RIS3 Productivity and Efficiency Research

Office of Rail and Road

10 November 2023

REVISED FINAL REPORT

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EXECUTIVE SUMMARY

The ORR commissioned CEPA to undertake research on productivity growth and efficiency in capital intensive sectors. The aim of this research is to provide contextual evidence which might inform ORR's assessment of National Highways' RIS3 efficiency proposals as part of the upcoming RIS3 Efficiency Review.

We submitted our Final Report to ORR in March 2023. However, after the submission of our report, the Luiss Lab of European Economics published a further release of the EU KLEMS dataset using more recent national accounts data. To take account of this latest EU KLEMS release, the ORR asked CEPA to update the EU KLEMS analysis and submit this Revised Final Report in October 2023.

All efficiency percentage values presented herein are on a per annum basis unless otherwise stated.

Productivity growth in capital intensive sectors

Most economic regulators in the UK set an 'ongoing efficiency' challenge, also known as 'frontier shift'. In simple terms, this represents the scope for productivity growth that even the most efficient firm in that industry will be able to achieve, for example due to improvements in technology and management practices over time.

Recent regulatory determinations have set an ongoing efficiency challenge of around 1%. In setting that challenge, most regulators rely upon 'growth accounting' analysis to estimate the underlying rate of productivity growth for a range of comparator industries which bear some resemblance to the activities carried out by the regulated companies. We also use a growth accounting approach in this research – building on our earlier 2018 report for ORR[1] – using the EU KLEMS database (2023 release) published by the Luiss Lab of European Economics. The results of our growth accounting analysis are summarised in Table 0.1 below:

Table 0.1 Productivity estimates (average annual growth rate, 1996-2016)

Average growth (%)	TFP GO	TFP VA	LP
Narrow set: renewals (weighted)	-0.4%	-0.5%	0.0%
Narrow set: enhancements (weighted)	-0.4%	-0.5%	0.0%
Broader comparator set (unweighted)	1.0%	2.7%	3.5%
Market economy (weighted average)	0.3%	0.6%	1.5%

Source: CEPA analysis of EU KLEMS data

We acknowledge that the 2023 release produces an underlying TFP estimate of -0.4% in the TFP GO and TFP VA growth rates for the narrow comparator sets. However, in our view, it would not be appropriate to set the lower end of the range based only on the average TFP growth rate in the construction sector over the period 1996–2019. There are several factors which have hindered productivity growth in the construction sector, such as the fragmented nature of the sector and the unpredictable pipeline of work, some of which the 5-year RIS framework was meant to address. Moreover, public infrastructure and the civil engineering sub-sectors more broadly are only a subset of the construction sector, and the data suggests that they are more productive than the sector average.

This suggests that comparisons between construction sector TFP growth and the scope for productivity growth in the highways sector in RIS3 should be made with caution. If this were the only relevant comparator, it would imply that the scope for technological change in the highways sector over the next 5-year investment period is negative, when in practice there remains opportunities to make greater use of modular and automated construction methods; enhanced data and digital design and monitoring of assets; and more advanced modelling and understanding of risk and how to manage it.

We think ORR would be justified in putting some weight on the broader comparator set because it is a proxy for the scope for greater innovation and ambition relative to historically weak productivity growth in the construction sector. But it should also seek to identify a proportionate balance between this more innovative proxy and

[1] CEPA (July 2018) "Productivity growth in capital intensive sectors" available online.

alignment with the basis on which it has estimated efficiency challenges in the past – as represented by the narrow comparator set.

Long-run average productivity growth rates are useful, but the results from growth accounting analysis should not be applied mechanistically. This is because it is based on historical data which may not reflect the scope for productivity growth in future periods. In the most recent regulatory determinations in the UK energy and water sectors, Ofwat, Ofgem and the Competition and Markets Authority (CMA) have brought in a range of associated wider factors to contextualise the growth accounting evidence. For example:

- Ofgem considered a broader range of industries in its consideration of the EU KLEMS data. Its aim was to capture the opportunities for transformational change in the electricity distribution sector over RIIO-ED2. Ofgem intends that RIIO-ED2 will facilitate the development of a more decentralised and digitalised electricity distribution system which will support the transition to net zero, enabled by substantial innovation funding over the previous decade which unlocks cost efficiencies.
- Ofgem has also taken into consideration the ongoing efficiency challenges proposed by the most ambitious companies in each sector. For example, ENWL and UKPN (both 1%) and National Grid Electricity Transmission (1.1% for opex) all proposed ongoing efficiency challenges at or above 1%.
- Ofgem, Ofwat and the CMA all consider the applicability of the 'productivity puzzle' to their regulated sectors. None of them found compelling evidence to suggest that the wider productivity slowdown should fully impact on the potential for ongoing productivity gains in the regulated utilities sectors. Ofgem notes that the regulated companies benefit from the relative certainty provided by the 5-year price control period, which establishes a visible pipeline of investment and enables the companies to work with their supply chain to invest in efficiency measures ahead of time.

In our view, the underlying scope for productivity growth for an efficient operator in the highways maintenance and construction sector over the RIS3 period is similar to the scope for productivity growth in other regulated sectors. **Therefore, we recommend an estimate for underlying productivity growth of 0.0% to 1.0% for both capital and operating expenditure:**

- The bottom of the range (0%) represents a pessimistic view of the rate of underlying productivity growth, because National Highways is reliant on the performance of the construction sector more broadly; and
- The top of the range (1%) represents a more optimistic view rate of underlying productivity growth – taking into account both VA and GO-based measures of TFP from the market economy and broader comparator sets – because National Highways should be able to exploit the designated innovation funding and the relative certainty provided by its 5-year investment periods to drive efficiency gains through its wider supply chain. 1% is also consistent with recent regulatory decisions by regulators including Ofwat, Ofgem, the CAA and the Competition and Markets Authority (CMA).

On the basis that the water and wastewater companies are proposing a frontier shift challenge of at least 0.5% in their PR24 Business Plans[2] – and Ofgem, Ofwat, the CAA and the CMA all alight on 1% in recent regulatory decisions – we suggest that ORR considers aiming for the top half of the range. But ORR may also wish to recognise that National Highways' financial framework is less flexible than that which applies to the regulated energy and water networks, which might inhibit its ability to invest in efficiency enhancing measures for future capital projects, or to incentivise investment in productivity improvements via its supply chain.

Efficiency targets in other regulated sectors

Since National Highways was transformed into a government-owned company in 2015, various ORR studies have found that it has made significant progress and has become a more mature asset management and capital delivery organisation.[3] But they also conclude that there is scope for further development in the organisation's capabilities and maturity of plans and processes. Moreover, the NAO concluded that by 2025 National Highways will have completed less work during RIS2 and at a higher cost than originally planned, and that it should have done more to

[2] The most ambitious water companies are proposing 1.0% (SES Water; Portsmouth Water) and 1.1% (South Staffs Water).

[3] ORR (June 2019) "RIS2 Efficiency Review" available online.

plan for and manage the potential risks to the portfolio of enhancement projects.[4] Altogether, the Company's performance is not that of a company which operates at the efficiency frontier and in our view there remains significant scope to plan the work programme and procure from the supply chain more efficiently. In that context, there should be substantial further efficiency gains as the Company embeds various transformation initiatives which may bear fruit during RIS3.

We analysed a range of recent regulatory determinations in the UK and Ireland (across the energy, water, rail and aviation sectors) to derive an estimate of the range of 'catch-up' efficiency challenges applied elsewhere. Our analysis extends the work that we did for ORR in 2018 and finds that the average catch-up efficiency challenge in the most recent regulatory determinations range from around 0.3% for RIIO-ED2 (electricity distribution) to 1.5% for PR18 (Network Rail). But for the least efficient companies the catch-up challenge is much greater, typically between 2.2% for RIIO-GD2 (gas distribution) to 4.4% for PR19 (water and wastewater).[5]

As the wider evidence suggests that National Highways is several years behind other similar organisations – and bearing in mind that the Company is entering only its third Road Period – it may not be appropriate to compare it to the latest regulatory determinations in other sectors as these often relate to the fifth, sixth or seventh price control. In our view, there is no perfect benchmark against which we can compare the scope for efficiency in RIS3. We suggest that it would be more appropriate to compare the scope for efficiency in RIS3 with the targets set in other regulatory determinations made between 2009 and 2014. But our analysis finds that the catch-up efficiency challenge across the sectors tends to reduce over time, and so the implied scope for catch-up efficiency might be considered conservative relative to the efficiency gains that might be achievable for National Highways in RIS3. Therefore, we find that much of the evidence presented in our 2018 report remains relevant – and ORR might also take note of the greater efficiency targets set in the third or fourth price controls in other regulated sectors.

Outturn efficiencies achieved in other regulated sectors

We also analysed three recent academic papers which sought to estimate productivity growth in the electricity and water sectors since privatisation.[6] In our view, there is robust evidence that the regulated energy and water companies have been able to deliver substantial productivity growth since privatisation, but precisely how much growth is sensitive to the method of analysis. **We would caution against using this analysis to derive specific assumptions about the precise scope for productivity growth in RIS3.**

The historical evidence supports the hypothesis that the rate of productivity growth in other regulated sectors was greater in the earlier price control periods and has probably slowed as the inefficiencies of the pre-privatisation era have been driven out. But over time the energy and water companies delivered a wider range of outputs such as reliability, reduced leakage, improved customer service and better environmental outcomes. As a result, the measurement of productivity has become more challenging. It seems plausible that some studies underestimate productivity growth in more recent periods as the regulators have placed greater emphasis on these wider outputs.

Ofgem has also recently carried out a more targeted 'high-level' exercise to assess the historical 'outperformance' of the gas distribution and transmission networks relative to their RIIO-1 expenditure allowances. It found that the frontier gas distribution company – and the gas distribution sector as a whole – had significantly outperformed the RIIO-1 efficiency challenge. Exactly how much of that outperformance was attributable to efficiency improvements was a point of contention in the CMA appeals, but Ofgem argued that it was reasonable to suppose that some of it could be, as this was consistent with the network companies' own statements. Ultimately, Ofgem concluded that it found its historical analysis of outperformance during RIIO-1 helpful as a 'cross-check', but it was not determinative of what the underlying scope for productivity growth should be for RIIO-GD2.[7]

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[4] NAO (November 2022) "Road enhancements: progress with the second road investment strategy" available online.

[5] Care should be taken when directly comparing catch-up efficiency challenges across regulatory determinations as the methods for calculating catch-up efficiency vary considerably. These challenges are discussed further later in this document.

[6] Frontier Economics (2017) "Productivity improvement in the water industry in England since privatization" available online; NERA (2021) "Ongoing efficiency improvement at RIIO-ED2 – report for the ENA", Section 4, available online; Ajayi et al. (2021) "Incentive regulation, productivity growth and environmental effects: electricity networks in GB" available online.

[7] CMA (2021) Energy Licence Modification Appeals: Joined Grounds Volume 2B, para 7.295–7.347, p.144–156, available online.

ORR should note that direct comparisons between the efficiency challenges applied elsewhere and National Highways should be made with care because: (a) the analytical challenges in arriving at like-for-like estimates for the efficiency challenges set across different price controls are complex; and (b) there are significant differences between the incentive-based regulatory frameworks which apply to the energy, water and aviation sectors, and the regulatory, commercial and policy framework which applies to National Highways.

Interactions with the Capability Reviews and recommendations for RIS3

Given issues of comparability between RIS3 and the most recent regulatory determinations in other sectors, we recommend that ORR uses the evidence presented in this research as a 'cross-check' for the more detailed and targeted estimates which emerge from the RIS3 Capability Reviews.

- The Asset Management Capability review finds that National Highways has made improvements across a range of maturity areas and is now more consistently 'effective'. Significant improvements are yet to be made in key areas such as risk assessment, organisational culture, and asset performance and health monitoring, and overall National Highways remains behind the improvement trajectory identified in 2018. **It recommends an efficiency range of 5% to 15% cumulative between RP2 and RP3** supported by case studies of the efficiency improvements made by other similar organisations based on a similar trajectory.
- The Procurement and Project Management Capability review identifies a top-down efficiency range which can be applied to individual projects and adjusted depending on the programme to which that project belongs and its position in the project life cycle.[8] **It recommends an efficiency range of:**
    - **9% to 16% for enhancement projects at the 'During Options' stage** (as % of project cost).
    - **6% to 11% for projects at the 'After Options' stage; and**
    - **1% to 3% for projects at the 'After Development' stage.**

  At the time of our research, the headroom for new enhancement projects and the overall size of the RIS3 funding package is uncertain but is likely to be a multi-billion pound investment.

Overall, we conclude that our research lends support to the upper end of the efficiency ranges which emerge from the Capability Reviews:

- Our analysis of the catch-up challenge applied in other regulatory determinations made between 2009 and 2014 suggests efficiency improvements of between roundly 0.5% and 3.5% p.a. The mid-point of this range is consistent with the mid-point of the annualised improvements implied by the Capability Reviews.
- This analysis is likely to be conservative, in that National Highways is entering only its third Road Period and the experience from other regulated sectors illustrates that the scope for catch-up efficiency tends to reduce as the inefficiencies from the pre-privatisation era are driven out.
- Our understanding is that the Capability Reviews are substantially based on 'catching up' to best practice rather than improvements in the technological frontier. But in practice the distinction between these two concepts is difficult to identify, so ORR will need to consider any overlaps between the efficiencies identified in the Capability Reviews to avoid the scope for 'double-counting'; and it should form a view on whether the efficiencies identified represent 'catch-up' to best practice or improvements in the technological frontier.

Based on the catch-up efficiency challenge implied by the emerging Capability Reviews and overlaying an additional challenge for frontier shift, an appropriate efficiency range would be as shown in Table 0.2 below. But ORR should note that the upper and lower point of the total efficiency range requires certain assumptions which are unlikely to hold because:

[8] We understand it is likely to recommend that the scope for efficiency improvements reduces as projects mature from the 'Options' stage to the 'Construction' stage.

- Frontier shift of 0% implies a view that the scope for productivity growth in the highways maintenance and construction sector has stalled and is substantially less than other infrastructure sectors.
- In practice there is potential for some overlap between 'catch up' and 'frontier shift' efficiencies identified by the Capability Reviews, and the most robust approach is to show that this has been taken into account.

Table 0.2: Efficiency implied by the catch-up efficiency ranges for RIS3 based on the capability reviews (% p.a.)

Category	Catch up	Frontier shift	Total efficiency
Operations and maintenance	1.0% – 2.8%	0.0% – 1.0%	1.0% – 3.8%
Renewals	1.0% – 2.8%	0.0% –1.0%	1.0% – 3.8%
Enhancements (during Options stage)	1.7% –3.0%	0.0% –1.0%	1.7% – 4.0%
Enhancements (after Options stage)	1.2% – 2.1%	0.0% –1.0%	1.2% – 3.1%
Enhancements (after Development stage)	0.2% – 0.6%	0.0% – 1.0%	0.2% – 1.6%

Source: Catch-up efficiency drawn from CEPA analysis of efficiency ranges presented in Nichols (2023) "RIS3 Procurement and Project Management Capability Review" and AMCL (2023) "Asset Management Capability and Efficiency Review". Frontier shift efficiency based on the research presented in this report.

1. INTRODUCTION

1.1. CONTEXT

National Highways operates, maintains and improves the Strategic Road Network (SRN) in England. It is a government-owned company funded by the Department for Transport (DfT). DfT sets out its strategic vision for the SRN, objectives for National Highways and the funding that it will make available in 5-yearly periodic Road Investment Strategies. DfT and National Highways are currently preparing for the third Road Investment Strategy (RIS3) which sets the outputs that National Highways must deliver during Road Period 3 (RP3) and will run from April 2025 to 2030.

