities**	**R-S**
31	Arts, entertainment and recreation	R
32	Other service activities	S
33	Activities of households as employers; undifferentiated goods and services producing activities of households for won use	T
34	Activities of extraterritorial organisations and bodies	U

Source: 'EU KLEMS Growth and Productivity Accounts 2017 Release, Statistical Module.' Kirsten Jaeger (2017).

3.3.2 Composite index assumptions

As frontier shift assumptions are required for each price control area, for opex we created a composite index, whereby we 'weighted' sectors within EU KLEMS based on our assessment of their comparability.

As explained previously, in considering what comparators are appropriate, a critical issue is the mix of labour and capital that are used as inputs to production. Consequently, we calculated an indicative range for the ratio of capex to the sum of capex and labour costs, by price control area for the industry – the results of which are shown below.

Table 34: Capex as a % of capex + labour costs

Price control area	Water resources	Water network plus	Wastewater network plus	Wastewater bioresources
Ratio of capex to capex plus labour	60% - 70%	80% - 90%	80% - 90%	80% - 90%

Source: Economic Insight analysis

As can be seen, in practice the mix of labour and capital is very similar for the network plus controls and bioresources. However, water resources is less capex intensive in relative terms. Given this, we consider that:

- the comparators included in our index for water network plus, wastewater network plus and bioresources should be the same; however
- it would be appropriate to use a somewhat different mix for water resources, drawing on sectors with lower capital intensity.

Following from the above, we used ONS data from the Annual Business Survey to calculate equivalent ratios by sector. We then 'ranked' these by relevance to the price control areas to help identify the most suitable comparators. We also took into account the similarity of the activities undertaken within the sectors. Following these steps, we arrived at the weightings set out in the table overleaf – which provided us with our composite TFP indices for opex. In the case of capex, we applied a 50/50 weighing to the construction and transport and storage sectors across all price control areas.

Table 35: Weightings used in composite EU KLEMS index – for use in opex

Sectors used for composite opex index and % weightings	Price control areas				
	Whole-sale Water resource	Whole-sale water network plus	Whole-sale waste-water network plus	Whole-sale waste-water bio-resources	Retail
Total industries (whole UK)	75%	75%	75%	75%	75%
Agriculture, forestry and fishing		12.5%	12.5%	12.5%	
Total manufacturing	12.5%				
Wholesale trade, except of motor vehicles and motorcycles	12.5%				
Real estate activities		12.5%	12.5%	12.5%	
Financial and insurance activities					12.5%
Retail trade, except of motor vehicles and motorcycles					12.5%

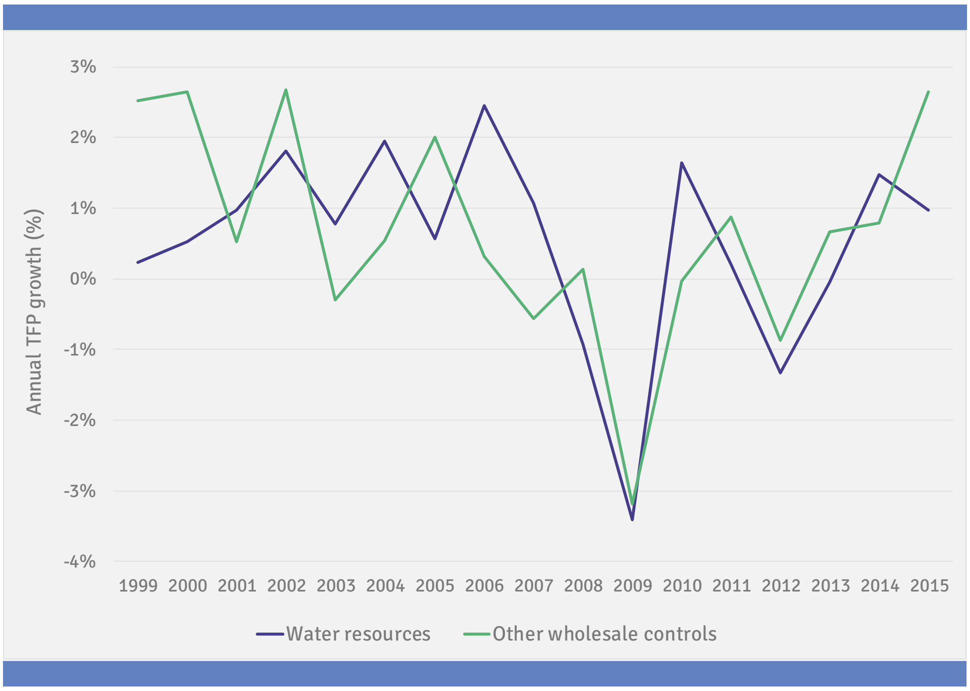
Source: Economic Insight analysis

It should be noted that, across all the control areas, we attach a 75% weight to the ‘whole UK’ index. This reflects:

- the subjectivity inherent in selecting comparators – and a desire not to make our results overly sensitive to the choices we made; and
- the fact that, whilst one can make arguments one way or another as to whether the water industry should either out or underperform relative to overall UK TFP, we consider that the wider economy’s productivity performance provides a sensible benchmark.

The chart below shows the historical TFP performance of our opex indices. As noted above, separate figures are shown for water resources and 'all other wholesale controls'.

Figure 27: Historical TFP performance – composite opex index



Source: Economic Insight analysis

3.4 Results

Based on the evidence set in the preceding sections, the following tables set out our forecasts for the scope for frontier shift efficiency savings over PR19. These are set out by price control area and by 'opex' and 'capex'.

We further present figures based on a 'central case'; a 'high case' and a 'low case'. In all cases, the makeup of the composite index for opex is the same. What varies is the time-period from which the data is drawn. Specifically:

- **Our central case is based on the last 16 years from 1999 to 2015.** We have chosen this period as our central estimate because it attaches an equal balance of weight to the 8-year period of low productivity growth since the financial crisis and the eight preceding years. As the EU KLEMS data does not contain a 'whole' business cycle (and because one cannot be certain when the next one will occur) we consider this to be a neutral and balanced interpretation of the data. Implicit in this assumption is that the UK's productivity will improve over PR19 relative to current performance.

- **Our high case is based on the period 1999 – 2008.** This includes the period of growth since the early 90s recession (albeit not the whole period), and the start of the 2007 recession. This is our high scenario, because it effectively 'ignores' the last decade of low productivity performance. As such, this scenario implicitly assumes that the UK quickly returns to its longer-term productivity growth trend. We consider this to be unlikely.

- **Our low case is based on the period 2007 to 2015.** Our low scenario assumes that the UK's productivity performance since 2007 persists in the near-term. Given the unusual length of the current 'flatlining' productivity performance, and the uncertainty arising from Brexit, we also consider this to be a plausible basis for forecasting frontier shift over PR19.

The following tables set out the results of our analysis, for each scenario above, by price control area. For business planning purposes, we consider that:

- In relation to capital related costs, Ofwat's data tables distinguish between infrastructure and non-infrastructure, capex and maintenance. In practice, we do not think it is meaningful to identify 'different' frontier shift estimates across these dimensions. As such, our frontier shift estimates for capex should be used.
- Similarly, we do not consider it appropriate to forecast any particular 'profile' of frontier shift by year. Rather, our analysis provides an indication of the 'average' amount of frontier shift productivity gain that can be achieved per annum. As such, we have reported a constant frontier shift numbers over PR19.

3.4.1 Central case frontier shift estimates

Table 36: scope for frontier shift efficiency savings **(central case)**

Year / price control area	Cost type	2020-21	2021-22	2022-23	2023-24	2024-25
Wholesale Water resources	Opex	0.53%	0.53%	0.53%	0.53%	0.53%
	Capex	0.28%	0.28%	0.28%	0.28%	0.28%
Wholesale water network plus	Opex	0.67%	0.67%	0.67%	0.67%	0.67%
	Capex	0.28%	0.28%	0.28%	0.28%	0.28%
Wholesale wastewater network plus	Opex	0.67%	0.67%	0.67%	0.67%	0.67%
	Capex	0.28%	0.28%	0.28%	0.28%	0.28%
Wholesale bioresources	Opex	0.67%	0.67%	0.67%	0.67%	0.67%
	Capex	0.28%	0.28%	0.28%	0.28%	0.28%
Retail	Opex	0.42%	0.42%	0.42%	0.42%	0.42%
	Capex	0.28%	0.28%	0.28%	0.28%	0.28%

Source: Economic Insight analysis

3.4.2 High case frontier shift estimates

Table 37: scope for frontier shift efficiency savings **(high case)**

Year / price control area	Cost type	2020-21	2021-22	2022-23	2023-24	2024-25
Wholesale Water resources	Opex	0.94%	0.94%	0.94%	0.94%	0.94%
	Capex	0.56%	0.56%	0.56%	0.56%	0.56%
Wholesale water network plus	Opex	1.05%	1.05%	1.05%	1.05%	1.05%
	Capex	0.56%	0.56%	0.56%	0.56%	0.56%
Wholesale wastewater network plus	Opex	1.05%	1.05%	1.05%	1.05%	1.05%
	Capex	0.56%	0.56%	0.56%	0.56%	0.56%
Wholesale bioresources	Opex	1.05%	1.05%	1.05%	1.05%	1.05%
	Capex	0.56%	0.56%	0.56%	0.56%	0.56%
Retail	Opex	1.10%	1.10%	1.10%	1.10%	1.10%
	Capex	0.56%	0.56%	0.56%	0.56%	0.56%

Source: Economic Insight analysis

3.4.3 Low case frontier shift estimates

Table 38: scope for frontier shift efficiency savings **(low case)**

Year / price control area	Cost type	2020-21	2021-22	2022-23	2023-24	2024-25
Wholesale Water resources	Opex	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%
	Capex	-0.31%	-0.31%	-0.31%	-0.31%	-0.31%
Wholesale water network plus	Opex	0.05%	0.05%	0.05%	0.05%	0.05%
	Capex	-0.31%	-0.31%	-0.31%	-0.31%	-0.31%
Wholesale wastewater network plus	Opex	0.05%	0.05%	0.05%	0.05%	0.05%
	Capex	-0.31%	-0.31%	-0.31%	-0.31%	-0.31%
Wholesale bioresources	Opex	0.05%	0.05%	0.05%	0.05%	0.05%
	Capex	-0.31%	-0.31%	-0.31%	-0.31%	-0.31%
Retail	Opex	-0.42%	-0.42%	-0.42%	-0.42%	-0.42%
	Capex	-0.31%	-0.31%	-0.31%	-0.31%	-0.31%

Source: Economic Insight analysis

3.5 Regulatory precedent

We recommend that Northumbrian base its efficiency assumptions relating to frontier shift on the analysis set out in the previous subsection. However, as a further source of evidence – and also as a 'cross check' - we have undertaken a review of regulatory precedent.