The Office of Rail and Road (ORR) – through its Highways Monitor function – is responsible for monitoring and enforcing the performance and efficiency of National Highways. Of particular relevance to this assignment, it is responsible for leading the RIS3 Efficiency Review, an assessment of the level of efficiency that National Highways proposes to achieve in its draft Strategic Business Plan (dSBP) for RIS3.

1.2. PROJECT OBJECTIVE AND SCOPE

In that context, the ORR commissioned CEPA to research productivity growth and efficiency in capital intensive sectors to provide contextual evidence which might inform ORR's assessment of National Highways' RIS3 efficiency proposals.

The scope of the research is split into two parts:

- First, to provide evidence on underlying trends in the productivity growth of capital intensive sectors or sectors relevant to National Highways' functions as an operator, maintainer, and constructor of roads. The scope also includes qualitative consideration of the applicability of this evidence to National Highways.
- Second, to review evidence on the efficiency targets set by other regulators in the UK and, where available, evidence on efficiency gains which have been achieved by other regulated companies in practice. As part of this task, ORR wishes to distinguish between efficiency targets and/or delivery in capital spending and operations.

1.3. APPROACH TO THIS PROJECT

With respect to the evidence on productivity growth in capital intensive sectors, our approach was three-fold:

- First, we collated the 'ongoing efficiency' challenges set in other recent regulatory determinations in the UK and Ireland and the key factors which were cited in support of each decision. The ongoing efficiency challenge (sometimes referred to as 'frontier shift') represents the efficiency which even the most productive firm in the relevant sector can achieve. In simple terms, it can be thought of as the scope for future productivity growth in the relevant sector due to improvements in the technological frontier.
- Second, we used the EU KLEMS database to analyse long-term, industry-level productivity growth across several different baskets of industries which might be considered relevant to the activities that National Highways undertakes, or informative of the scope for productivity growth in the highways maintenance and construction sector between 2025 and 2030.
- Third, we consider the relevance of this evidence to the scope for National Highways to achieve productivity improvements in RIS3, including the limitations of this evidence, and explore the factors and assumptions which ORR should consider when interpreting the scope for productivity growth in RIS3.

With respect to the evidence on the efficiency targets set by other regulators in the UK and efficiency gains which have been achieved by other regulated companies, our approach was two-fold:

- Using publicly available datasets and documentation, and our extant knowledge, we analysed the efficiency challenges set in recent regulatory determinations in the UK and Ireland, with a focus on the energy, water, aviation, and rail sectors. In each case we estimate an average 'catch-up' efficiency[9] challenge for the industry overall, and a catch-up efficiency range for the most and least efficient companies in the sector.
- We reviewed publicly available documentation and academic studies which seek to quantify the extent of regulated company outperformance in recent price control periods, or to estimate actual productivity growth in the period since privatisation according to different analytical methods.

The final aspect of our research was to bring together the evidence on underlying productivity growth trends in capital intensive sectors, the efficiency challenges which have been set in other regulated sectors, and the evidence on the efficiency improvements which have been delivered by other regulated companies in practice, to form an overall view on the scope for efficiency improvements in RIS3. Our approach to this task was to:

- Draw on CEPA's extant knowledge and understanding of the environment in which National Highways is funded and operates, and compare that environment to the situation of other regulated sectors.
- Review the emerging findings from the Capability Reviews
- Observe the efficiency trajectory that has been observed as other regulated sectors as they enter the fifth, sixth and/or seventh investment period, and compare this to the scope for efficiency with the highways sector as National Highways enters its third Road Period.

1.4. STRUCTURE OF THIS REPORT

The remainder of this report is structured as follows:

- Section 2 sets out the evidence on productivity growth in capital intensive sectors. This was written in March 2023 and is retained in this revised version to support the traceability of our work.
- Section 3 sets out the evidence on the efficiency targets set by other regulators in the UK and efficiency gains which have been achieved by other regulated companies; and
- The Postscript – written in October 2023 – updates the growth accounting analysis presented in Section 2 to take account of the 2023 release of EU KLEMS.
- Appendix A sets out further detail behind our analysis of the EU KLEMS evidence (based on the 2019 release).
- Appendix B sets out further detail behind our analysis of the 'catch up' efficiency challenges set in other regulated infrastructure sectors in the UK and Ireland; and
- Appendix B provides a summary of the academic literature on outturn productivity growth in the regulated electricity and water sectors.

[9] The 'catch-up' efficiency challenge is the percentage reduction in submitted costs (adjusted for exclusions) to allowed (or modelled) costs prior to any ongoing efficiency (or frontier shift) adjustment.

2. PRODUCTIVITY GROWTH IN CAPITAL INTENSIVE SECTORS

Important note: The analysis presented in this section was written in March 2023, but was subsequently superseded by the updated analysis which is set out in the Postscript.

Recent regulatory determinations have set an ongoing efficiency challenge of around 1%. Most regulators rely in part on 'growth accounting' analysis to estimate the underlying rate of productivity growth for a range of comparator industries. Using the EU KLEMS database, we find average TFP growth rates of between 0.3% and 1.5%, and average labour productivity growth rates of between 0.9% and 2.3% for a range of different comparator sets over the period 1996 to 2016.

Long-run average productivity growth rates are useful, but the results from the growth accounting analysis should not be applied mechanistically. This is because it is based on historical data which may not reflect the scope for productivity growth in future periods. In the most recent regulatory determinations in the UK energy and water sectors, other regulators have considered a range of wider factors to contextualise the growth accounting evidence.

Taking these wider factors into account, we find that the underlying scope for productivity growth for an efficient operator in the highways maintenance and construction sector over the RIS3 period is similar to the scope for productivity growth in other regulated sectors. But we also recognise that National Highways' financial framework is less flexible than that which applies to the regulated energy and water networks, which might inhibit its ability to invest in efficiency enhancing measures for future capital projects. Therefore, **we recommend an estimate for underlying productivity growth of 0.5% to 1.2% for capex, and 0.8% to 1.2% for opex**.

In this section, we analyse the evidence on productivity growth in capital intensive and regulated infrastructure sectors. We then consider the applicability of this evidence to National Highways and set out an estimated range for underlying productivity growth in the highways maintenance and construction sector during RIS3.

2.1. BACKGROUND

In other UK regulated industries, it is common for the economic regulator to set an 'ongoing efficiency' challenge as part of the price review determination (sometimes known as 'frontier shift'). In simple terms, the ongoing efficiency challenge represents the scope for productivity growth that even the most efficient firm in that industry will be able to achieve, for example due to improvements in technology and management practices over time.

ORR did not explicitly apply the concept of 'ongoing efficiency' as part of its RIS2 Efficiency Review. But it considered similar analysis which formed the basis of a previous report we produced for ORR in 2018.[10] The aim of that work was similar, in that it was undertaken to inform ORR's advice on the scope for capex efficiency in RIS2. ORR also commissioned a series of Capability Reviews[11] to benchmark National Highways against other similar organisations and assess the scope for efficiency improvements in RIS2. In our 2018 report, we concluded that the efficiency estimates identified in the Capability Reviews seemed likely to be predominantly catch-up efficiencies, and that improvements via frontier shift would be additional.

2.2. REGULATORY PRECEDENT

Most regulators in the UK and Ireland have set an ongoing efficiency challenge of around 1% in recent regulatory determinations, as shown in Table 2.1 below.

[10] CEPA (July 2018) "Productivity growth in capital intensive sectors" available online.

[11] The capability reviews assess National Highways' ability to manage and deliver critical activities such as asset management (its ability to maintain and renew the network to keep it in good condition), portfolio and programme management (its ability to deliver a portfolio of enhancement projects), and procurement and contract management.

Table 2.1 Ongoing efficiency from recent GB regulatory determinations

Country	Regulator	Sector	Period	Ongoing efficiency (% p.a.)	Use of EU KLEMS data
Ireland	CRU	Electricity Transmission & Distribution (PR5)	2021-25	1.0% (opex, ESBN) 0.4% (opex, EirGrid)	✓
		Water and sewerage (RC3)	2020-24	Not explicit	×
		Water and sewerage (RC2)	2017-19	Not explicit	×
		Gas transmission & distribution (PC4)	2017-22	1.0% (opex)	×
		Electricity transmission & distribution (PR4)	2016-20	Not explicit[12]	×
	CAR	Airports (Dublin 5th Determination)	2020-24	Not explicit	×
		Airports (Dublin 4th Determination)	2015-19	0.8%	×
	ComReg	Postal Services (An Post price cap)	2014-19	0% (opex)	×
Northern Ireland	UR	Gas transmission sector (GT22)	2022-27	0.8% (opex/repex)	×
		Electricity system operator (SONI)	2020-25	0.6% (totex)	×
		Gas distribution sector (GD23)	2023-28	1.0% (opex) 1.0% (capex)	✓
		Electricity transmission & distribution (RP6)	2017-24	1.0% (opex) 1.0% (capex)	✓
		Water & Sewerage (PC21)	2021-27	0.8% (opex) 0.6% (capex)	✓
		Water & Sewerage (PC15)	2015-21	0.9% (opex) 0.6% (capex)	✓
		Gas distribution (GD17)	2017-22	1.0% (opex) 1.0% (capex)	✓
England & Wales	CMA	Water (PR19)[13]	2020-24	1.0% (totex)	✓
	Ofwat	Water (PR19)	2020-24	1.1% (totex)	✓
GB	CMA	Gas Distribution and Transmission (RIIO-GD2 & T2)[14]	2021-26	1.05% (opex) 0.95% (capex/repex[15])	✓
	Ofgem	Electricity Distribution (RIIO ED2)	2023-28	1.0% (totex)	✓

[12] Ongoing productivity built into unit costs, rather than a percentage reduction across the board.

[13] Appeals by Anglian Water, Bristol Water, Northumbrian Water and Yorkshire Water.

[14] Appeals by the four Gas Distribution Networks and Scottish Power Transmission.

[15] Repex refers to replacement expenditure, such as that required by the gas distribution companies through the Iron Mains Replacement Programme.

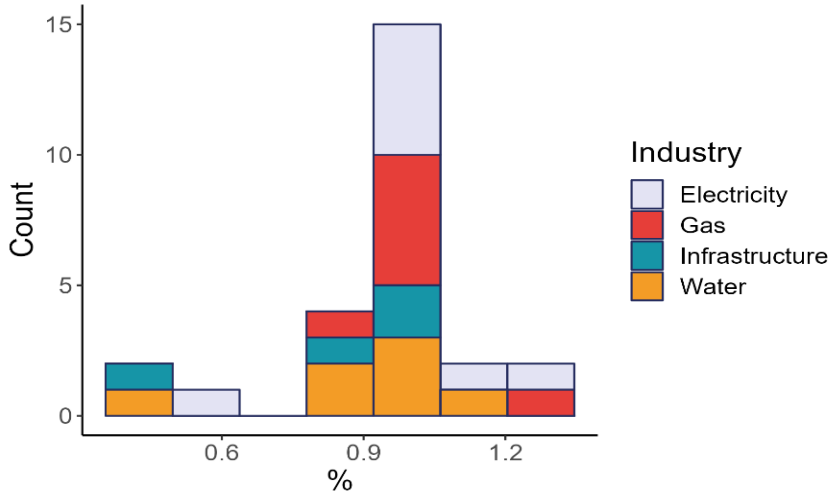
Country	Regulator	Sector	Period	Ongoing efficiency (% p.a.)	Use of EU KLEMS data
		Gas Distribution (RIIO-GD2)[16]	2021-26	1.25% (opex) 1.15% (capex/repex)	✓
		Transmission (RIIO-T2)	2021-26	1.25% (opex) 1.15% (capex/repex)	✓
		Electricity Distribution (RIIO-ED1)	2016-23	0.8%-1.1% (totex)	×
		Gas Distribution (RIIO-GD1)	2013-21	1.0% (opex) 0.7% (capex/repex)	✓
		Gas Distribution (RIIO-T1)	2013-21	1.0% (opex) 0.7% (capex/repex)	✓
	ORR	Rail (PR13)	2014-19	0.4% (enhancements)	✓

Source: CEPA analysis of past regulatory decisions

Of the determinations we surveyed, the most stretching targets were set by Ofgem in RIIO-GD2 and T2 at 1.25% for opex and 1.15% for capex and repex. However, these were revised down by a CMA appeal to 1.05% for opex and 0.95% for capex. The most conservative challenge was 0.25% for opex and 0.4% for capex set by Ofwat for water and wastewater in PR09. ORR also set an ongoing efficiency challenge of 0.4% for enhancements in PR13.

Figure 2.1 below plots Table 2.1 as a histogram to illustrate the clustering of decisions around 1%.

Figure 2.1 Ongoing efficiency challenges, UK & Ireland (2009 – present)



Source: CEPA analysis; Note: Bin width does not represent a range

Table 2.1 also shows that in many instances a different ongoing efficiency challenge was set for opex and capex (e.g. Ofgem at RIIO-GD2 and T2) but this is not universally the case. In some cases, the regulated companies themselves proposed different ongoing efficiency assumptions as part of their business plan.[17] It is worth noting that different regulators take different approaches to assessing efficiency, and there is a greater historical tendency for capex efficiency to be scrutinised from a technical engineering perspective, whilst opex has a longer history of having an ongoing efficiency assumption applied to incentivise efficiency improvements over time. But one can also observe a tendency for the regulator to set a higher ongoing efficiency challenge for opex than capex, which tends

[16] Ofgem's determination for RIIO-GD2 was superseded by the CMA ongoing efficiency determination in respect of the GDNs.

[17] National Grid Electricity Transmission (NGET) proposed an ongoing efficiency challenge of 1.1% for opex and capex labour costs as part of its RIIO-T2 business plan. NGET (December 2019) "Annex 14.14: RPE & Future Efficiency" available online.

to reflect the evidence for higher labour productivity growth rates (as we show in the next section) and the scope for capital substitution: i.e. replacing labour with capital to reduce the unit costs of production.

2.3. THE ROLE OF GROWTH ACCOUNTING EVIDENCE

Most regulators rely in part on 'growth accounting' analysis to estimate the underlying rate of historical productivity growth for a range of comparator industries, as use this as a proxy for the scope for future productivity gains that even the most efficient firm can achieve due to improvements in technology and management practices.

The EU KLEMS database is the most common source of data used to conduct this analysis, owing to its level of industry disaggregation and long-run time-series. The 2019 release[18] (published by the Vienna Institute for International Economic Studies) contains industry level measures of outputs, inputs and disembodied technical change for the 27 EU countries, the UK, US and Japan from 1995 to 2016 and is the primary source of our analysis.[19]

In this research we adopt a similar method to that which we previously applied for ORR in the lead up to RIS2 and more recently in our advice to Ofgem with respect to the RIIO GD2, T2[20] and ED2[21] price control determinations. Our approach is summarised as follows (further detail to support our approach is set out in Appendix A.1.):

- **Dataset.** We use the 2019 release of EU KLEMS on the basis that it is the most recent industry-level productivity data available at the time of our research.[22] Older datasets are still available which cover a longer time series back to 1970, but do not capture productivity growth since the Global Financial Crisis of 2008-09. We also analyse the 2011 dataset as a sensitivity check – see Appendix A.2.
- **Time period.** We include the full range of data from the 2019 release, covering the period 1995 to 2016. This removes any subjectivity around defining the start and end point of the most recent business cycle and is consistent with our advice to Ofgem in respect of RIIO-ED2.[23]
- **Productivity measures.** We report Total Factor Productivity (TFP) measures on both a gross output (GO) and value added (VA) basis (see Table 2.2 below). But the 2019 release of EU KLEMS only publishes VA measures of productivity. The GO measures of TFP have been estimated using the following formula:

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

  We also report labour productivity (LP) measures on a VA basis (only) which might be considered relevant to activities which are more labour intensive, such as National Highways' traffic officer service, the Regional Operations Centres, and its Corporate Support costs.

[18] The Vienna Institute for International Economic Studies (2019) "EU KLEMS Release 2019" available online.

[19] During our review, the Luiss Lab of European Economics published the 2023 release of EU KLEMS which contains more recent and revised data for the UK. Since the Luiss-led INTANProd project aims to update the EU KLEMS dataset and extend it with new estimates of intangible investment, we submitted several methodological queries. But at the time of this report, several queries remained outstanding. Therefore, we adopted the more analytically robust approach of focusing on the 2019 release.

[20] CEPA (November 2020) "RIIO-GD2 and T2: Cost Assessment – Advice on Frontier Shift policy for Final Determinations"

[21] CEPA (June 2022) "RIO-ED2: Cost Assessment – Frontier Shift methodology paper"

[22] We note that in late February 2023 the LUISS Lab of European Economics released "EUKLEMS & INTANProd – Release 2023" available online. At the time of writing, we are in contact with LUISS to understand any methodological changes.

[23] Given how close to zero the output gap is from 2014, using the full dataset avoids cherry-picking an end date to support a particular conclusion.

Table 2.2: Description of productivity measures

Productivity measure	Summary
TFP VA	Total factor productivity on a value added measure is calculated based on the year-on-year percentage change in the VATFP_I index published in the EU KLEMS 2019 database. VA is a measure of output that excludes intermediate inputs (materials, energy and services used up in the process of production). VA measures of productivity overcome the challenge of dealing with inter-industry and intra-industry flows of goods and services.
TFP GO	Total factor productivity on a gross output measure is calculated by converting TFP VA growth using the ratio of gross output to value added. GO is the measure of output that aligns with the theoretical production function on which growth accounting analysis is based. Includes intermediate consumption of goods and services.
LP	Labour productivity is growth rate of value added per hour worked, reported as a percentage in the series LP1_G in the EU KLEMS 2019 database.

Source: CEPA analysis and Productivity Commission (November 2003) "A Comparison of Gross Output and Value-Added Methods of Productivity Estimation" available online.

- **Comparator industries.** We show four possible comparator sets, starting with the construction industry on its own and then expanding out to a weighted average of the wider UK market economy. The rationale behind each comparator set is explained in Appendix A.3. In summary, we adopt an approach which is both reflective of the comparators we selected in our 2018 report, whilst also recognising that Ofgem, Ofwat and the CMA have more recently considered a wider range of industries to better contextualise the growth accounting evidence and consider its forward looking relevance.

Table 2.3: Description of the comparator sets analysed

Comparator set	Description of contents
Narrow comparator set	Construction (F); Transportation and Storage (H); and Professional, Scientific, Technical, Administrative and Support Service Activities (M-N).
Broader comparator set	Unweighted average of the above, plus Manufacturing sub-sectors for Chemicals and Chemical Products (C20); Computer, Electronic and Optical Products (C26); Electrical Equipment (C27); and Transport Equipment (C29-C30). Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G); and Information and Communication (J).
Market economy set	All industries apart from real estate, public administration, education, and health care, weighted by their VA-based share of total market economy output.

We recognise that the choice of comparator sets is perhaps the most challenging aspect of this analytical method. We think it is best practice to consider a range of options, in large part because none of the industries reported in the EU KLEMS database are a perfect proxy for the activities undertaken by National Highways, and inevitably some judgement must be applied in deciding on an appropriate combination. The advantage of including some of the broader comparator industries is not that they resemble National Highways, but that they are indicative of the potential scope for productivity growth in sectors which where companies must innovate to remain competitive – something which National Highways has received ring-fenced funding for over the past 10 years.

Table 2.4 shows the average annual TFP and LP growth rates using the 2019 EU KLEMS database. Depending on the comparator set, we find that TFP VA growth ranges from 0.5% to 1.5%, TFP GO growth ranges from 0.2% to 0.6%, and LP growth ranges from 0.7% to 2.3%.

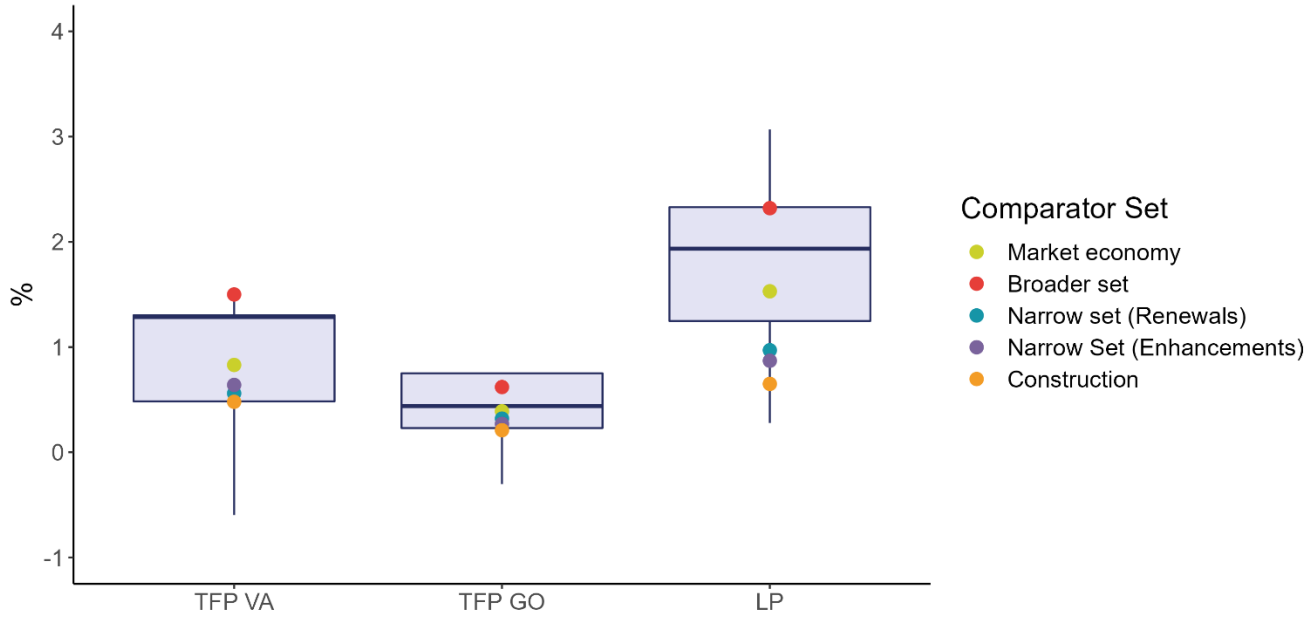
Table 2.4: Productivity estimates (average annual growth rate, 1996-2016)

Average growth (%)	TFP GO	TFP VA	LP
Full time series (1996-2016)			
Construction only	0.2%	0.5%	0.7%
Narrow set: renewals (weighted)	0.3%	0.6%	0.9%
Narrow set: enhancements (weighted)	0.3%	0.6%	1.0%
Broader comparator set (unweighted)	0.6%	1.5%	2.3%
Market economy (weighted average)	0.4%	0.8%	1.5%

Source: CEPA analysis of EU KLEMS data. For explanation of approach to weighting, see Appendix A.

Figure 2.2 shows the range of productivity growth rates across industries in the market economy and plots the average growth rate for each comparator set against this range. The broader comparator set is consistently towards the top of the range, and therefore might be considered as representing more stretching ongoing efficiency target. On the other hand, the construction industry is consistently at the bottom of the range, suggesting that any ongoing efficiency target which is based off construction alone is likely to be conservative.

Figure 2.2: Average productivity growth (1996-2016, market economy industries, weighted by value added)



Source: CEPA analysis of EU KLEMS data; Note: outliers have been removed

In our view, regulatory best practice is to take account of both the VA and GO-based measures of TFP. Therefore, EU KLEMS would support an underlying TFP estimate of between 0.35% and 1.05%, where:

- The bottom of that range represents a pessimistic view of the rate of underlying productivity growth, because National Highways is reliant on the performance of the construction sector more broadly; and
- The top of that range represents a more optimistic view rate of underlying productivity growth, because National Highways should be able to exploit the designated innovation funding and the relative certainty provided by its 5-year investment periods to drive efficiency gains through its wider supply chain.

We check the robustness of our analysis through a series of sensitivity checks in Appendix A. In particular, we conduct the same analysis using the 2011 release of EU KLEMS, adjust the weights in our narrow and broad comparator sets, and check the sensitivity of excluding each industry from our broad comparator set.

2.4. INTERPRETING THE EU KLEMS EVIDENCE IN THE WIDER CONTEXT

The long-run average productivity growth rates which can be obtained from EU KLEMS are useful. But the growth accounting approach also has its limitations, and in our view the results should not be applied mechanistically.

By its nature, EU KLEMS is based on historical data. However, the UK's productivity performance over the past 20 years may not reflect the future scope for productivity growth in the highways maintenance and construction sector. For example, over the course of RIS3 and beyond, National Highways might find that opportunities emerge to employ more innovative and digitalised methods of asset management, and to test the potential for artificial intelligence and data-driven approaches to asset interventions. It will continue to seek opportunities to standardise methods of design and construction, promote off-site construction and assembly, and speed up delivery. This potential is unlikely to be fully reflected in the underlying data in EU KLEMS.

In the most recent regulatory determinations in the UK energy and water sectors, Ofwat, Ofgem and the CMA have brought in a range of associated wider factors to contextualise the growth accounting evidence. In practice, this means that all three regulators have adopted ongoing efficiency challenges at or above the top end of the range which might be implied if EU KLEMS were applied in isolation.

More specifically:

- For RIIO-ED2, Ofgem considered a broader range of industries in its consideration of the EU KLEMS data. Its aim was to capture the opportunities for transformational change in the electricity distribution sector over the next price control period. Ofgem intends that RIIO-ED2 will facilitate the development of a more decentralised and digitalised electricity distribution system which will support the transition to net zero, enabled by substantial innovation funding over the previous decade which unlocks cost efficiencies.
- Ofgem has also taken into consideration the ongoing efficiency challenges proposed by the most ambitious companies in each sector. For example, ENWL and UKPN (both 1%) and National Grid Electricity Transmission (1.1% for opex) all proposed ongoing efficiency challenges at or above 1%.
- Ofgem, Ofwat and the CMA all consider the applicability of the 'productivity puzzle' to their regulated sectors. None of them have found compelling evidence to suggest that the wider productivity growth since the GFC should fully impact on the potential for ongoing productivity gains in the regulated utilities sectors. Ofgem in particular notes that the regulated companies benefit from the relative certainty provided by the 5-year price control period, which establishes a visible pipeline of investment and enables the companies to work with their supply chain to invest in efficiency measures ahead of time.
- EU KLEMS measures (imperfectly) disembodied technical change but does not capture embodied technical change. Embodied technical change occurs when better quality inputs (capital and labour) replace previous inputs, increasing productivity. In its redetermination of PR19, the CMA stated that "*it was important to ensure the cost savings reflect both embodied and disembodied technical change*".[24] But the evidence on the potential magnitude of the impact of embodied technical change is limited, so the CMA decided "*to consider the adjustment for embodied technical change as a qualitative factor together with other adjustments in the round*".[25]

Therefore, we find that there is significant regulatory precedent for interpreting the evidence from EU KLEMS 'in the round' and concluding that it likely understates the potential scope for underlying productivity growth in RIS3.

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[24] CMA (2019) "Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations", page 246, available online.

[25] Ibid, page 249.

In that context, it is reasonable for ORR to consider whether there is any reason(s) why the underlying scope for productivity growth in the highways maintenance and construction sector is any different to that in other regulated infrastructure sectors. In our view, there is no definitive evidence one way or the other and there is scope for ORR to apply its expert discretion as long as it can explain and reasonably defend the rationale behind its decision.

In common with other sectors, National Highways will be affected by productivity improvements and technological change within the construction and engineering sectors more widely. It also benefits from designated innovation funding; is facing similar challenges with regards to the innovation and disruption required to decarbonise its maintenance and construction activities; and has the relative certainty provided by a 5-year investment programme. But, unlike other regulated sectors, National Highways does not operate within the same financial framework that would allow it to raise external finance and/or to reprofile expenditure across the 5-year investment period. This may limit its relative ability to invest in productivity enhancing measures with a future pay-off, compared to a water or energy utility for example.

2.5. Conclusions

In summary, we recommend an underlying 'frontier shift' productivity growth estimate of 0.5% to 1.2% for capital expenditure, and 0.8% to 1.2% for operating expenditure. However, ORR should note that that the upper and lower point of this range implies certain assumptions which are unlikely to hold because:

- 0.5% implies a view that the scope for frontier shift in the highways maintenance and construction sector is substantially less than other infrastructure sectors; that it is primarily driven by historical productivity growth in the construction sector; and that there is relatively little value in the 5-year RIS settlement in supporting National Highways to work with its supply chain to drive more efficient ways of delivering.
- 1.2% would imply that the scope for productivity growth in the highways sector is higher than other regulated infrastructure sectors, for example, because there is greater scope for innovation, digitalisation, and transformational change in the highways sector than elsewhere.[26]

An estimate of 1% is consistent with recent regulatory decisions in the UK energy, water and aviation sectors. It is also consistent with a more positive interpretation of EU KLEMS which takes into account a range of wider factors that influence the scope for future productivity growth in the highways maintenance and construction sector.

However, if the ORR adopts a more conservative stance, it might justify a small downward adjustment towards the bottom half of the proposed range. This would be consistent with the view that the narrower comparator set provides the most relevant evidence for setting the rate of frontier shift in RIS3; that National Highways is more limited in its ability to drive productivity improvements through its supply chain because of a less flexible financial framework; and that National Highways is wholly affected by the recent slowdown in UK productivity growth despite the protection of the RIS framework.

We also think there is scope for ORR to adopt a higher estimate for productivity growth for opex based on the LP results from the EU KLEMS analysis, scope for the capital substitution effect, and previous regulatory precedent. But ORR should note that any difference between opex and capex is not possible to quantify with precision, and that the most robust approach would be to adopt a broadly similar estimate for both.

[26] Although National Grid Gas Transmission, National Grid Electricity Transmission and SSEN Transmission did not appeal the ongoing efficiency challenge in Ofgem's RIIO-T2 Final Determination. Whilst this does not imply that those companies agreed with the ongoing efficiency challenge that was set, they are subject to an ongoing efficiency challenge of 1.15% for capex/repex and 1.25% for opex.

3. EFFICIENCY TARGETS IN OTHER REGULATED SECTORS

National Highways has made significant progress since 2015 but is not yet operating close to the efficiency frontier. This conclusion is supported by the findings of the Capability Reviews which recommend efficiency ranges of between:

- 5% to 15% cumulatively between RP2 and RP3 in relation to maintenance and renewals; and
- 9% to 16% for enhancement schemes during the Options stage, reducing to 1% to 3% for schemes after the Development stage and/or are already in flight.

We analysed a range of recent regulatory determinations in the UK and Ireland to back out an estimate of the range of 'catch-up' efficiency challenges applied elsewhere. We find that the average catch-up efficiency challenge in the most recent regulatory determinations range from around 0.3% for RIIO-ED2 (electricity distribution) to 1.5% for PR18 (Network Rail). But for the least efficient companies the catch-up challenge is much greater, typically between 2.2% for RIIO-GD2 (gas distribution) to 4.4% for PR19 (water and wastewater).

In our view, direct comparisons between the efficiency challenges applied elsewhere and National Highways should be made with care because:

- The analytical challenges in arriving at like-for-like estimates for the efficiency challenges set across different price controls are complex; and
- There are significant differences between the incentive-based regulatory frameworks which apply to the energy, water and aviation sectors, and the regulatory, commercial and policy framework which applies to National Highways.