Here, and as noted above, a key issue is that care must be taken as to the interpretation of existing evidence and precedent. In particular, one must distinguish between:

- explicitly set assumptions regarding frontier shift for opex of capex (which are directly relevant);
- expectations for overall opex and capex productivity gains in regulated sectors (which may be indirectly relevant, if inferences relating to the frontier element can be drawn); and
- analysis of actual productivity gains achieved in industries (again, where the relevance of these will turn on whether frontier shift can be meaningfully inferred from the data).

In the following we summarise our review of the precedent of relevance.

3.5.1 Evidence relating to opex

The following table summarises recent regulatory decisions in relation to network companies' opex.

Table 39: Opex productivity assumptions (frontier shift) in other price control reviews

Regulator - price control	% reduction in opex per annum	What is being measured	Notes on adjustments
ORR – Network Rail, opex (CP4)[23]	0.2%	*Ongoing productivity improvements* ('frontier shift') that even the best performing companies would be expected to achieve, above that reflected in general inflation. Measured as *TFP (net of economy TFP)* based on Oxera (2007) study on the scope for CP4 efficiency improvement.	Lowered amount for maintenance and renewals (60%) of Oxera's estimate as a prudent value, to account for the possibility of double counting productivity improvements in the TFP estimates and in the input price estimates produced by LEK for Network Rail.
ORR – Network Rail, maintenance (CP4)[24]	0.7%		
Ofwat – water and sewerage (PR09)[25]	0.25%	*Continuing efficiency* - a continuing improvement factor linked to the improvement that can be expected from the leading or frontier companies.	N/A
CC - Bristol Water PR09[26]	0.9%	*Productivity improvement*	Marginally lower than the 1 per cent figure, which appeared to be the consensus view. This downward adjustment reflected the CC's view of the balance between two offsetting factors: (i) the scale of the industry capital investment programme, which at £22 billion was higher than in any other previous five-year period, presenting an opportunity for continuing efficiency improvements for the water sector; and (ii) the fact that some of the forecasts of productivity improvements reviewed were based in part on historic averages that incorporate the catch-up element of improvement in productivity which needs to be netted out from our estimate.
PPP Arbiter – underground infracos,	0.7%	unclear	unclear

[23] *'Periodic Review 2008: Determination of Network Rail's outputs and funding for 2009-14.' Office of Rail and Road (October 2008).*
[24] *'Periodic Review 2008: Determination of Network Rail's outputs and funding for 2009-14.' Office of Rail and Road (October 2008).*
[25] *'Future water and sewerage charges 2010-15: Final determinations.' Ofwat (2009)*
[26] *'Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991 Report.' Competition Commission (4 August 2010).*

Regulator - price control	% reduction in opex per annum	What is being measured	Notes on adjustments
central costs (2010)[27]			
PPP Arbiter – underground infracos, opex (2010)[28]	0.9%	unclear	unclear
UR – water and sewerage (PC13)[29]	0.9%	*Productivity improvement* measured by EU KLEMS TFP growth rates in comparator sectors.	Adjustments for capital substitution and catch-up efficiency cancel each other out.
Ofgem – electricity and gas transmission (T1)[30]	1.0%	The *ongoing efficiency assumption* is a measure of the *productivity improvements* that are expected to be made by the network companies over the price control period. EU KLEMS sector comparators on total factor productivity (TFP) measures and partial factor productivity (PFP) measures. Review of recent regulatory reports, including a report by Reckon commissioned by the ORR in May 2011.[31]	Excluded industries (namely, utilities) from EU KLEMS comparator set where systematic catch-up was expected, i.e. where the historic productivity improvements for these industries will reflect a material element of movement to the efficiency frontier (which Ofgem's comparative efficiency assessment addresses), as well as movement of the efficiency frontier (which is the element Ofgem needs to identify).
Ofgem – gas distribution (GD1)[32]	1.0%		
UR – gas distribution (GD14)[33]	1.0%	The move of the frontier – or frontier shift – describes the *efficiency gains* resulting from companies becoming more efficient over time, e.g. through technological progress. The frontier shift in real terms can be measured as follows: *input price inflation – forecast RPI (measured inflation) – productivity increase.*	This 1.0% is the estimated average annual productivity increase.
CC – NIE (RP5)[34]	1.0%	*Annual productivity growth* based on the following evidence: (i) review of regulatory precedent; (ii)	

27 *'Northern Ireland Electricity Limited price determination A reference under Article 15 of the Electricity (Northern Ireland) Order 1992 – Final Determination.' Competition Commission (26 March 2014) Table 11.1.*

28 *'Northern Ireland Electricity Limited price determination A reference under Article 15 of the Electricity (Northern Ireland) Order 1992 – Final Determination.' Competition Commission (26 March 2014) Table 11.1.*

29 *'PC13 Annex D The Rate of Frontier Shift Affecting Water Industry Costs.' First Economics (December 2012).*

30 *'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix.' Ofgem (17 December 2012).*

31 *'Productivity and unit cost change in UK regulated network industries and other UK sectors: initial analysis for Network Rail's periodic review.' Reckon (May 2011).*

32 *'RIIO-GD1: Final Proposals – Supporting document - Cost efficiency.' Ofgem (17 December 2012).*

33 *'GD14 Price Control for northern Ireland's Gas Distribution Networks for 2014-2016 Final Determination.' Utility Regulator (20 December 2013).*

34 *'Northern Ireland Electricity Limited price determination A reference under Article 15 of the Electricity (Northern Ireland) Order 1992 – Final Determination.' Competition Commission (26 March 2014).*

Regulator - price control	% reduction in opex per annum	What is being measured	Notes on adjustments
		EU KLEMS growth and productivity accounts based on comparator analysis; and (iii) recent business plans submitted by GB DNOs.	
Ofgem – electricity distribution (ED1)[35]	1.0% (midpoint of 0.8% and 1.1%)	*Ongoing efficiency assumption,* whereby even the most efficient DNO should make *productivity improvements* over the price control period, such as by employing new technologies. These improvements are captured by the ongoing efficiency assumption which represents the potential reduction in input volumes that can be achieved while delivering the same outputs.	
UR – water and sewerage (PC15)[36]	0.9%	*Productivity gains* which the frontier companies are expected to deliver over the price control period.	
CMA - Bristol Water PR14 (totex)[37]	1.0%	*Productivity improvements*	
UR – gas distribution (GD17)[38]	1.0% (midpoint of 0.5% and 1.5%)	*Productivity growth*: it is necessary to apply a productivity assumption to both opex and capex so as to take account of continuing efficiencies which the industry can achieve over the price control period. This is a base level of efficiency which even frontier companies would be expected to achieve as they continually improve their business over time (with new technologies and working practices for example).	
UR – electricity networks (RP6)[39]	1.0% (midpoint of	*Productivity assumption* applied to opex and capex so as to take account of continuing efficiencies	

35 *'RIIO-ED1: Final determinations for the slowtrack electricity distribution companies.' Ofgem (28 November 2014).*

36 *'Water & Sewerage Services Price Control 2015-21 Final Determination – Main Report.' Utility Regulator (December 2014).*

37 *'Bristol Water plc: A reference under section 12(3)(1) of the Water Industry Act 1991 Report.' Competition and Markets Authority (6 October 2015).*

38 *'Annex 6: Real Price Effects & Frontier Shift GD17 Final Determination.' Utility Regulator (15 September 2016).*

39 *'Annex C Frontier Shift: Real Price Effects & Productivity RP6 Final Determination.' Utility Regulator (30 June 2017).*

Regulator - price control	% reduction in opex per annum	What is being measured	Notes on adjustments
	0.5% and 1.5%)	which the industry can achieve over the price control period. This is a base level of efficiency which even frontier companies would be expected to achieve as they continually improve their business over time. For example with the use of new technologies, new working practices or other means to enable their businesses to run more efficiently.	

Source: various, see footnotes

In relation to the precedent set out in the above table, some key points to note include:

- The average frontier shift assumed by regulators across all the decisions relating to opex is 0.85%.
- There seems to be a general pattern of more recent decisions settling on figures of around 1.0% pa (i.e. consistent with the upper bound of our forecast). However, older decisions seem to include lower assumptions (for example, opex frontier shift as low as 0.2% pa has been assumed by regulators during the last decade).
- In hindsight, the decisions have systematically overshot the UK's actual delivered productivity performance. As even the UK's overall productivity performance (measured in TFP terms) may overestimate true 'frontier' shift, the overestimation of productivity potential by regulators may be even greater than this implies.

3.5.2 Evidence relating to capex

The following table illustrates recent regulatory decisions in relation to capex ongoing productivity.