However, if utilised as a 'cross-check' then our research lends support to the upper end of the efficiency ranges which emerge from the Capability Reviews because:

- Our analysis of the catch-up challenge applied in other regulatory determinations between 2009 and 2014 suggests efficiency improvements of between 0.5% and 3.5% p.a. The mid-point of this range is consistent with the mid-point of the annualised improvements implied by the Capability Reviews.
- This analysis is likely to be conservative, in that National Highways is entering only its third Road Period and the experience from other regulated sectors illustrates that the scope for catch-up efficiency tends to reduce as the inefficiencies from the pre-privatisation era are driven out.
- Our understanding is that the Capability Reviews are substantially based on 'catching up' to best practice rather than improvements in the technological frontier. But in practice the distinction between these two concepts is difficult to identify, so ORR will need to consider any overlaps between the efficiencies identified in the Capability Reviews to avoid the scope for 'double-counting'; and it should form a clear view on whether the efficiencies identified represent 'catch-up' to best practice or improvements in the technological frontier.

Since National Highways was transformed into a government-owned company in 2015, various ORR studies have found that it has made significant progress and has become a more mature asset management and capital delivery organisation.[27] But they also conclude that there is scope for further development in the organisation's capabilities and maturity of plans and processes.

Moreover, the NAO recently concluded that by 2025 National Highways will have completed less work during RIS2 and at a higher cost than originally planned, and that it should have done more to plan for and manage the potential risks to the portfolio of enhancement projects.[28] Altogether, the Company's current performance is not that of a

[27] ORR (June 2019) "RIS2 Efficiency Review" available online.

[28] NAO (November 2022) "Road enhancements: progress with the second road investment strategy" available online.

company which operates at the efficiency frontier and in our view there remains significant scope to improve its planning and the stability of the work programme, and to procure from the supply chain more efficiently.

In that context, there should be substantial further efficiency gains as the Company catches up with best practice in other regulated sectors, and embeds transformation initiatives which may bear fruit during RIS3. In this section, we analyse the efficiency challenges that have been set in other regulated sectors and evaluate an overall efficiency range that would represent a reasonable challenge for ORR to set National Highways during the RIS3 period.

3.1. CATCH-UP EFFICIENCY TARGETS IN RECENT PRICE CONTROL REVIEWS

Catch-up efficiency is distinct from ongoing efficiency. It is a measure of the relative efficiency of individual firms within an industry in comparison to the productivity frontier. Therefore, catch-up efficiency is often company-specific, and there can be significant scope to catch-up to the most efficient firm in the sector, as we discuss below.

The method used to determine an appropriate catch-up efficiency challenge differs between regulators and determinations. Broadly, the method can be categorised by the type of approach:[29]

- **Top-down:** benchmarking costs on a total (totex) or aggregated basis (opex or capex). Regulators often construct a regression model (or range of regression models) using 'modelled costs' which remove unique (or company-specific) costs items, to estimate efficient costs based on costs drivers.
- **Bottom-up:** an assessment of costs on an individual cost category basis. Regulators often take a 'base-step-trend' approach, taking a view of an efficient 'base' year (sometimes based on realised costs from a previous outturn year). 'Base' costs are then adjusted for 'steps' up or down and cost 'trends'.

Some regulators also use a mixture of these approaches, either taking a weighted average of different models, or using top-down benchmarking to adjust bottom-up base costs. Regulators are most likely to undertake a bottom-up assessment where there are no appropriate comparators for an industry, if there is only one firm in an industry, or when the company data is poor. We provide a brief summary of the process undertaken in the RIIO-ED2 price review and the PC4 determination in Appendix B, to illustrate how cost assessment processes can differ.

Cost assessment is an analytically intensive exercise, requiring a myriad of methodological decisions based on the specific context of the industry, availability of data, and confidence in the accuracy of the modelling. Given the complexities and differences present in the different determinations that hinder a like-for-like comparison across the regulated sectors, we have made several simplifications for analytical purposes in order to present the catch-up efficiencies as a single annual percentage figure.[30] Therefore, we suggest that the catch-up efficiency values presented in this section of the report are interpreted as approximations rather than precise estimates.

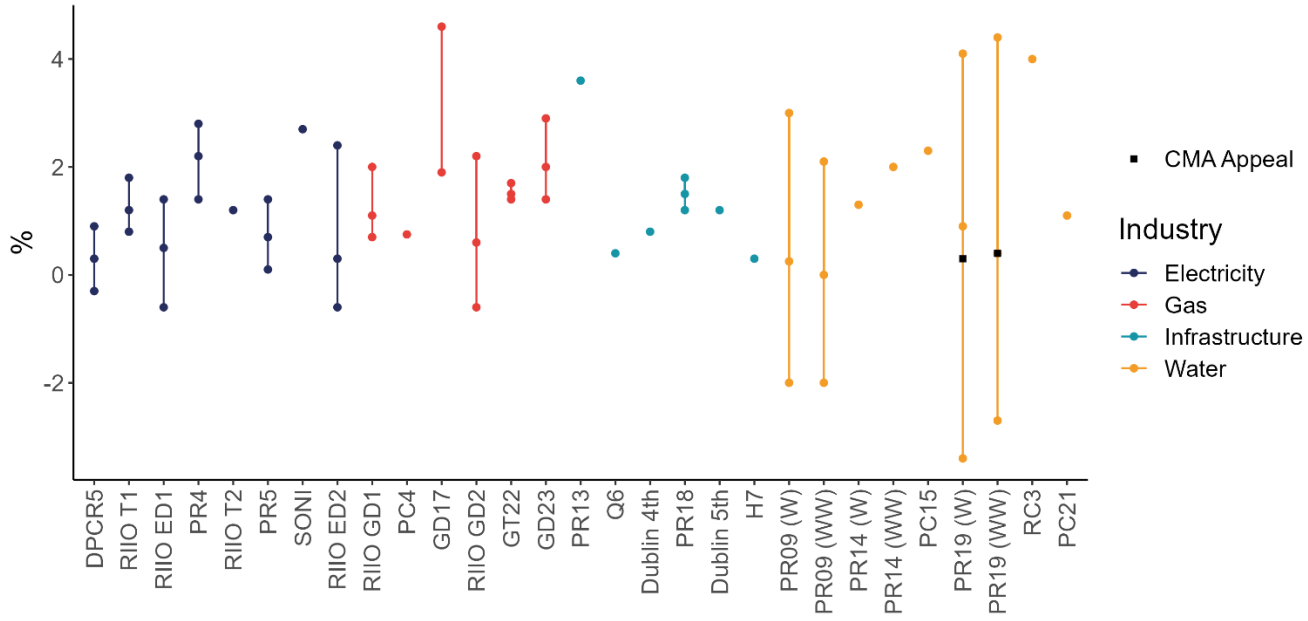
We have extended the analysis which informed our 2018 report. Figure 3.1 and Table 3.1 below present our analysis of the most recent regulatory determinations in the UK and Ireland. We show both the average catch-up efficiency challenge for the sector overall (i.e. a measure of the distance from the efficiency frontier of the theoretical industry average firm), as well as the range of catch-up efficiency challenges set by the regulator. Firms which are operating beyond the efficiency benchmark are represented with negative values in the figure.[31]

[29] These are the most common methodologies for calculating catch-up efficiency, but regulators also employ other approaches.

[30] Catch-up efficiency is typically presented as a cut to a company's costs (submitted or historic) as opposed to an annual % change. We calculated an annual percentage change to make the figure comparable to the presentation of ongoing efficiency.

[31] Negative values are possible as regulators often set the efficiency benchmark below their calculated frontier (e.g. at the level of the upper-quartile efficient firm). Regulators may choose to apply a 'ratchet' which caps allowances and prevents relatively efficient companies from receiving more than their submitted costs.

Figure 3.1 Catch-up efficiency ranges for selected UK & Ireland regulatory decisions (% p.a., 2009 – present)



Source: CEPA analysis of Regulatory and CMA Final Determinations

Table 3.1 Recent catch-up efficiency targets set in Great Britain

Industry	Price control (period)	Method	Catch up (%, p.a.)	
			Average	Range
Water	PR19 (2020-24)	Top-down 4th place company*	0.9% (totex)*	-3.4% to 4.1% (totex)*
Wastewater	PR19 (2020-24)	Top-down 3rd place company*	0.4% (totex)*	-2.7% to 4.4% (totex)*
Electricity	ED2 (2023-28)	Top-down Glidepath UQ to 85th	0.3% (totex)	-0.6% to 2.4% (totex)
Gas	GD2 (2021-26)	Top-down Glidepath UQ to 85th	0.5% (totex)	-0.6% to 2.2% (totex)
Rail	PR18 (2019-24)	Bottom-up for different asset types	1.5% (OSMR)	1.2% to 1.8% (OSMR) between NR routes

*Source: CEPA analysis of Regulatory Final Determinations; Note: negative values represent firms that are more efficient than the catch-up efficiency benchmark. *Revised by the CMA appeal.*

We provide a more comprehensive table of figures in Appendix B.

Our analysis shows that a broad range of catch-up efficiency challenges have been set over the past 15 years. The average catch-up efficiency challenge (i.e., the difference between the industry average and the benchmark) ranges from 0.3% for RIIO-ED2 to 1.5% for Network Rail in PR18, which was set after significant underperformance against the PR13 efficiency challenge.[32]

But for the least efficient firm in each sector, the catch-up efficiency challenge has varied from 2.2% in RIIO-GD2 to 4.4% in PR19. We discuss why the magnitude of catch-up efficiency challenges differs between individual

[32] We have interpreted ORR's efficiency challenge for Network Rail in PR18 as a catch-up efficiency challenge as each region's costs were benchmarked against each other and no explicit ongoing-efficiency challenge was set.

companies and sectors below. But at a high-level, the difference is reflective of the drivers which cause firms to be closer or further from the catch-up efficiency frontier, and in some cases reflects the methodological choices made by the regulator which can be subject to challenge. For example, Ofwat's PR19 efficiency challenge was revised down by the CMA to 0.3% and 0.4% for the notional industry average firm. The CMA decided that a less stretching benchmark (at the upper quartile) better represented limitations in the econometric modelling.[33]

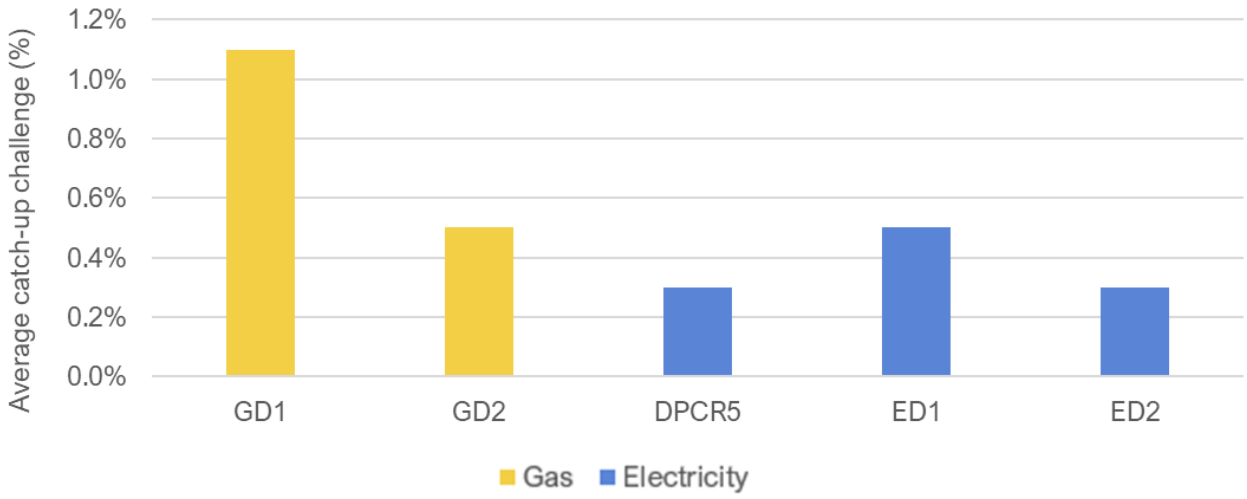
3.2. THE EVOLUTION OF CATCH-UP EFFICIENCY OVER TIME

As the catch-up efficiency challenge is intended to incentivise relatively inefficient companies to adopt industry best practices and reduce the gap to the efficiency frontier, then in theory (assuming the incentives work) the catch-up efficiency challenge will typically reduce over time as inefficiency is driven out.

This effect was observed in CEPA's 2018 report for ORR. In that report, we presented the evolution of catch-up efficiency challenges that Ofgem set the electricity distribution companies for the first four regulatory periods, showing that catch-up efficiency was most significant after the first and second regulatory periods, but levelled off after the third.[34]

We briefly update this analysis by looking at recent trends in the energy sector, for gas and electricity distribution companies since 2010. We exclude electricity and gas transmission as it is assessed on a bottom-up basis, on account of its predominantly bespoke investment package, which makes the efficiency challenge less representative of a year-on-year annual percentage change. The results are presented in Figure 3.2 below.

Figure 3.2 Evolution of catch-up efficiency challenge, GB energy sector (average annual, %)



Source: CEPA analysis of Regulatory Final Determinations

Our analysis shows that the average annual catch-up efficiency challenge declined between GD1 and GD2, and remained relatively stable in the last three electricity distribution determinations but decreased between ED1 and ED2. [35] The figures for electricity distribution are significantly lower than the catch-up efficiency challenges set in gas distribution (ranging from 0.3% to 0.5% for ED and 0.5% to 1.1% for GD).

[33] CMA (2019) "Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations", pages 232-233, available online.

[34] CEPA (July 2018) "Productivity growth in capital intensive sectors" available online.

[35] As stated earlier, estimates are sensitive to the method of estimation. This has been decided based on the availability of data. For the ED2 figures, we have been able to calculate the difference between the modelled regression line to the benchmark challenge for our estimate of the industry average catch-up efficiency. However, if we had used a different methodology (e.g. the average of the individual catch-up challenges) then the estimate would have been higher.

Inferring trends from the comparison of individual determinations should be done with care, both on account of changes in regulatory priorities which are not captured in efficiency challenge figures (for example requirements to improve quality of service, improve resilience or support wider environmental outcomes), as well as methodological differences underpinning top-down benchmarking (but which are not represented in a single annual figure). For example, the catch-up challenges in the figure above are calculated using different benchmarks: for ED1 and GD1 the benchmark was set at the upper quartile (with a glidepath for GD1), whereas for ED2 and GD2 it has been strengthened to the firm operating at the 85th percentile (both with a glidepath). These methodological decisions may reflect the scope for greater average efficiency in the industry, or alternatively greater confidence of the regulator in their efficiency models.[36]

3.3. ACTUAL COMPANY EFFICIENCY PERFORMANCE

3.3.1. Regulated company outperformance

In the previous section we show other regulated sectors have been set stretching efficiency challenges. In some cases, this amounts to an efficiency challenge of around 10% for the sector as a whole over 5 years (including frontier shift), or over 20% for the least efficient companies. This a significant reduction on their submitted or historic costs.

Despite the stretching nature of this challenge, there is relatively robust evidence that many regulated companies have been about to outperform their cost allowances and achieve substantial efficiency gains in practice.

In the gas distribution sector, Ofgem has observed significant outperformance against the RIIO-GD1 allowances. At the time of its GD2 Final Determination, all the GDNs were forecast to materially outperform their GD1 allowances. As part of its submission to the CMA in the RIIO-GD2 appeals Ofgem carried out a 'high-level' exercise to assess the extent of this historical outperformance.[37] It found that Northern Gas Networks (NGN) – as the frontier company over the course of RIIO-GD1 – had achieved efficiency improvements of around 1.5% per year over and above the GD1 ongoing efficiency challenge (0.85%) whilst the average for the overall gas distribution sector was 2.3%. Ofgem concluded that NGN's performance gave it comfort that the ongoing efficiency challenge set for RIIO-GD2 was stretching but achievable.

It is important to recognise that Ofgem could not attribute all the sector underspend to efficiency, but it argued that it was reasonable to suppose that some of it could be, as this was consistent with the network companies' own statements that efficiency improvements had contributed to the underspend. Ultimately, Ofgem concluded that it found its historical analysis of outperformance during RIIO-1 helpful as a 'cross-check', but it was not determinative of what the underlying scope for productivity growth should be for RIIO-GD2.[38]

Some regulated company outperformance is also observable in the water sector. Both Anglian Water (8%) and Northumbrian Water (6%) underspent significantly against their total allowed costs for PR14. The CMA stated that for these firms the underspend could be *"interpreted as suggesting that the [PR14] upper quartile efficiency challenge was particularly manageable".*[39] However, outperformance is not as pervasive in the water sector. On average the industry overspent their wholesale totex allowances by 1% between 2015 and 2020.

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[36] As acknowledged in the GD1 Final Determinations *"the use of the UQ rather than the frontier acknowledges that a part of the difference in costs across the GDNs relates to factors other than GDNs' relative efficiency (eg statistical errors)."* – Ofgem (December 2012) "RIIO-GD1: Final Proposals – Supporting document – Cost efficiency" available online.

[37] CMA (2021) Energy Licence Modification Appeals: Joined Grounds Volume 2B, para 7.295 to 7.347, p.144.–156, available online.

[38] The CMA found that Ofgem had erred in its calculation of the extent of NGN's outperformance, although NGN did not dispute that it had achieved efficiencies in excess of 1.2% p.a. during RIIO-GD1.

[39] CMA (2019) "Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations", page 228, available online.

3.3.2. Academic studies on historical productivity growth

We also reviewed three academic reports which sought to measure more directly the productivity gains which have been achieved in the energy and water sectors since privatisation:

- Frontier Economics (for Water UK) estimates that productivity improvements achieved in England's water and sewerage sectors averaged 2.1% over the period 1994–2017;[40]
- The University of Cambridge Energy Policy Research Group (EPRG) estimates that productivity growth amongst the GB electricity and distribution networks has been in the region of 1% p.a. over the period 1990/91 to 2018/19[41]; and
- NERA (for the Energy Networks Association) estimates that historical TFP growth in the electricity distribution sector has averaged around -0.1% to 0.4% over the period 2010/11 to 2019/20.[42]

A more detailed summary of the approach and key findings of each paper is provided in Appendix C.

One of the challenges of directly estimating outturn productivity growth in a sector subject to price cap regulation is that outputs are generally not purchased at market prices. In such circumstances, the conventional growth accounting approach to calculating TFP growth by comparing the value of outputs against the value of inputs is very challenging.

The three studies present significantly different results for productivity growth in their respective sectors. For example, Ajayi et al (2021) estimates that historic TFP growth achieved in the electricity distribution sector ranges from between -5.5% to 3.8% per annum depending on the model specification used. But the findings appear to support the hypothesis that the rate of productivity growth in other regulated sectors was greater in earlier price control periods and has probably slowed as the inefficiencies of the pre-privatisation era have been driven out. They also show that, as the energy and water companies have delivered a wider range of outputs such as reliability, reduced leakage, improved customer service and better environmental outcomes, the measurement of productivity has become more challenging. It seems plausible that some of these studies underestimate productivity growth in more recent periods as the regulators have placed greater emphasis on these wider outputs.

Overall, we conclude that the academic evidence on historical productivity growth in other regulated sectors is highly variable and appears dependent on the assumptions and variables used. In our view, there is robust evidence that the regulated energy and water companies have been able to deliver substantial productivity growth since privatisation, but precisely how much growth is sensitive to the method of analysis. We would caution ORR against using this analysis to derive specific assumptions about the precise scope for productivity growth in RIS3.

3.4. Interpretation of the efficiency evidence in the context of RIS3

In our 2018 report we concluded that the sectors which were most comparable to National Highways were:[43]

- Ofwat's determinations for England and Wales water and sewerage companies;
- Ofgem's determinations for GB electricity distribution companies; and
- ORR's determinations for Network Rail.

[40] Frontier Economics (2017) "Productivity improvement in the water industry in England since privatization" available online.

[41] Ajayi et al. (2021) "Incentive regulation, productivity growth and environmental effects: electricity networks in GB" available online.

[42] NERA (2021) "Ongoing efficiency improvement at RIIO-ED2 – report for the ENA", Section 4, available online.

[43] CEPA (2018) "Productivity growth in capital intensive sectors" available online.

We made these comparisons on the basis that each of these industries has large capex programmes, a feature which was shared by National Highways' RIS2 investment programme. At the outset of RIS2, National Highways was allocated £27.4 billion, of which £14.2bn of which was for defined enhancement schemes.[44]

The electricity and gas distribution networks, water companies and Network Rail are now in, or about to enter, their seventh price control period. In our view, it would not be appropriate to compare the scope for efficiency in RIS3 with the targets set in the most recent price controls because:

- National Highways is preparing to enter only its third road period; and
- The emerging RIS3 Capability Reviews find that it will take several road periods to fully implement and catch-up with best practice in other sectors.

Instead, we suggest that it would be more appropriate to compare the scope for efficiency in RIS3 with the targets set in other regulatory determinations which were made between 2009 and 2014, as shown in Table 3.2 below.

Table 3.2 Comparable price control determinations set between 2009 and 2014

Industry	Price control (period)	Catch up (%, p.a.)		Ongoing efficiency	Total efficiency (average)	
		Average	Range		Average	Range
Water	PR09 (2010-15)	Not reported	0% to 2.9% (opex)	0.25% (opex)	Not reported	0.25% to 3.15% (opex)
		0.2% (capex)*	-2.8% to 3.1% (capex)*	0.4% (capex)	c. 0.6% (capex)	c. -2.4% to 3.5%
Waste-water	PR09 (2010-15)	Not reported	0% to 2.2% (opex)	0.25% (opex)	Not reported	0.25% to 2.5%
		0% (capex)*	-3.1% to 2.0% (capex)*	0.4% (capex)	c. 0.4% (capex)	-2.7% to 2.4% (capex)
Gas	GD1 (2013-21)	1.1% (totex)	0.7% to 2.0% (totex)	1% (opex); 0.7% (capex and repex)	c. 2.0%	c. 1.6% to 2.9%
Electricity	ED1 (2015-23)	0.5% (totex)	-0.5% to 1.4% (totex)	0.8% - 1.1%	c. 1.4%	c. 0.5% to 2.3%
Rail	CP5 (2014–19)	3.6% (OSMR)		0.4% (enhancements)	c. 4.0%	N/A%

*Source: CEPA analysis of Regulatory Final Determinations; Note: negative values represent firms that are more efficient than the catch-up efficiency benchmark; * we have combined values for capex infrastructure and capex non-infrastructure*

We find a catch-up efficiency range of between -3.1% and 3.1% and a total efficiency range of between -2.7% and 3.5% (including ongoing efficiency). The PR09 determination sets the upper and lower bounds. This is partly accounted for by Ofgem's choice of benchmark (the median company) which by design will result in a lower average industry score and more companies achieving better efficiency scores. In later determinations Ofwat has transitioned to using a more stretching benchmark, although the CMA revised the challenge down for some companies in both PR14 and PR19.

[44] This was later revised to £24bn via the Government's Spending Review 2021, with £3.4bn moved into RP3.

The RIIO-GD1 determination represents what appears to be the most stretching average industry challenge. But the outperformance of the GDNs across the period (underspending by around 10% on average) – and achieved without compromising on delivery standards[45] – suggests that this level of efficiency was achievable.

These determinations represent the fifth and sixth control periods in these sectors. In our view, there is no perfect benchmark against which we can compare the scope for efficiency in RIS3. On the one hand, much of the inefficiency of the pre-privatisation era had been driven out of these sectors by the time of the price controls shown in Table 3.2. Therefore, those efficiency targets might be considered conservative relative to the efficiency gains that might be achievable for National Highways in RIS3. On the other, it is increasingly difficult to make comparisons with efficiency targets set 15–20 years ago given the gradual evolution over time in the economic and commercial environment in which these companies operate. We think our approach finds a reasonable balance.

3.5. Conclusions on the scope for efficiency gains in RIS3

Based on the catch-up efficiency targets set in other recent price reviews and placing greatest weight on those determinations which took place around 10–15 years ago, we find that **regulatory precedent supports an annual catch-up efficiency challenge of between 1.5% and 2.5%** and that a frontier shift challenge of between 0.5% and 1.2% could be applied on top.

However, given issues of comparability between the framework within which National Highways will operate in RIS3 and the most recent regulatory determinations in other sectors, we recommend that ORR uses the evidence presented in this research as a 'cross-check' for the more detailed and targeted estimates which are emerging from the RIS3 Capability Reviews.

The RIS3 Capability Reviews had not been finalised at the time of our research. But we understand that:

- The Asset Management Capability review is likely to find that National Highways has made improvements across a range of maturity areas and is now more consistently 'effective'. Significant improvements are yet to be made in key areas such as risk assessment, organisational culture, asset performance and health monitoring, and overall National Highways remains behind the improvement trajectory identified in 2018 (for example, it states that National Highways is still to achieve ISO 55001 accreditation for the maturity of its asset management processes). **The review is likely to recommend an efficiency range of 5% to 15% cumulative over RIS3** supported by case studies of the efficiency improvements made by other similar organisations based on a similar trajectory.
- The Procurement and Project Management Capability review is likely to identify a top-down efficiency range which can be applied to individual projects and adjusted depending on the programme to which that project belongs and its position in the project life cycle.[46] **It is likely to recommend an efficiency range of 9% to 16% for enhancement projects at the 'During Options' stage and 6% to 11% for projects at the 'After Options' stage.** At the time of our research, the headroom for new enhancement projects and the overall size of the RIS3 funding package is uncertain but is likely to be a multi-billion pound investment.

ORR will need to consider any overlaps between the efficiencies identified in the Capability Reviews to avoid the scope for 'double-counting'. At a high level, the efficiencies identified in the Asset Management Capability review are more applicable to maintenance and renewals, whilst the efficiencies identified in the Procurement and Project Management Capability review are more applicable to enhancements. But there may be common areas of efficiency: for example, the (draft) Procurement and Project Management Capability review identifies 'Quality Management' as one of National Highways' capability initiatives, which intends to encourage a 'whole life' reduction in waste and improved efficiency across all capital works.

[45] CEPA (for Ofgem, 2018) "Review of the RIIO Framework and RIIO-1 Performance" available online.

[46] We understand it is likely to recommend that the scope for efficiency improvements reduces as projects mature from the 'Options' stage to the 'Construction' stage.

ORR should form a view on whether the efficiencies identified represent 'catch-up' to best practice or 'frontier shift', although we recognise that the boundary is difficult to define in practice. For example, the 'Innovation Re-applied' initiative is meant to improve productivity via a systematic and repeatable production approach to major projects development and delivery. It also makes a significant contribution to the emerging efficiency range in the Procurement and Project Management Capability review. Depending on the innovation in question, this might be considered 'frontier shift' but in our experience it is more likely that National Highways is at a stage where it is applying good practice from elsewhere to better incentivise innovation in the supply chain. Overall, we anticipate that the Capability Reviews identify efficiency gains which seem likely to be predominantly catch-up efficiencies.

ORR should also seek to understand the basis on which National Highways has benchmarked its RIS3 enhancement costs and form a view on whether 'frontier shift' efficiencies are likely to be baked into those estimates already. Sometimes, other regulators such as Ofgem do not apply frontier shift to the costs of more bespoke enhancement projects which have been assessed from a technical engineering perspective, to avoid the risk of double counting the scope for efficiency gains.

We note that the overall size and shape of the RIS3 programme is still uncertain. ORR should note the possibility that this may impact National Highways' ability to obtain efficiencies through enhancement schemes which are currently going through the 'Options' stage, e.g. via earlier engagement with potential contractors on scheme design. However, we expect this to have less of an impact on maintenance and renewals, since the overall volume of work exhibits a greater consistency across years given the more repeatable nature of most activities in general.

Overall, we conclude that our research lends support to the upper end of the efficiency ranges which emerge from the RIS3 Capability Reviews. Additionally, ORR concluded that in the round the evidence was sufficient to conclude that National Highways achieved its efficiency KPI target for RIS1[47] and the Company reports that it is broadly on-track in RIS2 (although it notes that additional challenges have materialised, including the impact of increasing inflation).[48] In our view, this suggests that a target in the upper half of the proposed ranges would be challenging but achievable.

Table 3.3: Efficiency implied by the catch-up efficiency ranges for RIS3 based on the capability reviews (% p.a.)

Category	Catch up	Frontier shift	Total efficiency
Operations and maintenance	1.0% – 2.8%	0.8% – 1.2%	1.8% – 4.0%
Renewals	1.0% – 2.8%	0.5% –1.2%	1.5% – 4.0%
Enhancements (during Options stage)	1.7% –3.0%	0.5% –1.2%	2.2% – 4.2%
Enhancements (after Options stage)	1.2% – 2.1%	0.5% –1.2%	1.7% – 3.3%
Enhancements (after Development stage)	0.2% – 0.6%	0.5% – 1.2%	0.7% – 1.8%

Source: Catch-up efficiency drawn from CEPA analysis of efficiency ranges presented in Nichols (2023) "RIS3 Procurement and Project Management Capability Review" and AMCL (2023) "Asset Management Capability and Efficiency Review". Frontier shift efficiency based on the research presented in this report. Note that frontier shift may not be applicable to all enhancement schemes if it has already been baked into the method of cost estimation.

[47] ORR (2020) "Annual assessment of Highways England: End of Road Period 1", p.57., available online.

[48] National highways (2022) "Efficiency Report Year 2: 2020–22" available online.

POSTSCRIPT

After the completion of our Final Report in March 2023, the Luiss Lab of European Economics published a new release of the EU KLEMS dataset using more recent national accounts data (the "2023 release").[49] As well as incorporating the latest national accounts data, the 2023 release also extends the time period over which Total Factor Productivity ("TFP") growth can be calculated for the UK, which now extends from 1995 to 2020.

To take account of the latest EU KLEMS release, the ORR asked CEPA to update the EU KLEMS analysis and consider whether this additional evidence would affect the scope for 'frontier shift' productivity growth in the highways sector during RIS3.

Changes reflected in the 2023 release of EU KLEMS

EU KLEMS now incorporates more recent national accounts data for the UK. As such, it also reflects important changes to the measurement of current price and volume gross domestic product ("GDP") introduced by the ONS as part of Blue Book 2021.[50] Blue Book 2021 helped to improve the international comparability of the UK GDP estimates, with a package of improvements made in line with international best practice. Amongst other improvements, the Blue Book 2021 introduced:

- Double deflation, which is widely recognised as the best approach to produce volume ('real') estimates of gross value added ("GVA"), where GVA is output minus intermediate consumption. For every industry, the current price estimate of its output is deflated by a price index for output and separately the current price estimate of its inputs is then deflated by an input price index.[51]
- More granular reconciliation of volume estimates of production and expenditure within the Supply and Use Tables ("SUT") framework, at a lower industry and product level.
- An updated telecoms deflator, to include data on business-to-consumer sales, broadband and mobile data. This captured the effect of bundling of services, tackled the underrepresentation of internet services, and improved the handling of access charges, resulting in new estimates of price changes within telecoms.
- The new Financial Services Survey to better estimate the output and intermediate consumption of Other Financial Institutions and capture the changing nature of the financial services industry.[52]

In combination, these improvements resulted in relatively modest revisions to aggregate volume UK GDP. It reduced average volume GDP growth in the period 1998 to 2007 by around 0.2% per year, whereas annual GDP growth over the period 2010 to 2019 was revised up by around 0.2% per year.[53]

But the changes at the industry level are more significant, which drives significant differences between average annual TFP growth between the 2019 release and the 2023 release of EU KLEMS. In particular, the impact of the Blue Book 2021 means that EU KLEMS now shows stronger TFP growth in many manufacturing sectors, weaker TFP growth in many services and other non-manufacturing sectors (except for information and communications) and a larger contraction in the construction industry during the years of the global financial crisis ("GFC").