Table 40: Capex productivity assumptions (frontier shift) in other price control reviews

Regulator - price control	% reduction in capex per annum	What is being measured	Notes on adjustments
ORR – Network Rail, renewals (CP4)[40]	0.7%	See previous table.	See previous table.
Ofwat – water and sewerage (PR09)[41]	0.4%	See previous table.	See previous table.
PPP Arbiter – underground infracos, central costs (2010)[42]	1.2%	unclear	unclear
Ofgem – electricity and gas transmission (T1)[43]	0.7%	See previous table.	See previous table.
Ofgem – gas distribution (GD1)[44]	0.7%	See previous table.	See previous table.
ORR – Network Rail, enhancements (CP5)[45]	0.4%	*Frontier shift*: on-going productivity improvements that even the best performing companies would expect to achieve above that reflected in general inflation. In other words, over time, even the best companies can get better at what they do.	Adopted an approach that assesses Network Rail's expenditure as a whole, rather than separating out elements of expenditure
UR – gas distribution (GD14)[46]	1.0%	See previous table.	See previous table.
CC – NIE (RP5)[47]	1.0%	See previous table.	See previous table.
Ofgem – electricity distribution (ED1)[48]	1.0% (midpoint of 0.8% and 1.1%)	See previous table.	See previous table.

[40] *'Periodic Review 2008: Determination of Network Rail's outputs and funding for 2009-14.' Office of Rail and Road (October 2008).*

[41] *'Future water and sewerage charges 2010-15: Final determinations.' Ofwat (2009)*

[42] *'Northern Ireland Electricity Limited price determination A reference under Article 15 of the Electricity (Northern Ireland) Order 1992 – Final Determination.' Competition Commission (26 March 2014) Table 11.1.*

[43] *'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix.' Ofgem (17 December 2012).*

[44] *'RIIO-GD1: Final Proposals – Supporting document - Cost efficiency.' Ofgem (17 December 2012).*

[45] *'Periodic Review 2013: Final determination of Network Rail's outputs and funding for 2014-19.' Office of Rail Regulation (October 2013).*

[46] *'GD14 Price Control for northern Ireland's Gas Distribution Networks for 2014-2016 Final Determination.' Utility Regulator (20 December 2013).*

[47] *'Northern Ireland Electricity Limited price determination A reference under Article 15 of the Electricity (Northern Ireland) Order 1992 – Final Determination.' Competition Commission (26 March 2014).*

[48] *'RIIO-ED1: Final determinations for the slowtrack electricity distribution companies.' Ofgem (28 November 2014).*

Regulator - price control	% reduction in capex per annum	What is being measured	Notes on adjustments
UR – water and sewerage (PC15)[49]	0.6%	See previous table.	See previous table.
CMA - Bristol Water PR14 (totex)[50]	1.0%	See previous table.	See previous table.
UR – gas distribution (GD17)[51]	1.0% (midpoint of 0.5% and 1.5%)	See previous table.	See previous table.
UR – electricity networks (RP6)[52]	1.0% (midpoint of 0.5% and 1.5%)	See previous table.	See previous table.

Source: various, see footnotes

The key points that follow from the two tables above are as follows:

- Most regulators consider the frontier shift assumptions as part of their real price effects analysis and coin it as '*ongoing efficiencies*', or *'productivity gains'* that even the most efficient firm could achieve.

- Some regulators consider some adjustments to their '*ongoing productivity*' estimates, such as adjustments for capital substitution and catch-up efficiency. However, most regulators, in their justification for their choice of productivity assumptions cite previous regulatory precedent and some form of TFP growth analysis of comparator sectors (which can include catch-up, as set out by some).

[49] *'Water & Sewerage Services Price Control 2015-21 Final Determination – Main Report.' Utility Regulator (December 2014).*

[50] *'Bristol Water plc: A reference under section 12(3)(1) of the Water Industry Act 1991 Report.' Competition and Markets Authority (6 October 2015).*

[51] *'Annex 6: Real Price Effects & Frontier Shift GD17 Final Determination.' Utility Regulator (15 September 2016).*

[52] *'Annex C Frontier Shift: Real Price Effects & Productivity RP6 Final Determination.' Utility Regulator (30 June 2017).*

Box 1: Productivity improvement since privatisation

Water UK commissioned Frontier Economics to quantify the productivity gains achieved by water and sewerage companies in England since privatisation in 1989.

Frontier Economics define the level of productivity as the ratio of the quantity of outputs produced to the quantity of inputs used in production. As such, important sources of productivity gains are **efficiency improvements**. However, these are not just related to 'frontier shifts', as they can originate from multiple sources, such as fewer resources needed as they are used more efficiently given the existing technology, technological change which reduces the efficient level of inputs required and / or improvements in the characteristics and quality of outputs produced and changes in the operating environment.

Their measure of total factor productivity (TFP) captures all the above, and as such it will be hard to disentangle the true 'frontier shift' from the 'catch-up' efficiencies of the water companies – which could also help explain the high productivity savings in the early years, as established by Frontier Economics.

Frontier Economics estimated that annual productivity growth has averaged 2.1% since privatisation, when adjusting for output quality. The range of annual productivity growth ranges from ca. 6% in 1997 to -1.5% in 2003 and 2016. Without an adjustment for output quality, average annual productivity growth amounted to 1% since privatisation. The following table sets out their overall results.

Table 41: Annual TFP growth estimates over price review periods

Period	TFP average growth (no quality adjustment)	TFP average growth (quality adjustment)
1994-1995	2.9%	3.5%
1996-2000	2.2%	4.5%
2001-2005	0.7%	2.0%
2006-2010	1.4%	2.2%
2011-2015	-0.5%	-0.2%
2016-2017	-0.2%	0.0%
1994-2008 (Business Cycle 1)	1.6%	3.2%
2009-2017 (Business Cycle 2)	-0.1%	0.1%
1994-2017	1.0%	2.1%

Source: 'Productivity improvement in the water and sewerage industry in England since Privatisation.' Frontier Economics (September 2017).

3.6 Conclusions on frontier shift

WE BELIEVE THAT MORE WEIGHT SHOULD BE PLACED ON OUR CENTRAL AND LOW ESTIMATES FOR FRONTIER SHIFT.

In conclusion, our key findings are as follows:

- Our composite index analysis implies frontier shift for opex of around 0.0% to 1.1% pa (with some variation by price control area). Similarly, for capex we find frontier shift potential to be between -0.3% to 0.6%.

- This is based on a careful consideration of comparators, consistent with the theory regarding drivers of TFP.

- Which assumptions Northumbrian should select depend on a number of considerations, including how challenging it wishes this element of its Plan to be. Objectively, however, **we think perhaps more weight should be placed on our central and low estimates, rather than our high estimates.** This is because:

  - Our low case is based on the nine most recent available years of data. Here, it is important to emphasise that the UK's overall productivity has flatlined since 2008 – and there are no immediate signs that this is likely to change near-term. As such, data over this period may, in fact, provide a very plausible indication of likely performance potential for PR19.
  - Our central case is based on the 16 most recently available years of data. As such, whilst still including the UK's recent low productivity performance, it also includes years prior to this. Thus, from a forecasting perspective, it implicitly includes some reversion to a longer-term average over PR19. This too, is plausible.
  - Our high case, however, omits all years after 2008 – and so ignores the current productivity slump. From a forecasting perspective, this is akin to assuming the UK will have fully returned to its long-term productivity position by PR19. This, in our view, seems unlikely.

- The Frontier Economics Report for Water UK is broadly consistent with our findings. Specifically, it found that long-term TFP in the sector has been between 1.0% and 2.0% pa (depending on the method). As the TFP measure will include the (substantial) catch-up inefficiency in the sector that has been reduced since privatisation, this **implies that frontier shift must be well below those numbers.**

4. Annex A: Reconciliation to Appointee Table 24

This annex provides more detail on how the results set out in the main report relate to Appointee Table 24.

We note that in Appointee Table 24, companies are required to provide % breakdowns of **totex** by price control area and cost category, as follows:

- labour;
- energy;
- chemicals;
- materials, plant and equipment; and
- other.

Consequently, to assist in ensuring internal consistency, the following table shows how the cost splits we have used in deriving our inflation forecasts translate to the required totex cost splits for Appointee Table 24. Here, the key points to note are as follows:

- We have assumed that all 'capex' costs fall into the "materials, plant and equipment" category. The percentage figures shown here therefore are based on the company's capex spend, as reported in its latest regulatory accounts, for the relevant price control area.

- The opex related percentages are based on the same absolute values used in our inflation forecasts, but are rebased over totex (again, as per the company's latest regulatory accounts).

- We have ensured that overall totex by price control is consistent with that reported in the company's latest regulatory accounts – and all percentage splits are therefore consistent with this.

- As Appointee Table 24 further requires the above percentage totex splits to be forecast over PR19, below we set out our projections for this, consistent with our inflation forecasts. Note, Northumbrian should not necessarily populate Table 24 with these figures. Instead, and as per our remarks regarding Table 24a in the introduction, should (i) firstly clarify with Ofwat how is envisages Tables 24 and 24a being derived; and then (ii) ensure that Table 24 is populated in a manner consistent with this. Specifically:

  » The splits shown below reflect our 'central case' inflation forecasts (which are set out in the relevant sections of chapter 2 of the main report). If Northumbrian were to apply different inflation assumptions, it would accordingly need to revise the projected cost splits over time.

  » Similarly, we have based these projections **solely** on the effect of input price inflation over time. In practice, Northumbrian's Plan may include changes in cost 'mix' over time (most obviously, relating to the timing of

capital spend over the Plan period, which could materially affect mix). As such, the numbers entered in Table 24 should reflect this.

Table 42: Projected percentage cost splits (totex) over PR19 by type of cost

Price control area	Cost type	2020-21	2021-22	2022-23	2023-24	2024-25
Water resources	Labour	9.64%	9.65%	9.65%	9.65%	9.63%
	Energy	11.03%	11.10%	11.16%	11.29%	11.56%
	Chemicals	0.73%	0.75%	0.76%	0.77%	0.78%
	Materials	15.03%	15.15%	15.27%	15.38%	15.47%
	Other	63.56%	63.35%	63.15%	62.91%	62.56%
	Total	100%	100%	100%	100%	100%
Water network plus	Labour	21.06%	21.00%	20.93%	20.84%	20.75%
	Energy	5.57%	5.58%	5.59%	5.63%	5.75%
	Chemicals	3.09%	3.12%	3.13%	3.16%	3.18%
	Materials	47.80%	47.99%	48.19%	48.37%	48.51%
	Other	22.47%	22.32%	22.16%	22.00%	21.82%
	Total	100%	100%	100%	100%	100%
Wastewater network plus	Labour	18.17%	18.09%	18.00%	17.89%	17.76%
	Energy	10.94%	10.97%	11.00%	11.09%	11.32%
	Chemicals	0.26%	0.26%	0.27%	0.27%	0.27%
	Materials	45.10%	45.32%	45.53%	45.72%	45.84%
	Other	25.52%	25.36%	25.20%	25.02%	24.81%
	Total	100%	100%	100%	100%	100%
Wastewater bioresources	Labour	66.89%	66.69%	66.48%	66.26%	66.00%
	Energy	2.93%	2.94%	2.96%	2.99%	3.06%
	Chemicals	6.09%	6.13%	6.16%	6.20%	6.23%
	Materials	24.08%	24.24%	24.40%	24.56%	24.71%
	Other	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	100%	100%	100%	100%	100%

Source: Economic Insight analysis

5. Annex B: econometrics

This annex provides more detail on our approach for forecasting the various input costs set out in the main report.

We have used econometric models to forecast the following input costs:

- staff cost inflation; and
- chemical cost inflation.

5.1 Labour cost econometrics

Overleaf, we provide more detail on the labour cost index, as well as on the econometrics used for the labour cost forecasting.

5.1.1 Labour cost index

Table 43: SOC codes used in Northumbrian Water's labour cost index - 2 digit

SOC	SOC 2010	SOC 2000	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bioresources
Corporate managers and directors	11	11	184	11.4	92.5	59.6	12.7
Other managers and proprietors	12	12	112	8.4	68.4	29	6.2
Science, research, engineering and technology professionals	21	21	376	25.7	208.4	116.5	24.9
Business, media and public service professionals	24	24	38	2.6	20.8	11.7	2.5
Science, engineering and technology associate professionals	31	31	103	7	57	32.1	6.9
Culture, media and sports occupations	34	34	12	0.8	6.5	3.7	0.8
Business and public service associate professionals	35	35	150	5.8	47.5	79.8	17
Administrative occupations	41	41	312	2	16.4	80	17.1
Secretarial and related occupations	42	42	69	0.4	3.6	53.9	11.5
Skilled metal, electrical and electronic trades	52	52	28	3	24.5	0.6	0.1
Customer service occupations	72	72	650	0.1	0.5	0.3	0.1
Process, plant and machine operatives	81	81	343	37.5	304.2	1	0.2
Elementary administration and service occupations	92	92	1	0.1	0.6	0.3	0.1

Source: Economic Insight

Table 44: SOC codes used in Northumbrian Water's labour cost index - 3 digit

SOC	SOC 2010	SOC 2000	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bioresources
Chief executives and senior officials	111	111	176	11.4	92.5	59.6	12.7
Managers and proprietors in other services	125	123	112	8.4	68.4	29	6.2
Engineering professionals	212	212	376	25.7	208.4	116.5	24.9
Business, research and administrative professionals	242	115	38	2.6	20.8	11.7	2.5
Science, engineering and production technicians	311	311	103	7	57	32.1	6.9
Design occupations	342	342	12	0.8	6.5	3.7	0.8
Business, finance and related associate professionals	353	353	150	5.8	47.5	79.8	17
Administrative occupations: Records	413	356	116	2	16.4	80	17.1
Secretarial and related occupations	421	421	69	0.4	3.6	53.9	11.5
Electrical and electronic trades	524	524	28	3	24.5	0.6	0.1
Customer service managers and supervisors	722	114	37	0.1	0.5	0.3	0.1
Plant and machine operatives	812	812	343	37.5	304.2	1	0.2
Elementary administration occupations	921	921	1	0.1	0.6	0.3	0.1
Customer service occupations	721	721	613	0	0	0	0
Managers and directors in retail and wholesale	119	116	8	0	0	0	0
Administrative occupations: Office managers and supervisors	416	415	196	0	0	0	0

Source: Economic Insight

5.1.2 Regressions in percentage changes

Our regressions in *percentage changes* had the following functional forms:

1) *Northumbrian Water nominal wage growth*$_t$ *= constant +* $\beta \cdot$ *UK nominal GDP growth*$_t$ $+ \varepsilon_t$
2) *Northumbrian Water nominal wage growth*$_t$ *= constant +* $\beta \cdot$ *UK nominal average wage growth*$_t$ $+ \varepsilon_t$

The tables below show the estimation results for these models.

Table 45: Econometric estimates of the relationship between Northumbrian Water labour cost index and **nominal GDP** (percentage changes) – 2 digit SOC

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Constant	0.0030	0.0000	-0.0001	0.0002	0.0002
Standard error	0.0066	0.0067	0.0067	0.0073	0.0073
P-value	0.6512	0.9950	0.9941	0.9753	0.9742
Nominal GDP	0.3928	0.4900	0.4899	0.4252	0.4250
Standard error	0.1535	0.1575	0.1576	0.1717	0.1716
P-value	0.0250	0.0090	0.0091	0.0292	0.0292
R-squared	35%	45%	45%	34%	34%
F statistic	6.5483	9.6746	9.6601	6.1303	6.1303

Source: Economic Insight

Table 46: Econometric estimates of the relationship between Northumbrian Water labour cost index and **nominal GDP** (percentage changes) – 3 digit SOC

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Constant	-0.0080	-0.0118	-0.0118	-0.0146	-0.0146
Standard error	0.0129	0.0160	0.0160	0.0161	0.0160
P-value	0.5466	0.4770	0.4764	0.3798	0.3800
Nominal GDP	0.6849	0.8250	0.8248	0.8124	0.8116
Standard error	0.3008	0.3752	0.3749	0.3759	0.3753
P-value	0.0419	0.0482	0.0481	0.0516	0.0515
R-squared	30%	29%	29%	28%	28%
F statistic	5.1825	4.8353	4.8409	4.6705	4.6768

Source: Economic Insight

Table 47: Econometric estimates of the relationship between Northumbrian Water labour cost index and **average UK wages** (percentage changes) – 2 digit SOC

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Constant	-0.0090	-0.0115	-0.0115	-0.0129	-0.0129
Standard error	0.0048	0.0053	0.0053	0.0056	0.0056
P-value	0.0818	0.0491	0.0488	0.0394	0.0394
Average wages	1.0288	1.1437	1.1440	1.1155	1.1151
Standard error	0.1672	0.1843	0.1843	0.1960	0.1957
P-value	0.0000	0.0000	0.0000	0.0001	0.0001
R-squared	76%	76%	76%	73%	73%
F statistic	37.8639	38.5253	38.5176	32.4084	32.4592

Source: Economic Insight

Table 48: Econometric estimates of the relationship between Northumbrian Water labour cost index and **average UK wages** (percentage changes) – 3 digit SOC

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Constant	-0.0173	-0.0216	-0.0216	-0.0217	-0.0217
Standard error	0.0146	0.0186	0.0186	0.0192	0.0192
P-value	0.2611	0.2688	0.2678	0.2791	0.2790
Average wages	1.3398	1.5612	1.5616	1.4388	1.4377
Standard error	0.5135	0.6531	0.6524	0.6734	0.6722
P-value	0.0228	0.0341	0.0339	0.0539	0.0537
R-squared	36%	32%	32%	28%	28%
F statistic	6.8075	5.7135	5.7292	4.5656	4.5746

Source: Economic Insight

5.1.3 Regressions in levels

The regressions in levels had the following functional forms:

1) $\textit{Northumbrian Water labour cost index}_t = \textit{constant} + \beta \cdot \textit{UK nominal GDP index}_t + \gamma \cdot \textit{Northumbrian Water labour cost index}_{t-1} + \varepsilon_t$

2) $\textit{Northumbrian Water labour cost index}_t = \textit{constant} + \beta \cdot \textit{UK average wage index}_t + \gamma \cdot \textit{Northumbrian Water labour cost index}_{t-1} + \varepsilon_t$

The tables below show estimation results for these models.

Table 49: Econometric estimates of the relationship between Northumbrian Water labour cost index and **nominal GDP** (levels) – 2 digit SOC

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Constant	19.4533	21.9088	21.9157	20.6713	20.6739
Standard error	6.1782	6.6254	6.6332	7.6123	7.6084
P-value	0.0093	0.0070	0.0070	0.0201	0.0200
Nominal GDP	0.0975	0.0788	0.0787	0.0569	0.0570
Standard error	0.0546	0.0587	0.0588	0.0583	0.0583
P-value	0.1018	0.2071	0.2076	0.3503	0.3491
Lag	0.7338	0.7388	0.7388	0.7689	0.7687
Standard error	0.1084	0.1151	0.1152	0.1242	0.1241
P-value	0.0000	0.0000	0.0000	0.0001	0.0001
R-squared	98%	98%	98%	97%	97%
F statistic	283.0416	238.3377	237.7501	173.0509	173.2902

Source: Economic Insight

Table 50: Econometric estimates of the relationship between Northumbrian Water labour cost index and **nominal GDP** (levels) – 3 digit SOC

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Constant	28.6578	33.1844	33.1684	35.6849	35.6469
Standard error	11.9090	13.0208	13.0193	15.2167	15.2023
P-value	0.0348	0.0271	0.0271	0.0388	0.0388
Nominal GDP	0.1073	0.1197	0.1193	0.0865	0.0864
Standard error	0.1071	0.1252	0.1250	0.1142	0.1141
P-value	0.3379	0.3597	0.3607	0.4648	0.4649
Lag	0.6482	0.6046	0.6052	0.6090	0.6095
Standard error	0.2036	0.2210	0.2209	0.2342	0.2340
P-value	0.0087	0.0194	0.0192	0.0247	0.0245
R-squared	91%	88%	88%	83%	83%
F statistic	56.9286	39.0578	39.0644	27.1784	27.2799