[49] Available at https://euklems-intanprod-llee.luiss.it/

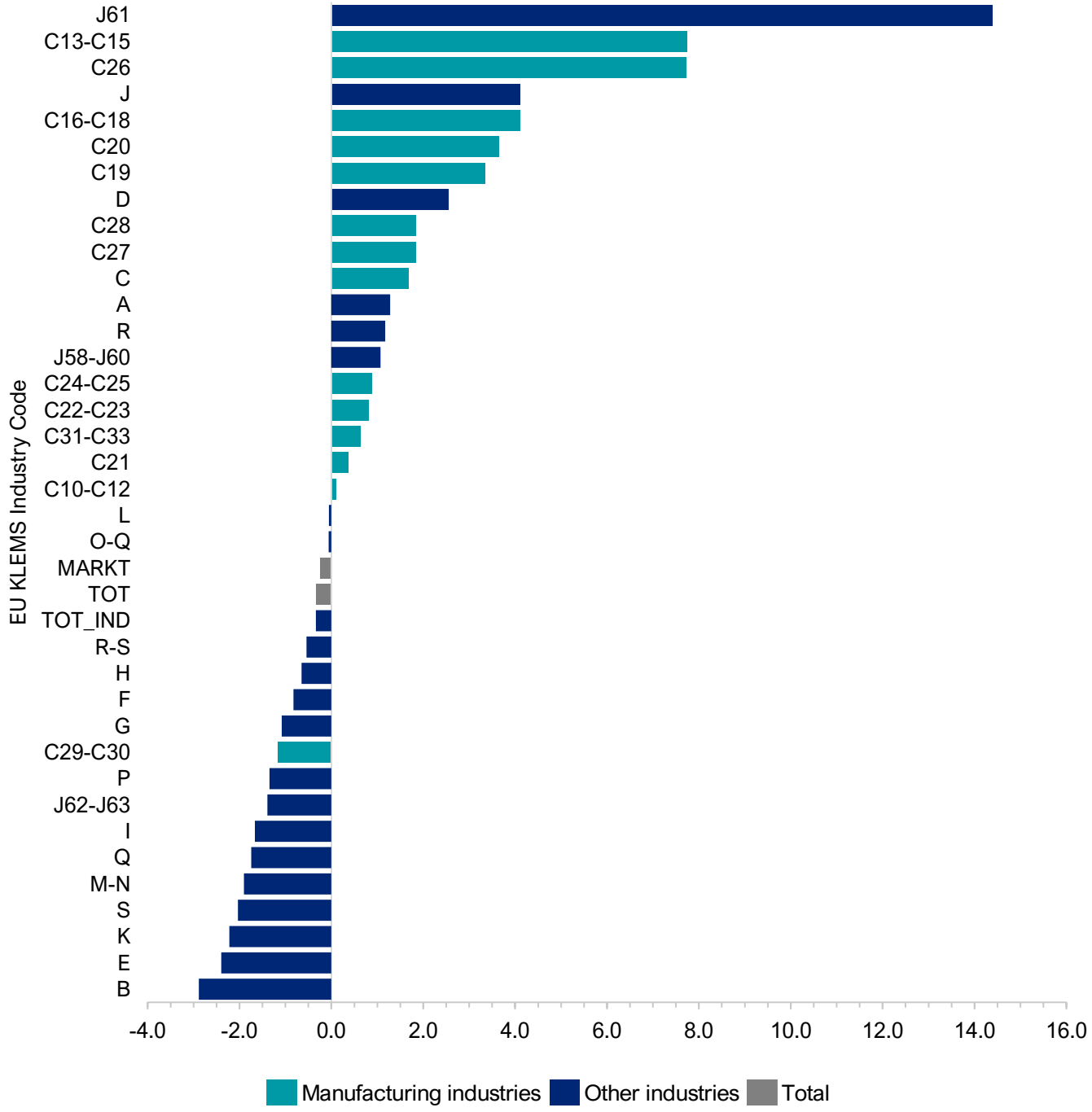
[50] ONS (June 2021) "Impact of Blue Book 2021 changes on current price and volume estimates of gross domestic product" available at ons.gov.uk.

[51] ONS (May 2021) "Double deflation methods and deflator improvements to UK National Accounts" available at ons.gov.uk.

[52] ONS (June 2021) "Financial services sector methods changes: 1997 to 2019" available at ons.gov.uk.

[53] ONS (June 2021) "Impact of Blue Book 2021 changes on current price and volume estimates of gross domestic product" available at ons.gov.uk.

Figure 3: Differences in average annual TFP VA growth (1996-2016) by industry, percentage point difference using the 2019 and 2023 releases of the EU KLEMS database



Updated EU KLEMS results

For the purposes of this postscript, we updated the results of the growth accounting analysis which is presented in Section 2.3 of the main body of this report. We adopt the same measures of productivity and the same comparator sets but, since EU KLEMS now includes an additional 4 years of data, we extend the time period from 1996–2016 to 1996–2019.[54]

[54] We decided to exclude TFP growth rates for 2020 from this analysis due to the exceptional impact of Covid-19 on output and labour, and therefore productivity. We also note that the ONS' understanding of the impact of Covid-19 on the macroeconomy continues to improve over time. This is reflected in recent revisions to GDP data for 2020 and 2021 which showed that the economic recovery was stronger than previously understood (see bbc.co.uk).

The results are shown in Table 3.4 below which shows that, depending on the comparator set, TFP VA growth ranges from -0.52% to +2.73%, TFP GO growth from -0.36% to +1.03%, and LP growth from 0.00% to 3.51%.

Table 3.4 Productivity estimates (average annual growth rate, 1996-2019)

Average growth (%)	TFP GO	TFP VA	LP
Construction	-0.54%	-0.37%	-0.10%
Transport and storage	-0.31%	-0.30%	0.37%
Professional, scientific, technical, administrative and support service activities	-0.54%	-0.34%	0.28%
Information and communication	7.09%	3.88%	8.27%
Manufacture of chemicals and chemical products	5.93%	2.13%	6.04%
Manufacture of computer, electronic and optical products	8.14%	2.95%	8.74%
Manufacture of electrical equipment	3.64%	1.34%	4.21%
Manufacture of transport equipment	1.61%	0.27%	3.26%
Narrow set: renewals (weighted)	-0.36%	-0.51%	0.00%
Narrow set: enhancements (weighted)	-0.36%	-0.52%	0.02%
Broader comparator set (unweighted)	1.03%	2.73%	3.51%
Market economy (weighted average)	0.26%	0.58%	1.45%

Source: CEPA analysis of EU KLEMS data from the 2023 release

The 2023 release supports a much wider underlying TFP estimate of between -0.4% (the simple average of the TFP GO and TFP VA growth rates for the narrow comparator sets) and +1.9% per year (the simple average of the TFP GO and TFP VA growth rates for the broader comparator set), where:

- The bottom end of the range reflects the significant downwards revision to TFP growth in the Construction sector and the Professional, scientific, technical, administrative and support service activities sector.
- The top end of the range reflects the significant upwards revision to some of the sectors in the 'broader comparator set', specifically the Information and Communications sector and Manufacturing sub-sectors for Chemicals and Chemical Products; Computer, Electronic and Optical Products; and Electrical Equipment.
- The market economy comparator set has been revised down slightly (by 0.1%–0.2%) due to the inclusion of 3 years of new data, during which aggregate UK TFP growth remained below the pre-GFC trend.

Interpretation of the latest EU KLEMS results and the scope for frontier shift

Setting the lower end of the range

In our view, it would not be appropriate to set the lower end of the range based only on the average TFP growth rate in the construction sector over the period 1996–2019. To do so would imply that the scope for technological change in the highways sector over the next 5-year investment period is negative.

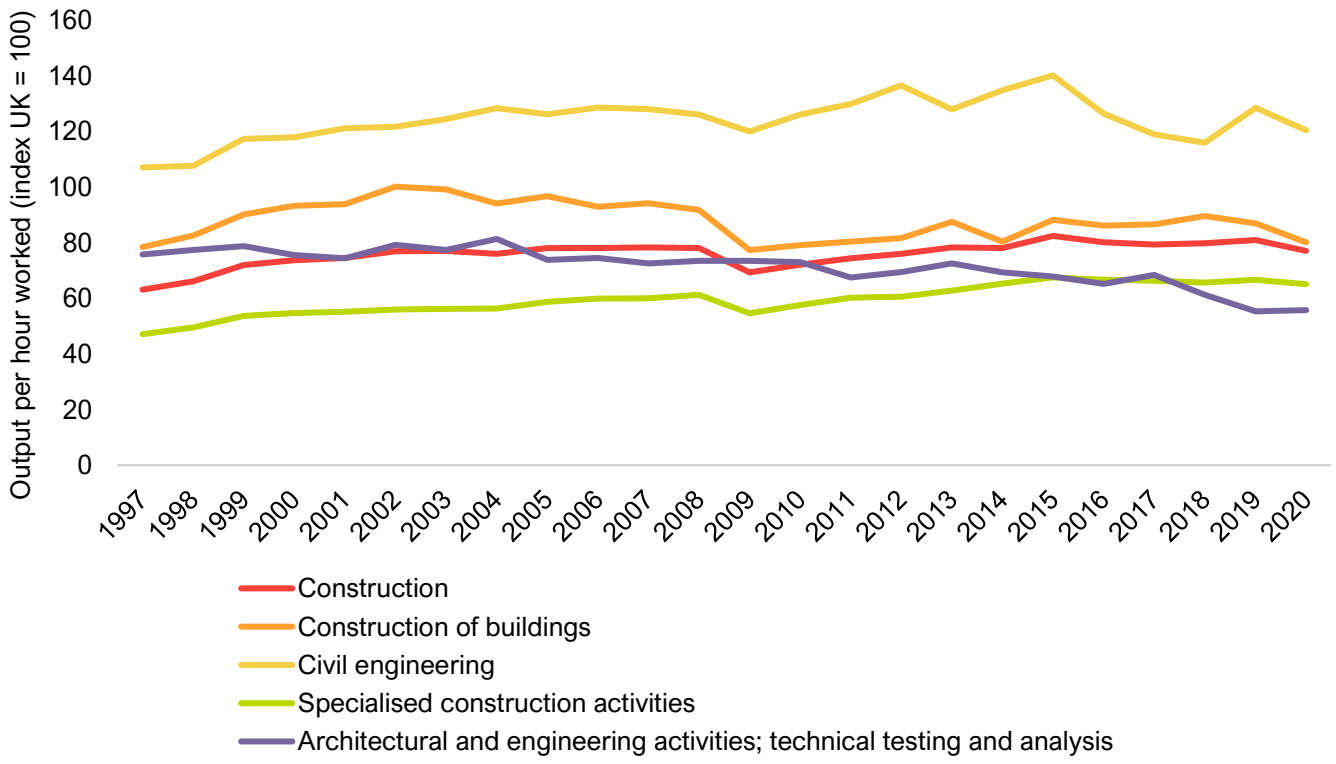
There are several factors which are generally regarded as hindering productivity growth in the construction sector relative to the UK economy as whole.[55] For example, HM Treasury's *Infrastructure Cost Review* found that:

[55] We note that poor construction sector productivity growth is not limited to the UK, and is also an issue in the US, for example.

- The industry is relatively dependent on public sector demand and is highly 'stop-start', which results in an unpredictable pipeline of work, insufficient planning and the inefficient ramping up and ramping down of resources.
- The industry is highly fragmented and competitive, which increases transaction costs, suppresses margins and deters a more strategic approach to investment in skills, technology and innovation.
- Clients are often risk averse, and prone to over-specification and unnecessary standards.
- The sector is adjusting to produce higher quality outputs which are not well reflected in the economic statistics but add to the cost of delivering infrastructure projects, such as new and evolving standards to reduce the environmental impact of construction and improve the safety of construction workers.[56]

Although productivity growth in the construction sector as a whole has been weak since at least the early 1990s, the construction of highways, public infrastructure and the civil engineering sub-sectors more broadly are only a subset of the construction sector. Civil engineering accounts for only 20% of construction sector GVA on average over the past 10 years.[57] Infrastructure accounts for about 20% of all new construction output on average over the past 10 years, although this has increased to 25% since Covid-19 due to a slowdown in the private commercial sub-sector.[58] We also note that the civil engineering sub-sector is more productive relative to the UK average on an output per hour worked basis (see Figure 4 below) and output was less affected by the GFC and its impact on housebuilding (see Figure 5 below). This suggests that any findings from total construction sector TFP growth to the scope for productivity growth in the highways sector in RIS3 should be made with caution.

Figure 4: Output per hour worked, construction industry and sub-industries, UK, 1997 to 2020, level relative to whole economy (index UK = 100)[59]



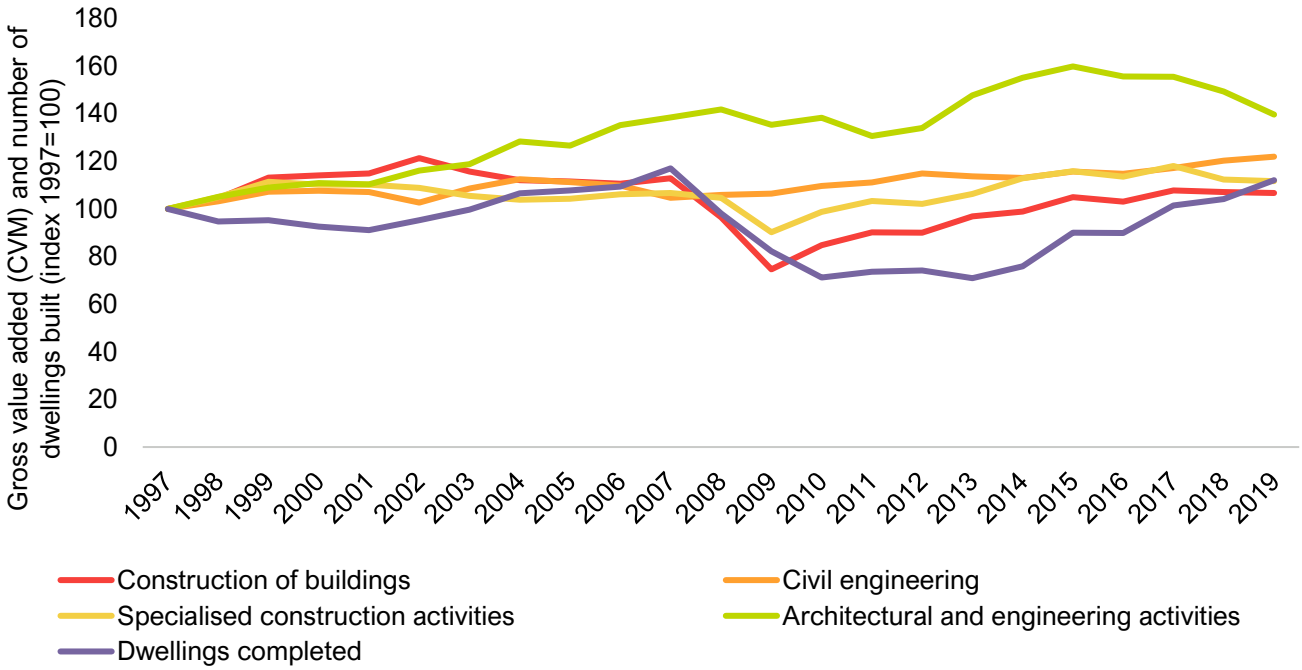
[56] HM Treasury (December 2010) "Infrastructure Cost Review: Main Report", available online.