Source: Economic Insight

Table 51: Econometric estimates of the relationship between Northumbrian Water labour cost index and **average UK wages** (levels) – 2 digit SOC

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Constant	18.9875	20.3583	20.3688	19.9555	19.9578
Standard error	6.1876	6.4293	6.4380	7.6529	7.6512
P-value	0.0107	0.0090	0.0090	0.0244	0.0243
Average wages	0.2424	0.1592	0.1590	0.1144	0.1146
Standard error	0.1433	0.1443	0.1443	0.1362	0.1362
P-value	0.1187	0.2936	0.2941	0.4188	0.4177
Lag	0.5917	0.6745	0.6746	0.7187	0.7185
Standard error	0.1948	0.1937	0.1938	0.1989	0.1988
P-value	0.0113	0.0051	0.0051	0.0041	0.0041
R-squared	98%	98%	98%	97%	97%
F statistic	276.4701	227.2730	226.7473	169.3779	169.5890

Source: Economic Insight

Table 52: Econometric estimates of the relationship between Northumbrian Water labour cost index and **average UK wages** (levels) – 3 digit SOC

	Company	Water resources	Water network plus	Wastewater network plus	Wastewater bio-resources
Constant	27.6594	30.1510	30.1529	34.5344	34.5043
Standard error	10.3038	11.0533	11.0554	13.4823	13.4695
P-value	0.0212	0.0197	0.0197	0.0265	0.0264
Average wages	0.2837	0.2879	0.2869	0.1945	0.1944
Standard error	0.2176	0.2304	0.2302	0.2036	0.2036
P-value	0.2189	0.2374	0.2386	0.3599	0.3600
Lag	0.4805	0.4669	0.4679	0.5126	0.5130
Standard error	0.2834	0.2788	0.2787	0.2862	0.2862
P-value	0.1180	0.1222	0.1213	0.1008	0.1006
R-squared	92%	88%	88%	84%	84%
F statistic	60.5502	41.4794	41.4725	28.1364	28.2409

Source: Economic Insight

5.2 Chemical cost econometrics

Below, we provide more detail on the econometrics used for the chemical cost forecasting.

5.2.1 Regressions in percentage changes

We estimated the following set of regressions in **percentage changes**.

(a) $\%\Delta\, chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\, nominal\ GDP_{t-1} + \beta_2 \cdot \%\Delta\, oil\ price_t + \beta_3 \cdot \%\Delta\, oil\ price_{t-1} + \beta_3 \cdot 2008\ year\ dummy + \varepsilon_t$

(b) $\%\Delta\, chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\, nominal\ GDP_t + \varepsilon_t$

(c) $\%\Delta\, chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\, oil\ price_t + \varepsilon_t$

(d) $\%\Delta\, chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\, construction_t + \varepsilon_t$

(e) $\%\Delta\, chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\, nominal\ GDP_t + \beta_2 \cdot \%\Delta\, oil\ price_t + \varepsilon_t$

(f) $\%\Delta\, chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\, oil\ price_t + \beta_2 \cdot \%\Delta\, construction_t + \varepsilon_t$

(g) $\%\Delta\, chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\, nominal\ GDP_t + \beta_2 \cdot \%\Delta\, oil\ price_t + \beta_3 \cdot \%\Delta\, construction_t + \varepsilon_t$

The table overleaf presents our preferred regressions, which we used in econometric forecasting.

Table 53: Preferred regressions

	Whole company	Water network plus	Wastewater network plus	Wastewater bioresources
Constant	-0.1076	-0.1058	-0.1072	-0.1229
Standard error	0.0304	0.0318	0.0286	0.0431
P-value	0.0046	0.0067	0.0032	0.0158
GDP lag	3.9521	4.0995	3.9398	4.4516
Standard error	0.8576	0.8957	0.8060	1.2167
P-value	0.0008	0.0008	0.0005	0.0038
Oil price	0.0864	0.0650	0.0864	0.0901
Standard error	0.0471	0.0492	0.0443	0.0669
P-value	0.0940	0.2136	0.0771	0.2047
Oil price lag	-0.6067	-0.6537	-0.6086	-0.6622
Standard error	0.2276	0.2377	0.2139	0.3229
P-value	0.0220	0.0189	0.0159	0.0649
Dummy	0.1632	0.1732	0.1707	0.1521
Standard error	0.0461	0.0482	0.0434	0.0655
P-value	0.0047	0.0042	0.0023	0.0403
R-squared	86%	85%	87%	77%
F statistic	16.5276	15.1899	19.1936	9.1568

Source: Economic Insight

The following tables set out the remaining regression results.

Table 54: Regressions in percentage changes for whole company

	Whole company					
Constant	0.0273	0.0374	0.0517	0.0774	0.0386	0.1680
Standard error	0.0525	0.0209	0.0258	0.0480	0.0228	0.0782
P-value	0.6116	0.0944	0.0648	0.1309	0.1148	0.0528
GDP	0.5983			-1.1352		-4.2914
Standard error	1.2309			1.2265		2.4954
P-value	0.6344			0.3716		0.1111
Oil price		0.2055		0.2537	0.2049	0.3978
Standard error		0.0811		0.0968	0.0841	0.1368
P-value		0.0239		0.0211	0.0300	0.0132
Construction			-0.0689		-0.0423	0.7555
Standard error			0.3100		0.2668	0.5264
P-value			0.8273		0.8766	0.1768
R-squared	2%	31%	0%	36%	32%	45%
F statistic	0.2363	6.4199	0.0494	3.6054	2.9990	3.2862

Source: Economic Insight

Table 55: Regressions in percentage changes for water resources

	Water resources					
Constant	0.0432	0.0441	0.0589	0.0925	0.0467	0.1783
Standard error	0.0532	0.0217	0.0259	0.0494	0.0237	0.0815
P-value	0.4304	0.0619	0.0394	0.0838	0.0703	0.0492
GDP	0.3296			-1.3752		-4.3655
Standard error	1.2475			1.2621		2.6011
P-value	0.7955			0.2957		0.1191
Oil price		0.1911		0.2495	0.1898	0.3860
Standard error		0.0844		0.0996	0.0873	0.1426
P-value		0.0401		0.0263	0.0487	0.0191
Construction			-0.1205		-0.0958	0.7157
Standard error			0.3113		0.2768	0.5487
P-value			0.7046		0.7349	0.2165
R-squared	0%	27%	1%	33%	27%	41%
F statistic	0.0698	5.1202	0.1498	3.1880	2.4589	2.8073

Source: Economic Insight

Table 56: Regressions in percentage changes for water network plus

	Water network plus					
Constant	0.0275	0.0377	0.0522	0.0782	0.0390	0.1672
Standard error	0.0526	0.0208	0.0259	0.0479	0.0228	0.0782
P-value	0.6096	0.0923	0.0630	0.1265	0.1111	0.0538
GDP	0.6019			-1.1518		-4.2544
Standard error	1.2342			1.2239		2.4964
P-value	0.6333			0.3638		0.1141
Oil price		0.2077		0.2567	0.2071	0.3983
Standard error		0.0810		0.0966	0.0840	0.1369
P-value		0.0225		0.0197	0.0284	0.0131
Construction			-0.0752		-0.0482	0.7426
Standard error			0.3108		0.2665	0.5266
P-value			0.8124		0.8591	0.1839
R-squared	2%	32%	0%	36%	32%	45%
F statistic	0.2378	6.5757	0.0585	3.7039	3.0771	3.3200

Source: Economic Insight

Table 57: Regressions in percentage changes for wastewater network plus

	Wastewater network plus					
Constant	0.0287	0.0397	0.0538	0.0807	0.0401	0.1881
Standard error	0.0586	0.0240	0.0288	0.0555	0.0262	0.0899
P-value	0.6320	0.1199	0.0830	0.1699	0.1503	0.0584
GDP	0.6331			-1.1633		-4.9104
Standard error	1.3736			1.4176		2.8705
P-value	0.6519			0.4267		0.1129
Oil price		0.2135		0.2630	0.2133	0.4339
Standard error		0.0931		0.1119	0.0967	0.1574
P-value		0.0379		0.0352	0.0460	0.0174
Construction			-0.0437		-0.0159	0.8969
Standard error			0.3461		0.3066	0.6055
P-value			0.9014		0.9594	0.1643
R-squared	1%	27%	0%	31%	27%	42%
F statistic	0.2124	5.2571	0.0159	2.9039	2.4426	2.8451

Source: Economic Insight

Table 58: Regressions in percentage changes for wastewater bioresources

	Wastewater bioresources					
Constant	0.0171	0.0314	0.0430	0.0620	0.0308	0.1593
Standard error	0.0517	0.0211	0.0255	0.0494	0.0232	0.0797
P-value	0.7461	0.1604	0.1138	0.2309	0.2061	0.0688
GDP	0.6831			-0.8710		-4.2621
Standard error	1.2115			1.2604		2.5437
P-value	0.5818			0.5017		0.1197
Oil price		0.1904		0.2275	0.1907	0.3822
Standard error		0.0822		0.0994	0.0853	0.1395
P-value		0.0361		0.0396	0.0436	0.0179
Construction			-0.0054		0.0194	0.8117
Standard error			0.3066		0.2706	0.5365
P-value			0.9862		0.9440	0.1562
R-squared	2%	28%	0%	30%	28%	41%
F statistic	0.3179	5.3699	0.0003	2.8236	2.4967	2.8317

Source: Economic Insight

5.2.2 Regressions in levels

We estimated the following set of regressions in **levels**.

(h) $chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot nominal\ GDP_t + \beta_2 \cdot chemical\ cost\ index_{t-1} + \varepsilon_t$

(i) $\%\Delta\ chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\ oil\ price_t + \beta_2 \cdot chemical\ cost\ index_{t-1} + \varepsilon_t$

(j) $\%\Delta\ chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\ construction_t + \beta_2 \cdot chemical\ cost\ index_{t-1} + \varepsilon_t$

(k) $\%\Delta\ chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\ nominal\ GDP_t + \beta_2 \cdot \%\Delta\ oil\ price_t + \beta_3 \cdot chemical\ cost\ index_{t-1} + \varepsilon_t$

(l) $\%\Delta\ chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\ oil\ price_t + \beta_2 \cdot \%\Delta\ construction_t + \beta_3 \cdot chemical\ cost\ index_{t-1} + \varepsilon_t$

(m) $\%\Delta\ chemical\ cost\ index_t = \beta_0 + \beta_1 \cdot \%\Delta\ nominal\ GDP_t + \beta_2 \cdot \%\Delta\ oil\ price_t + \beta_3 \cdot \%\Delta\ construction_t + \beta_4 \cdot chemical\ cost\ index_{t-1} + \varepsilon_t$

The tables below present the results for these regressions, which we used in econometric forecasting.

Table 59: Regressions in levels for whole company

	Whole company					
Constant	14.3763	27.7461	27.7461	5.3132	-1.3232	-1.6882
Standard error	30.3245	10.6680	10.6680	22.9545	24.5287	25.8545
P-value	0.6433	0.0220	0.0220	0.8209	0.9579	0.9491
Lag	0.8275	0.7016	0.7016	0.5543	0.7004	0.6767
Standard error	0.1794	0.0847	0.0847	0.1579	0.0825	0.2477
P-value	0.0005	0.0000	0.0000	0.0043	0.0000	0.0195
GDP	0.1550			0.3244		0.0526
Standard error	0.3860			0.2945		0.5143
P-value	0.6945			0.2924		0.9203
Oil price		0.1310		0.1390	0.1362	0.1369
Standard error		0.0416		0.0419	0.0407	0.0430
P-value		0.0077		0.0061	0.0058	0.0087
Construction			0.1310		0.2327	0.2065
Standard error			0.0416		0.1779	0.3163
P-value			0.0077		0.2153	0.5274
R-squared	91%	95%	95%	95%	95%	95%
F statistic	65.1377	118.2765	118.2765	80.5461	83.7367	57.6264

Source: Economic Insight

Table 60: Regressions in levels for water resources

	Water resources					
Constant	8.0553	23.8134	1.1845	-4.0495	-6.3558	-7.4021
Standard error	34.0664	10.5970	33.8771	26.4617	26.1686	28.1882
P-value	0.8168	0.0426	0.9726	0.8809	0.8122	0.7977
Lag	0.8259	0.7430	0.9125	0.5941	0.7431	0.7040
Standard error	0.1723	0.7430	0.0719	0.1513	0.0770	0.2737
P-value	0.0004	0.3356	0.0000	0.0020	0.0000	0.0259
GDP	0.2189			0.3731		0.0979
Standard error	0.4186			0.3254		0.6554
P-value	0.6098			0.2739		0.8839
Oil price		0.1304		0.1379	0.1354	0.1363
Standard error		0.0436		0.0436	0.1354	0.0452
P-value		0.0104		0.0082	0.3370	0.0117
Construction			0.1851		0.2405	0.1905
Standard error			0.1851		0.1915	0.3895
P-value			0.3356		0.2331	0.6343
R-squared	92%	95%	93%	96%	96%	96%
F statistic	78.8993	134.6462	80.7245	72.3518	94.2717	64.9489

Source: Economic Insight

Table 61: Regressions in levels for water network plus

	Water network plus					
Constant	12.3556	27.0742	2.5867	3.3567	-2.5191	-3.0756
Standard error	30.8053	10.6527	33.0513	23.1642	24.6608	26.0012
P-value	0.6949	0.0246	0.9388	0.8872	0.9203	0.9080
Lag	0.8197	0.7040	0.8991	0.5521	0.7032	0.6685
Standard error	0.1799	0.0841	0.0776	0.1562	0.0818	0.2485
P-value	0.0005	0.0000	0.0000	0.0041	0.0000	0.0210
GDP	0.1792			0.3395		0.0780
Standard error	0.3903			0.2954		0.5235
P-value	0.6538			0.2728		0.8843
Oil price		0.1324		0.1401	0.1376	0.1385
Standard error		0.0416		0.0417	0.0407	0.0429
P-value		0.0072		0.0057	0.0054	0.0080
Construction			0.1782		0.2366	0.1975
Standard error			0.2391		0.1789	0.3221
P-value			0.4694		0.2107	0.5522
R-squared	91%	95%	91%	95%	95%	95%
F statistic	65.2794	119.0627	67.1514	81.7753	84.5284	58.2361

Source: Economic Insight

Table 62: Regressions in levels for wastewater network plus

	Wastewater network plus					
Constant	21.5685	28.9116	3.0875	9.5997	0.4200	0.4716
Standard error	35.9268	11.9898	38.4270	26.7537	28.3738	30.1069
P-value	0.5586	0.0314	0.9372	0.7260	0.9884	0.9878
Lag	0.9049	0.7055	0.9384	0.5513	0.6787	0.6809
Standard error	0.2098	0.7055	0.0902	0.1704	0.0915	0.2504
P-value	0.0008	0.3356	0.0000	0.0072	0.0000	0.0199
GDP	0.0681			0.3014		-0.0053
Standard error	0.4552			0.3333		0.5452
P-value	0.8833			0.3836		0.9924
Oil price		0.1586		0.1536	0.1501	0.1500
Standard error		0.0469		0.0504	0.1501	0.0516
P-value		0.0049		0.0101	0.3370	0.0143
Construction			0.1855		0.2465	0.2492
Standard error			0.1855		0.2067	0.3461
P-value			0.3356		0.2561	0.4866
R-squared	89%	94%	89%	94%	95%	95%
F statistic	52.2165	103.7816	54.1221	66.4471	69.7663	47.9648

Source: Economic Insight

Table 63: Regressions in levels for wastewater bioresources

	Wastewater bioresources					
Constant	26.6544	34.8794	10.5796	23.2583	11.0532	11.1177
Standard error	24.2583	11.3466	29.5326	19.2686	23.0129	24.0302
P-value	0.2918	0.0089	0.7259	0.2507	0.6396	0.6526
Lag	0.8675	0.6579	0.8723	0.5431	0.6517	0.6755
Standard error	0.1826	0.0975	0.0820	0.1819	0.0962	0.2395
P-value	0.0004	0.0000	0.0000	0.0114	0.0000	0.0167
GDP	0.0034			0.2025		-0.0431
Standard error	0.3282			0.2689		0.3937
P-value	0.9918			0.4659		0.9147
Oil price		0.1158		0.1238	0.1218	0.1207
Standard error		0.0400		0.0420	0.0397	0.0426
P-value		0.0125		0.0122	0.0098	0.0163
Construction			0.1308		0.1947	0.2144
Standard error			0.2093		0.1644	0.2485
P-value			0.5428		0.2592	0.4068
R-squared	89%	94%	90%	94%	94%	94%
F statistic	54.7627	94.3043	56.6024	60.9655	65.2845	44.9351

Source: Economic Insight

6. Annex C: forecasts

This annex provides more detail on the independent forecasts used in the main report, as well as setting out the overall forecast results.

6.1 Independent forecasts

6.1.1 OBR

The following table illustrates the forecasts of economic fundamentals on which some of our econometric forecasts were based.

Table 64: OBR forecasts

	2016/ 17	2017/ 18	2018/ 19	2019/ 20	2020/ 21	2021/ 22	2022/ 23
Nominal GDP	4.16%	3.13%	2.80%	2.73%	3.07%	3.36%	3.35%
CPI growth	1.11%	3.00%	2.18%	1.82%	2.00%	2.00%	2.00%
Average earnings	2.94%	2.28%	2.17%	2.44%	2.69%	3.11%	3.07%

Source: OBR November 2017 forecast, note that 2016/17 is outturn data.

6.1.2 BEIS

The following table sets out the different fuels' inflation, based on BEIS's reference, low and high prices and low and high growth scenarios.

Table 65: BEIS forecasts for retail prices for industrial users

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Reference scenario										
Electricity (p/kWh)	-12.4%	6.7%	12.6%	1.8%	2.9%	12.6%	-1.9%	2.9%	3.2%	5.8%
Natural gas (p/kWh)	-34.0%	9.2%	0.5%	4.5%	4.0%	9.9%	9.0%	8.3%	7.7%	7.1%
Petroleum products (p/kWh)	-29.3%	10.7%	4.4%	3.1%	4.3%	4.1%	2.6%	3.7%	3.5%	3.4%
Low prices										
Electricity (p/kWh)	-16.2%	3.3%	15.4%	-0.1%	3.5%	14.2%	-4.0%	5.7%	0.2%	5.6%
Natural gas (p/kWh)	-45.1%	1.0%	0.7%	5.8%	5.1%	6.6%	8.9%	5.7%	7.8%	5.1%
Petroleum products (p/kWh)	-38.0%	-12.4%	4.3%	6.4%	4.2%	5.7%	3.6%	5.0%	3.3%	4.6%
High prices										
Electricity (p/kWh)	-6.4%	10.3%	9.3%	5.8%	4.0%	9.9%	-1.6%	0.5%	2.9%	1.9%
Natural gas (p/kWh)	-19.3%	16.7%	4.3%	7.1%	6.4%	5.3%	6.6%	4.7%	4.5%	4.4%
Petroleum products (p/kWh)	-14.0%	12.6%	5.8%	4.6%	4.4%	5.1%	3.9%	4.6%	3.6%	4.3%
Low growth										
Electricity (p/kWh)	-12.3%	6.8%	8.0%	6.0%	2.9%	12.0%	-1.6%	2.6%	3.5%	6.5%
Natural gas (p/kWh)	-34.0%	9.2%	0.5%	4.5%	4.0%	9.9%	9.0%	8.3%	7.7%	7.1%
Petroleum products (p/kWh)	-29.3%	10.7%	4.4%	3.1%	4.3%	4.1%	2.6%	3.7%	3.5%	3.4%
High growth										
Electricity (p/kWh)	-12.7%	7.2%	12.0%	2.2%	2.7%	12.6%	-1.8%	2.5%	2.8%	7.8%
Natural gas (p/kWh)	-34.0%	9.2%	0.5%	4.5%	4.0%	9.9%	9.0%	8.3%	7.7%	7.1%
Petroleum products (p/kWh)	-29.3%	10.7%	4.4%	3.1%	4.3%	4.1%	2.6%	3.7%	3.5%	3.4%

Source: BEIS 2016 Updated Energy & Emissions Projections

6.1.3 World Bank

For certain commodities, we used forecasts from the World Bank, as illustrated in the following table.