[57] ONS (April 2023) "Regional gross value added (balanced) by industry", Table 1b., available online.

[58] ONS (October 2023) "New orders in the construction industry", Table 2a., available online.

[59] ONS (October 2021): "Productivity in the construction industry, UK: 2021", Figure 3, available online.

Figure 5: Real output is cyclical in construction industries related to housebuilding, and steadier for civil engineering. Gross value added (CVM) and number of dwellings built, UK, 1997 to 2019, (index 1997= 100)[60]



Whilst there are several factors which limit productivity growth in the construction sector, there remain clear opportunities for future technological improvements which should support productivity growth such as:

- Greater modularisation and automation of construction and the manufacturing of components.
- Enhanced data and information including Building Information Modelling (BIM) and digital design and monitoring of assets.
- More advanced modelling and understanding of risk and how to manage it.

Based on our experience of working with National Highways over several years, we understand that the Company has begun to work with and incentivise its supply chain to exploit these opportunities. But there remains substantial scope to embed these opportunities into business as usual. Therefore, assuming that the effectiveness of existing technologies employed by National Highways does not deteriorate (which would seem an illogical assumption), the scope for productivity growth in RIS3 must be positive. But – taking the 2023 release into account – we set the lower end of the range at 0% (down from 0.5% in the original draft of our Final Report).

Setting the upper end of the range

In the original draft of our Final Report, we said that 1% is "*consistent with recent regulatory decisions in the UK energy, water and aviation sectors. It is also consistent with a more positive interpretation of EU KLEMS which takes into account a range of wider factors that influence the scope for future productivity growth in the highways maintenance and construction sector*."

In our view, this statement remains a balanced reflection of the underlying evidence base because:

- There have been no further regulatory decisions in the energy, water and aviation sectors which directly addressed the issue of ongoing efficiency; and
- A more positive interpretation of EU KLEMS would place some weight on TFP growth across the higher performing sectors represented in the broader comparator set, which continue to be above 1%.

[60] ONS (October 2021): "Productivity in the construction industry, UK: 2021", Figure 6, available online.

- The most ambitious companies in the water and wastewater sector have recently proposed ongoing efficiency challenges of between 0.8% and 1.1%.

However, we think that 1% would represent the most positive view of the scope for productivity growth in the highways sector that the evidence can support (down from 1.2% in the original draft of our Final Report).

Setting the upper end of the range any higher than 1% would show insufficient regard to the analysis of the 2023 release of EU KLEMS. Specifically, the combination of 3 years of more recent data (2017, 2018 and 2019) and the changes introduced in the Blue Book 2021 reduce the long-term average TFP growth rates for the market economy and narrow comparator set. Only the broader comparator set provides TFP growth rates above 1% (1.0% for TFP GO and 2.7% for TFP VA) which is a result of the inclusion of relevant manufacturing sub-sectors and the Information and Communications sector. We think ORR would be justified in putting some weight on the broader comparator set because it is a proxy for the scope for greater innovation and ambition relative to historically weak productivity growth in the construction sector. But it should also consider finding a proportionate balance between this more innovative proxy and alignment with the basis on which it has estimated efficiency challenges in the past – as represented by the narrow comparator set.

As we emphasise throughout our report, the long-run average productivity growth rates which can be obtained from EU KLEMS are useful but have their limits and the results should not be applied mechanistically. In Section 2.4 we identified several wider factors which other UK regulators have relied upon to support the conclusion that EU KLEMS likely understates the potential scope for underlying productivity growth in similar regulated sectors (such as the treatment of embodied technical change). These wider factors continue to hold, but we think that ORR would have to place disproportionate reliance on them to support an ongoing efficiency challenge of more than 1%.

Setting the range for capital and operating expenditures

In the original draft of our Final Report, we said that "*there is scope for ORR to adopt a higher estimate for productivity growth for opex based on the LP results from the EU KLEMS analysis, the capital substitution effect, and previous regulatory precedent. But ORR should note that any difference between opex and capex is not possible to quantify with precision. The most robust approach is to adopt a broadly similar estimate for both.*"

We observe that the Labour Productivity (LP) results for the narrow comparator set in the 2023 EU KLEMS release show 0% productivity growth – a significant reduction on the corresponding results in the 2019 release. The market economy average is marginally lower than the 2019 release, whilst the broader comparator set is significantly increased compared to the 2019 release.

So, whilst there is a conceptual case for setting a slighter higher range for opex relative to capex, in our view the 2023 release does not provide sufficient evidence to make a robust, quantitative adjustment.

Considering the available evidence together in the round, we recommend a revised estimate for underlying productivity growth of 0.0% to 1.0% for both capital and operating expenditure.

Aiming up or down within the range

Since the release of the new EU KLEMS data, the regulated water and wastewater companies in England and Wales have submitted their business plans to Ofwat as part of the 2024 price review (PR24). Most of the companies have embedded an ongoing efficiency challenge of around 0.45%–0.55% per year.[61] But the more ambitious companies have assumed 0.8% (Northumbrian Water[62], Anglian Water[63]), 1.0% (SES Water[64], Portsmouth Water[65]) and 1.1% (South Staffs[66]) respectively.

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[61] Many of the water and wastewater companies base their assumption on a study they commissioned by Economic Insight (April 2023) "Productivity and frontier shift at PR24", p.62., available online.

[62] Northumbrian Water (2023) "PR24 Appendix A3 – Costs", p.28., available online.

[63] Anglian Water (2023) "Our PR24 Business Plan", p.25., available online.

[64] SES Water (2023) "Chapter 7: Explaining our costs", p.12., available online.

[65] Portsmouth Water (2023) "Business Plan 2025 to 2030", p.98., available online.

[66] South Staffs Water (2023) "PR24 Data tables commentary – Costs wholesale water", p.3., available online.

There are important differences between the highways sector and the water and wastewater sector. For example, a significant proportion of activity in the latter is focused on pumping water and wastewater along the system and treating it at important intervals, which may support the use of a wider range of industries in the comparator set for the water industry. But National Highways is like the water companies in that it is the steward of a complex, long-lived asset which must be maintained and renewed on an ongoing basis. It also has longer-term certainty over the investment programme due to the 5-year RIS framework (albeit there has been less certainty around its larger enhancement projects in recent years due to legal challenges and affordability concerns) drawing on a supply chain of civil engineering and construction firms. In addition, the water and wastewater companies are proposing a significant step-up in investment, such that they will undertake more civil engineering and construction activity over the period 2025–2030 than they have in recent investment periods. In effect, the more ambitious companies continue to propose stretching efficiency targets even in periods where there is a heavy workload (where there is likely to be a strong parallel with RIS3).

In our view, the underlying scope for productivity growth for an efficient operator in the highways maintenance and construction sector over the RIS3 period is similar to the scope for productivity growth in other regulated sectors. We suggest that ORR considers aiming for the top half of the range on the basis that the water and wastewater companies are proposing a frontier shift challenge of at least 0.5% in their PR24 Business Plans – and Ofgem, Ofwat, the CAA and the CMA all alight on 1% in recent regulatory decisions. However, ORR may also wish to recognise that National Highways' financial framework is less flexible than that which applies to the regulated energy and water networks, which might inhibit its ability to invest in efficiency enhancing measures for future capital projects, or to incentivise investment in productivity improvements via its supply chain.

Appendix A EU KLEMS ANALYSIS

In this Appendix we set out the rationale behind the main methodological choices in our analysis of the EU KLEMS productivity data:

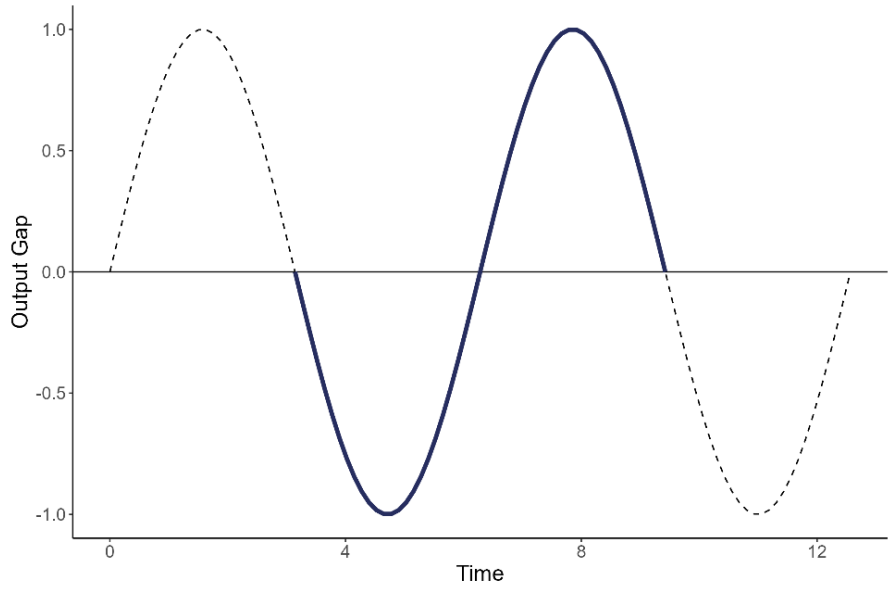
- Appendix A.1 explains our choice of time period over which we estimate productivity growth.
- Appendix A.2 explains our choice of comparator sets, the weightings used, and tests the sensitivity of results to different weightings and combinations of industries.
- Appendix A.3 tests the sensitivity of the productivity results to an older release of EU KLEMS (from 2011) which contains productivity data over a longer historical period (1970 to 2007).

A.1. CHOICE OF TIME PERIOD

Productivity growth tends to be pro-cyclical, accelerating during times of economic expansions and decelerating during periods of recession. To account for cyclical changes and isolate trends in productivity growth, it is best practice to estimate changes in productivity growth over the course of a business cycle.

But there are practical challenges in being able to confidently define and identify complete business cycles. In the US, the National Bureau of Economic Research (specifically the Business Cycle Dating Committee) identifies turning points retrospectively to account for uncertainties identifying turning points in real time.[67] Unfortunately, no similar committee exists in the United Kingdom and "*there is far weaker consensus regarding the exact dates of economic cycles*"[68]. We have previously used a definition based on the output gap, recognising that a business cycle may be defined as the output gap equalling zero three times (as illustrated by the blue line in **Error! R eference source not found.**).[69]

Figure A.1 Hypothetical business cycle based on the output gap definition



[67] The three most recent business cycles identified in the US are (trough-to-trough) March 1991 – November 2001, November 2001 – June 2009, and June 2009 – April 2020. See US Business Cycle Expansions and Contractions (2023), NBER, available at https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions.

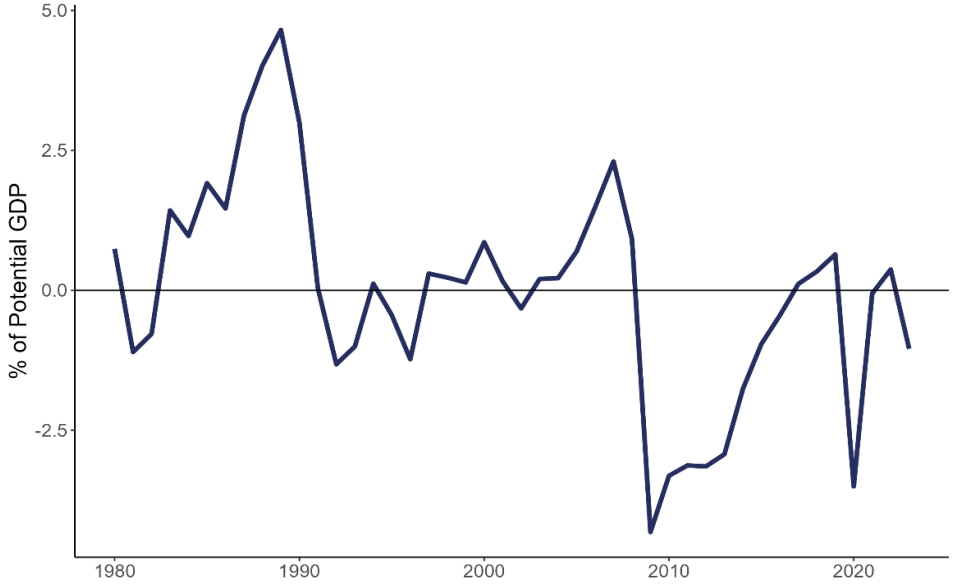
[68] Office for National Statistics (ONS), released 11 November 2022, ONS website, methodology, Communicating the UK Economic Cycle

[69] For example, see CEPA (2020) "RIIO-GD2 and T2: Cost Assessment – Advice on Frontier Shift policy for Final Determinations", p.18., available online.

Source: CEPA analysis

National accounts data are often subject to revisions that reflect genuine uncertainties about the underlying data. This means that estimates of the output gap change over time, and this has implications for efforts to identify the start and end point of a business cycle. With regards to the most recent business cycle in the UK, the output gap was very close to zero between 2015 and 2019 (see Figure A.2). Therefore, in our view, it is unavoidable that some judgement must be applied when identifying the start and end of the most recent business cycle.[70]

Figure A.2: UK output gap as a % of potential GDP, 1980-2023



Source: World Economic Outlook, IMF, October 2022

To avoid spurious debate about the start and end of the most recent UK business cycle, we include the full range of data from the 2019 release of the EU KLEMS database, covering the period from 1995 to 2016, as per our most recent advice to Ofgem in RIIO-ED2.[71]

A.2. COMPARATOR SETS

The choice of comparator set is perhaps the most challenging aspect of this analytical method. In our view, there is no comparator set which perfectly reflects the nature of activities that National Highways undertakes. Whilst a large part of what the Company delivers is maintenance and construction related activity, it is not credible to say that the Company cannot replicate or benefit from some of the improvements in productivity achieved in the wider economy or in sectors outside those that would appear to be the closest comparators. There is no solid dividing line that can be drawn between the activities carried out in the highways maintenance and construction sector and some of the activities done in sectors that (on their face) do not look like close comparators. In our view, there will be opportunities for National Highways to learn from productivity improvements from a range of other sectors and implement them in their own activities.

In that context, we considered three high-level comparator sets:

- Narrow comparator set – as per our 2018 report for ORR.

[70] We think it is likely that the large change in output gap that occurred during the Covid-19 pandemic is considered a more natural end to the most recent business cycle. But this data is not covered by the 2019 release of the EU KLEMS database.

[71] CEPA (November 2022) "RIIO-ED2 Final Determinations: Frontier Shift methodology paper, p.13–14.

- Broader comparator set – to capture the potential for productivity growth in a broader range of industries.
- Market economy comparator set – to capture productivity growth across the market economy.

A.2.1. Narrow Comparator Set

Our narrow comparator set was chosen for comparability of activities that National Highways undertakes and weighting to reflect the importance of these activities to National Highways. Using the NACE 2 industry classifications, our narrow comparator set is a weighted average of:

- Construction (F);
- Transportation and Storage (H); and
- Professional, Scientific, Technical, Administrative and Support Service Activities (M-N).

We used the same weights as our 2018 report for ORR which considered two different weighted averages for enhancements and renewals activities (see Table A.3).[72] The rationale for the weights used is that:

- Renewals and enhancements both involve a high proportion of construction activities;
- A higher proportion of renewals would be accounted for by construction relative to enhancements, as these renewals tend (on average) to be more repeatable in nature, resulting in less planning and design work.
- The remainder of renewals costs would be compromised mainly of transport and storage (e.g. of plant and materials), with only a small proportion allocated to professional services.
- Enhancements are more unique and complex in nature and therefore, the proportion of costs accounted for by professional service would be higher, reflecting the greater level of design and planning required; and
- The smallest proportion of enhancement would be transportation and storage as these projects tend to require less traffic management expenditure, relative to the overall project costs, than renewals.