Table 66: World Bank forecasts

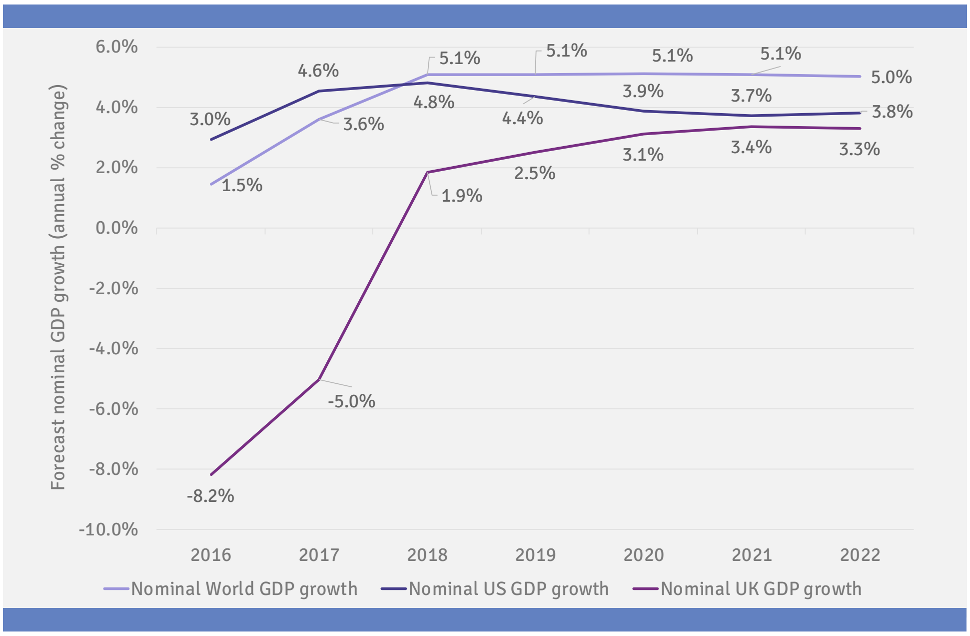
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Oil price ($/barrel)	-15.6%	23.8%	5.7%	5.4%	1.7%	1.6%	1.6%	1.6%	1.6%	1.6%
Diammonium phosphate	-24.74%	0.48%	-0.58%	2.24%	2.24%	2.24%	2.24%	2.24%	2.24%	2.24%
Phosphate rock	-4.51%	-18.87%	-1.10%	2.78%	2.78%	2.78%	2.78%	2.78%	2.78%	2.78%
Potassium chloride	-18.93%	-12.05%	-0.46%	3.37%	3.37%	3.37%	3.37%	3.37%	3.37%	3.37%
Triple Superphosphate	-24.55%	-4.65%	1.08%	2.58%	2.58%	2.58%	2.58%	2.58%	2.58%	2.58%
Urea, E. Europe, bulk	-26.99%	8.41%	-0.46%	2.82%	2.82%	2.82%	2.82%	2.82%	2.82%	2.82%

Source: World Bank Commodities Price Forecast (nominal US dollars), released 26 October 2017, note 2016 is outturn data.

6.1.4 IMF

For some models, we have used US data, as such the forecasts that we used were from the IMF, as illustrated in the following figure.

Figure 28: IMF forecasts



Source: IMF

6.1.5 BNP Paribas

We have based future exchanges on BNP Paribas forecasts to 2018, with expected exchange rates held constant from this point.

Table 67: BNP Paribas forecast pound-dollar exchange rate

	2016	2017	2018
Expected £/$ exchange rate	1.24	1.30	1.29

Source: BNP Paribas

6.2 Labour cost inflation forecasts

The following tables set out the full results for labour cost inflation, based on all of the methodologies set out in the main report.

Table 68: Northumbrian Water labour cost inflation forecasts, 2020/21 - 2024/25 – 2 digit SOC codes

Methodology	Wage inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
Company							
Economy-based	GDP econometrics – levels	1.22%	1.36%	1.38%	1.40%	1.43%	1.36%
	GDP econometrics – changes	1.51%	1.62%	1.62%	1.62%	1.62%	1.60%
	Wage econometrics – levels	1.66%	1.94%	1.94%	1.96%	1.98%	1.89%
	Wage econometrics – changes	1.87%	2.29%	2.25%	2.25%	2.25%	2.18%
	Wedge to UK wages inflation	1.86%	2.28%	2.24%	2.24%	2.24%	2.17%
	Wedge to CPI inflation	1.57%	1.57%	1.57%	1.57%	1.57%	1.57%
Extrapolation	Whole period trend	1.77%	1.77%	1.77%	1.77%	1.77%	1.77%
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
Water resources							
Economy-based	GDP econometrics – levels	1.01%	1.13%	1.15%	1.17%	1.20%	1.13%
	GDP econometrics – changes	1.50%	1.64%	1.64%	1.64%	1.64%	1.61%
	Wage econometrics – levels	1.38%	1.61%	1.62%	1.64%	1.67%	1.59%
	Wage econometrics – changes	1.93%	2.40%	2.36%	2.36%	2.36%	2.28%
	Wedge to UK wages inflation	1.92%	2.33%	2.29%	2.29%	2.29%	2.23%

Methodology	Wage inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
	Wedge to CPI inflation	1.63%	1.62%	1.62%	1.62%	1.62%	1.62%
Extrapolation	Whole period trend	1.82%	1.82%	1.82%	1.82%	1.82%	1.82%
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
Water network plus							
Economy-based	GDP econometrics – levels	1.01%	1.13%	1.15%	1.17%	1.20%	1.13%
	GDP econometrics – changes	1.50%	1.64%	1.64%	1.64%	1.64%	1.61%
	Wage econometrics – levels	1.38%	1.61%	1.62%	1.64%	1.66%	1.58%
	Wage econometrics – changes	1.93%	2.40%	2.36%	2.36%	2.36%	2.28%
	Wedge to UK wages inflation	1.92%	2.33%	2.29%	2.29%	2.29%	2.23%
	Wedge to CPI inflation	1.62%	1.62%	1.62%	1.62%	1.62%	1.62%
Extrapolation	Whole period trend	1.82%	1.82%	1.82%	1.82%	1.82%	1.82%
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
Wastewater network plus							
Economy-based	GDP econometrics – levels	0.83%	0.93%	0.95%	0.97%	0.99%	0.93%
	GDP econometrics – changes	1.33%	1.45%	1.45%	1.45%	1.45%	1.42%
	Wage econometrics – levels	1.16%	1.36%	1.37%	1.39%	1.41%	1.34%
	Wage econometrics – changes	1.72%	2.17%	2.14%	2.14%	2.14%	2.06%
	Wedge to UK wages inflation	1.70%	2.12%	2.08%	2.08%	2.08%	2.01%

Methodology	Wage inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
	Wedge to CPI inflation	1.41%	1.41%	1.41%	1.41%	1.41%	1.41%
Extrapolation	Whole period trend	1.61%	1.61%	1.61%	1.61%	1.61%	1.61%
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
Wastewater bioresources							
Economy-based	GDP econometrics – levels	0.83%	0.93%	0.95%	0.97%	0.99%	0.93%
	GDP econometrics – changes	1.33%	1.45%	1.45%	1.45%	1.45%	1.42%
	Wage econometrics – levels	1.16%	1.36%	1.37%	1.39%	1.41%	1.34%
	Wage econometrics – changes	1.72%	2.17%	2.14%	2.14%	2.14%	2.06%
	Wedge to UK wages inflation	1.70%	2.12%	2.08%	2.08%	2.08%	2.01%
	Wedge to CPI inflation	1.41%	1.41%	1.41%	1.41%	1.41%	1.41%
Extrapolation	Whole period trend	1.61%	1.61%	1.61%	1.61%	1.61%	1.61%
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%

Source: Economic Insight analysis

Table 69: Northumbrian Water labour cost inflation forecasts, 2020/21 - 2024/25 – 3 digit SOC codes

Methodology	Wage inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
Company							
Economy-based	GDP econometrics – levels	1.02%	1.14%	1.16%	1.19%	1.21%	1.14%
	GDP econometrics – changes	1.30%	1.50%	1.50%	1.50%	1.50%	1.46%
	Wage econometrics – levels	1.54%	1.79%	1.79%	1.82%	1.84%	1.75%
	Wage econometrics – changes	1.89%	2.43%	2.39%	2.39%	2.39%	2.30%
	Wedge to UK wages inflation	1.85%	2.26%	2.23%	2.23%	2.23%	2.16%
	Wedge to CPI inflation	1.56%	1.55%	1.55%	1.55%	1.55%	1.56%
Extrapolation	Whole period trend	1.76%	1.76%	1.76%	1.76%	1.76%	1.76%
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
Water resources							
Economy-based	GDP econometrics – levels	1.01%	1.13%	1.15%	1.18%	1.20%	1.14%
	GDP econometrics – changes	1.35%	1.60%	1.59%	1.59%	1.59%	1.54%
	Wage econometrics – levels	1.52%	1.77%	1.78%	1.80%	1.82%	1.74%
	Wage econometrics – changes	2.05%	2.69%	2.64%	2.64%	2.64%	2.53%
	Wedge to UK wages inflation	2.00%	2.41%	2.37%	2.37%	2.37%	2.30%
	Wedge to CPI inflation	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%
Extrapolation	Whole period trend	1.90%	1.90%	1.90%	1.90%	1.90%	1.90%

Methodology	Wage inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
Water network plus							
Economy-based	GDP econometrics – levels	1.01%	1.13%	1.15%	1.17%	1.20%	1.13%
	GDP econometrics – changes	1.35%	1.59%	1.58%	1.58%	1.58%	1.54%
	Wage econometrics – levels	1.52%	1.77%	1.77%	1.80%	1.82%	1.73%
	Wage econometrics – changes	2.05%	2.69%	2.64%	2.64%	2.64%	2.53%
	Wedge to UK wages inflation	1.99%	2.40%	2.37%	2.37%	2.37%	2.30%
	Wedge to CPI inflation	1.70%	1.69%	1.70%	1.70%	1.70%	1.70%
Extrapolation	Whole period trend	1.90%	1.90%	1.90%	1.90%	1.90%	1.90%
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
Wastewater network plus							
Economy-based	GDP econometrics – levels	0.75%	0.84%	0.86%	0.88%	0.90%	0.84%
	GDP econometrics – changes	1.03%	1.27%	1.26%	1.26%	1.26%	1.21%
	Wage econometrics – levels	1.14%	1.33%	1.34%	1.36%	1.39%	1.31%
	Wage econometrics – changes	1.70%	2.29%	2.24%	2.24%	2.24%	2.15%
	Wedge to UK wages inflation	1.66%	2.07%	2.04%	2.04%	2.04%	1.97%
	Wedge to CPI inflation	1.37%	1.36%	1.36%	1.36%	1.36%	1.36%
Extrapolation	Whole period trend	1.56%	1.56%	1.56%	1.56%	1.56%	1.56%

Methodology	Wage inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%
Wastewater bioresources							
Economy-based	GDP econometrics – levels	0.75%	0.84%	0.86%	0.88%	0.90%	0.84%
	GDP econometrics – changes	1.03%	1.27%	1.26%	1.26%	1.26%	1.21%
	Wage econometrics – levels	1.14%	1.33%	1.34%	1.36%	1.39%	1.31%
	Wage econometrics – changes	1.70%	2.29%	2.24%	2.24%	2.24%	2.15%
	Wedge to UK wages inflation	1.66%	2.07%	2.04%	2.04%	2.04%	1.97%
	Wedge to CPI inflation	1.37%	1.36%	1.36%	1.36%	1.36%	1.36%
Extrapolation	Whole period trend	1.56%	1.56%	1.56%	1.56%	1.56%	1.56%
Third-party	Independent forecasts	2.69%	3.11%	3.07%	3.07%	3.07%	3.00%

Source: Economic Insight analysis

6.3 Energy cost inflation forecasts

The following tables set out the full results for energy cost inflation, based on all of the methodologies set out in the main report.

Table 70: Northumbrian Water energy cost inflation forecasts, 2020/21 - 2024/25

Methodology	Energy inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
Company							
Economy-based	Wedge to UK GDP	3.03%	3.32%	3.31%	3.31%	3.31%	3.25%
	Wedge to CPI inflation	3.88%	3.87%	3.87%	3.87%	3.87%	3.88%
Extrapolation	Whole period trend	4.18%	4.18%	4.18%	4.18%	4.18%	4.18%
Third-party	BEIS reference case	2.16%	3.01%	2.98%	3.63%	5.09%	3.38%
	BEIS low prices	1.46%	2.40%	2.25%	3.19%	4.83%	2.83%
	BEIS high prices	3.50%	4.11%	4.02%	4.25%	4.87%	4.15%
	BEIS low growth	2.11%	2.92%	2.91%	3.54%	5.04%	3.30%
	BEIS high growth	2.14%	2.99%	2.96%	3.58%	5.08%	3.35%
Water resources							
Economy-based	Wedge to UK GDP	3.07%	3.36%	3.35%	3.35%	3.35%	3.29%
	Wedge to CPI inflation	3.88%	3.87%	3.87%	3.87%	3.87%	3.87%
Extrapolation	Whole period trend	4.18%	4.18%	4.18%	4.18%	4.18%	4.18%
Third-party	BEIS reference case	2.17%	3.02%	2.99%	3.64%	5.09%	3.38%
	BEIS low prices	1.48%	2.41%	2.26%	3.20%	4.83%	2.84%
	BEIS high prices	3.51%	4.11%	4.03%	4.25%	4.87%	4.15%
	BEIS low growth	2.12%	2.93%	2.92%	3.54%	5.03%	3.31%

Methodology	Energy inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
	BEIS high growth	2.15%	3.01%	2.97%	3.58%	5.07%	3.36%
Water network plus							
Economy-based	Wedge to UK GDP	3.05%	3.34%	3.32%	3.32%	3.32%	3.27%
	Wedge to CPI inflation	3.90%	3.89%	3.89%	3.89%	3.89%	3.89%
Extrapolation	Whole period trend	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%
Third-party	BEIS reference case	2.08%	2.93%	2.94%	3.62%	5.11%	3.34%
	BEIS low prices	1.37%	2.30%	2.19%	3.16%	4.84%	2.77%
	BEIS high prices	3.45%	4.06%	4.00%	4.26%	4.89%	4.13%
	BEIS low growth	2.04%	2.84%	2.87%	3.53%	5.05%	3.27%
	BEIS high growth	2.06%	2.92%	2.92%	3.57%	5.09%	3.31%
Wastewater network plus							
Economy-based	Wedge to UK GDP	3.02%	3.31%	3.30%	3.30%	3.30%	3.24%
	Wedge to CPI inflation	3.87%	3.86%	3.86%	3.86%	3.86%	3.86%
Extrapolation	Whole period trend	4.17%	4.17%	4.17%	4.17%	4.17%	4.17%
Third-party	BEIS reference case	2.21%	3.06%	3.01%	3.64%	5.08%	3.40%
	BEIS low prices	1.53%	2.47%	2.30%	3.22%	4.83%	2.87%
	BEIS high prices	3.54%	4.14%	4.04%	4.25%	4.86%	4.17%
	BEIS low growth	2.17%	2.97%	2.94%	3.55%	5.03%	3.33%
	BEIS high growth	2.19%	3.05%	2.99%	3.59%	5.06%	3.38%
Wastewater bioresources							

Methodology	Energy inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
Economy-based	Wedge to UK GDP	3.03%	3.32%	3.31%	3.31%	3.31%	3.26%
	Wedge to CPI inflation	3.88%	3.87%	3.88%	3.88%	3.88%	3.88%
Extrapolation	Whole period trend	4.18%	4.18%	4.18%	4.18%	4.18%	4.18%
Third-party	BEIS reference case	2.14%	2.99%	2.97%	3.63%	5.10%	3.37%
	BEIS low prices	1.44%	2.38%	2.24%	3.19%	4.84%	2.82%
	BEIS high prices	3.49%	4.10%	4.02%	4.25%	4.88%	4.15%
	BEIS low growth	2.10%	2.90%	2.90%	3.54%	5.04%	3.30%
	BEIS high growth	2.12%	2.98%	2.95%	3.58%	5.08%	3.34%

Source: Economic Insight analysis

6.4 Chemical cost inflation forecasts

The following tables set out the full results for chemical cost inflation, based on all of the methodologies set out in the main report.

Table 71: Northumbrian Water chemical cost inflation forecasts, 2020/21 - 2024/25

Methodology	Chemicals inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
Company							
Economy-based	Econometrics preferred model – changes	3.45%	3.54%	3.27%	3.52%	3.52%	3.46%
Extrapolation	Whole period trend	4.99%	4.99%	4.99%	4.99%	4.99%	4.99%
Third-party	Independent forecasts	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%
Water resources							
Economy-based	Econometrics preferred model – changes	4.01%	4.18%	3.89%	4.16%	4.16%	4.08%
Extrapolation	Whole period trend	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%
Third-party	Independent forecasts	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%
Water network plus							
Economy-based	Econometrics preferred model – changes	3.43%	3.54%	3.26%	3.52%	3.52%	3.45%
Extrapolation	Whole period trend	5.02%	5.02%	5.02%	5.02%	5.02%	5.02%
Third-party	Independent forecasts	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%
Wastewater network plus							
Economy-based	Econometrics preferred model – changes	3.79%	3.84%	3.53%	3.82%	3.82%	3.76%
Extrapolation	Whole period trend	5.26%	5.26%	5.26%	5.26%	5.26%	5.26%
Third-party	Independent forecasts	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%
Wastewater bioresources							

Methodology	Chemicals inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
Economy-based	Econometrics preferred model – changes	3.15%	3.15%	2.88%	3.13%	3.13%	3.09%
Extrapolation	Whole period trend	4.29%	4.29%	4.29%	4.29%	4.29%	4.29%
Third-party	Independent forecasts	2.76%	2.76%	2.76%	2.76%	2.76%	2.76%

Source: Economic Insight analysis

6.5 Construction cost inflation forecasts

The following table sets out the full results for construction cost inflation, based on all of the methodologies set out in the main report.

Table 72: Northumbrian Water construction cost inflation forecasts, 2020/21 - 2024/25

Methodology	Construction inflation forecasts (%)	2020/21	2021/22	2022/23	2023/24	2024/25	Avg
Maintenance of Building Non-Housing							
Economy-based	Wedge to UK GDP	2.43%	2.72%	2.71%	2.71%	2.71%	2.66%
	Wedge to CPI inflation	3.24%	3.23%	3.23%	3.23%	3.23%	3.23%
Extrapolation	Whole period trend	3.73%	3.73%	3.73%	3.73%	3.73%	3.73%
Building Non-Housing							
Economy-based	Wedge to UK GDP	2.25%	2.54%	2.53%	2.53%	2.53%	2.47%
	Wedge to CPI inflation	3.06%	3.05%	3.05%	3.05%	3.05%	3.05%
Extrapolation	Whole period trend	3.55%	3.55%	3.55%	3.55%	3.55%	3.55%

Source: Economic Insight analysis

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