Table A.3: Weights for narrow comparator set

	Renewals	Enhancements
Construction	75%	70%
Transportation and Storage	15%	10%
Professional, Scientific, Technical, Admin and Support Services	10%	20%

Source: CEPA (2018)

Ultimately, the choice of weights is judgement based, so we tested the sensitivity of the narrow comparator set estimates of productivity to changes in weights. We varied the weight placed on Construction (C%) between 50% and 100%, and the weights for Transport and Storage and Professional, Scientific, Technical, Administrative and Support Services were varied between 0% and 50%. The results are shown in Table A.4 and Figure A.5 below.

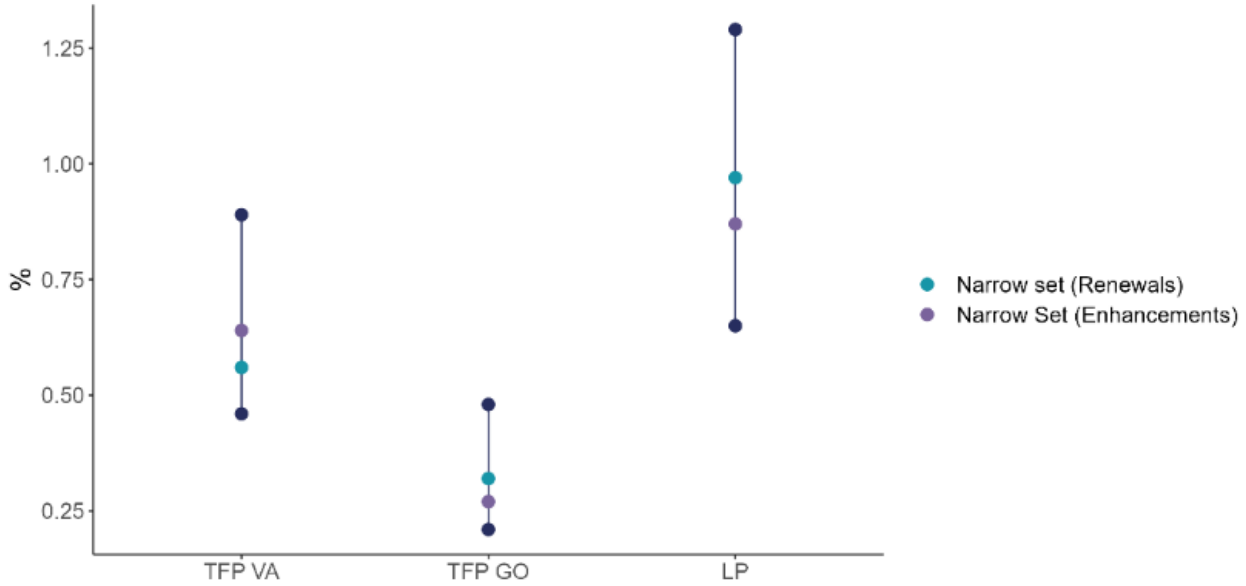
Table A.4: Narrow comparator set sensitivity results

Scenario	TFP VA	TFP GO	LP
Base case (Renewals)	0.56%	0.27%	0.87%
Base case (Enhancements)	0.64%	0.32%	0.97%
Highest	0.89%	0.48%	1.29%
Lowest	0.46%	0.21%	0.65%

[72] CEPA (2018) "Productivity growth in capital intensive sectors" available online.

Source: CEPA analysis of EU KLEMS (2019 release)

Figure A.5: Narrow comparator set sensitivity results



Source: CEPA analysis of EU KLEMS (2019 release)

Our base case estimates of productivity using the narrow comparator set lie just below the midpoint of the range of estimates generated in this sensitivity analysis. Adjusting the weights of the industries in the comparator set has a noticeable impact, but this impact does not significantly affect our conclusions. The maximum of the range is found by placing 50% weight on Professional, Scientific, Technical, Administrative and Support Service Activities, 50% weight on Construction, and no weight on Transport and Storage, which would not be reflective of National Highways' activities. The minimum of the range is found by placing no weight on Scientific, Technical, Administrative and Support Service Activities and 50% weight on Construction and Transport and Storage for measures of TFP, and 100% weight on Construction for labour productivity. These scenarios are extreme and would lend evidence to the bottom of our estimated range for TFP (0.35%).

A.2.2. Broader comparator set

Our broader comparator set was chosen to demonstrate the potential scope for productivity growth in the context that National Highways has been granted around £360m of innovation funding across RIS1 and RIS2 to facilitate the transformation of the highways maintenance and construction sector and deliver more efficiently.

Our broader comparator set is the unweighted average of the following industries:

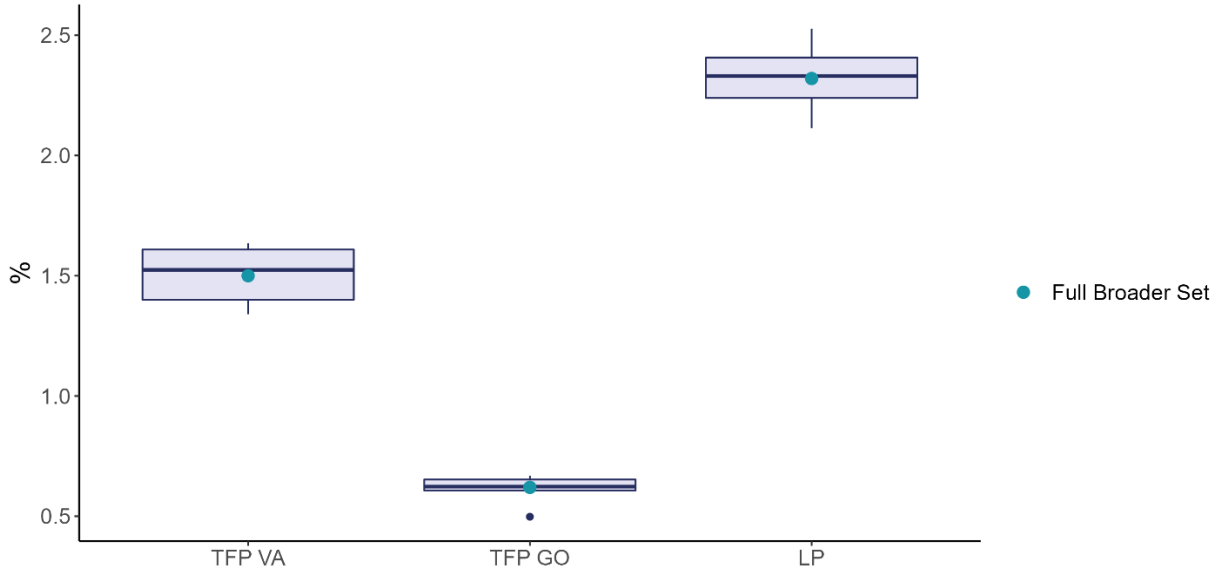
- Construction (F);
- Transportation and Storage (H);
- Professional, Scientific, Technical, Administrative and Support Service Activities (M-N);
- Manufacturing of
    - Chemicals and Chemical Products (C20);
    - Computer, Electronic and Optical Products (C26);
    - Electrical Equipment (C27); and
    - Transport Equipment (C29-C30).
- Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G); and

- Information and Communication (J).

Ultimately there is no comparator set which perfectly reflects the mix of activities that National Highways undertakes, so we have applied our judgement in terms of which industries to include in the broader comparator set. By including the above industries, we are not saying that the activities of National Highways or the industry it operates within is exactly like any those in the comparator set. Instead, we aimed to capture the potential for increased innovation and productivity growth due to the ongoing digital transformation of construction and asset management, the streamlining of manufacturing processes, and supply chain efficiency gains that other industries have experienced.

To test the sensitivity of this comparator set to the inclusion or exclusion of certain industries, we calculated the tested the results of the broader comparator set while systematically excluding each industry. This allowed us to investigate the importance of any one industry included in the sample.

Figure A.6: Range of productivity estimates when excluding one industry from the broader comparator set



Source: CEPA analysis of EU KLEMS

Removing Information and Communication from the broader comparator set leads to the biggest shift of the productivity estimates downwards (from 0.62% to 0.50% for TFP GP and 1.50% to 1.34% for TFP VA), but the range of results is not that significant and would not change our conclusions.

A.2.3. Market economy comparator set

Our economy-wide comparator set also captures broader productivity trends.

The economy-wide sample is the average of the market economy figures in EU KLEMS – defined as all industries excluding real estate activities (L), public administration & defence (O), education (P), health & social work activities (Q), arts, entertainment and recreation (R), other social services (S), activities of households as employers (T), and activities of extraterritorial organizations (U). The figures are weighted by the contribution of each sector to GDP (as shown in Table A.7 below).

Since the economy-wider comparator set is weighted according to the measured structure of the market sector of the UK economy, we did not carry out any sensitivity tests.

Table A.7: Weights of each industry in the market economy comparator set

Industry	TFP GO	TFP VA
Agriculture, forestry and fishing (A)	1.2%	1.1%
Mining and quarrying (B)	2.0%	2.9%
Total manufacturing (C)	22.7%	17.0%
Electricity, gas, stream and air conditioning supply (D)	3.7%	1.9%
Water supply; sewage; waste management and remediation activities (E)	1.5%	1.6%
Construction (F)	10.0%	8.8%
Wholesale and retail trade; repair of motor vehicles and motorcycles (G)	13.8%	16.2%
Transportation and storage (H)	6.7%	6.4%
Accommodation and food service activities (I)	3.8%	3.9%
Information and communication (J)	7.3%	8.9%
Finance and insurance activities (K)	10.6%	10.5%
Professional, scientific, technical, administrative and support services (M-N)	12.8%	16.0%
Arts, entertainment and recreation (R)	1.8%	2.1%
Other service activities (S)	2.0%	2.8%

Source: EU KLEMS (2019 release)

A.3. Choice of EU KLEMS release

In the analysis presented above and in the main body of the report, we focus on the 2019 release of EU KLEMS which covers the period 1995 to 2016. But there is an older release of EU KLEMS from 2011 which covers a longer period of time between 1970 and 2007. There is a trade-off in our choice of dataset: focusing on the 2019 release enables us to use the most up-to-date and relevant data, but the 2011 release would allow us to examine productivity growth trends over a longer period.

There are other differences in the industry classifications used and productivity measures reported:

- The 2011 release of EU KLEMS[73] uses the NACE 1.1 industry classification. Productivity data is reported on both gross output (GO) and value added (VA) measures. The potential advantage of using this dataset is the length of time it covers, which would allow analysis of productivity growth over multiple business cycles. However, the relevance of productivity measures before 2007 to the scope for productivity growth from 2025 to 2030 is at least uncertain.
- The 2019 release of EU KLEMS uses the NACE 2 industry classification. Productivity data is reported only on VA measures. This dataset captures the impact of the Global Financial Crisis and the subsequent period of lower productivity growth that has been recorded in the UK.

The results from the 2011 database release are presented in Table A.8 below.

[73] Groningen Growth and Development Centre (2011) "EU KLEMS Release 2011" available online.

Table A.8: Productivity estimates (average annual growth rate) from 2011 EU KLEMS

Average growth (%)	TFP GO	TFP VA	LP
Full time series (1970-2007)			
Construction only	0.3%	0.7%	1.1%
Narrow set: renewals (weighted)	0.3%	0.8%	1.2%
Narrow set: enhancements (weighted)	0.2%	0.5%	1.0%
Broader comparator set (unweighted)	0.7%	2.0%	2.9%
Market economy (weighted average)	0.4%	1.0%	2.5%
Latest business cycle (1990-2007)			
Construction only	0.2%	0.6%	1.2%
Narrow set: renewals (weighted)	0.3%	0.7%	1.4%
Narrow set: enhancements (weighted)	0.2%	0.7%	1.3%
Broader comparator set (unweighted)	0.9%	2.3%	3.4%
Market economy (weighted average)	0.5%	1.0%	2.5%

Source: CEPA analysis of EU KLEMS data (2011 release).

Due to differences in industry classifications between the two releases, the industries selected in the narrow and broader comparator sets do not align perfectly with the 2019 release of EU KLEMS. Using the NACE 1 industry codes and 2011 taxonomy, the narrow comparator set includes:

- Construction (F);
- Transport and Storage (60-63); and
- Finance, Insurance, Real Estate and Business Services (J-K).

In addition to these industries, the broader comparator set includes:

- Manufacturing of
    - Chemicals and Chemical Products (24);
    - Electrical and Optical Equipment (30-33); and
    - Transport Equipment (34-35).
- Wholesale and Retail Trade (G); and
- Transport and Storage and Communication (I).

Estimates of TFP (GO) do not change significantly across the datasets, while estimates of TFP (VA) are marginally higher using the 2011 release of EU KLEMS. Measures of labour productivity are significantly higher using the 2011 release of EU KLEMS. While there are clear differences in the estimates of productivity calculated using the 2011 release of EU KLEMS and the 2019 release, we believe the 2019 release is more appropriate in this case. However, ORR may note that if productivity growth is considered over a longer historical time period – as per the 2011 release – the evidence lends support to the top end of our proposed productivity growth range (0.5% to 1.2%).

Appendix B CATCH-UP ANALYSIS

In this appendix we provide further detail behind the analysis in Section 3 of our report, which reviews catch-up efficiency targets set in other regulated sectors. The aim of this analysis is to compare the 'catch up' efficiency challenges set and – together with our analysis of the scope for frontier shift – provide evidence which ORR might consider as a 'cross-check' for the total efficiency assumptions in National Highways' RIS3 dSBP.

It is important to note that the way in which the catch-up efficiency challenge is set differs between regulators and evolves over time, as set out in Appendix B.1 below. Therefore, comparisons between sectors and price controls should be interpreted carefully. Due to the budget constraints, timescales and high-level nature of the comparison required for this research, we adopted a proportionate approach which sought to simplify some of the complexity of comparing different methods across different sectors and price reviews, as described in Appendix B.2. Had our scope been to review a given set of determinations in greater focus, we may have adopted a more detailed method.

As such, the results presented in Appendix B.3 provide broadly accurate rather than precise estimates and should be considered 'in the round' rather than relying disproportionately on any single value.

B.1. COST ASSESSMENT CASE STUDIES

The specific cost assessment methodology employed by each regulator differs between jurisdictions, industries, and by regulatory period. The differences often reflect pragmatic decisions responding to the specific context of the industry, the availability of data, and confidence in the accuracy of the regulator's cost efficiency modelling. Below we provide high-level summaries of the cost assessment processes undertaken by two different regulators to highlight these differences. These are:

- RIIO-ED2, the GB electricity distribution price control for the period 2023 to 2028. Ofgem took a top-down approach to cost assessment.
- PC4, the Irish gas distribution price control for the period 2017 to 2022. The CRU took a bottom-up hybrid approach to cost assessment.

Top-down cost assessment: Ofgem, RIIO-ED2

The RIIO-ED2 Final Determination sets out allowances for the GB Distribution Network Operators (DNOs) for the period from 1 April 2023 to 31 March 2028. As part of the process to set allowances, Ofgem assessed the DNO's proposed costs to determine a company specific catch-up efficiency challenge.

Ofgem used both aggregated (totex) and disaggregated (activity level) benchmarking to construct 'modelled costs', their view of the average costs for the industry for different costs drivers based on regression analysis. Ofgem then applied a 'catch-up' efficiency challenge, requiring companies to perform as well as the benchmark company: this was the company at the 75th percentile of the efficiency scores in the first year of RIIO-ED2 and a 'glidepath' to the 85th percentile for the final two years. The benchmark is representative of the frontier efficient company. Often regulators do not use the most efficient firm in their modelling, acknowledging that the regression analysis is imperfect and might impose too strict a requirement on the catch-up companies. But this example also demonstrates the analytical challenge of comparing catch-up efficiency targets across price reviews, because Ofgem shifted its approach from ED1 (75th percentile) which (all else being equal) resulted in a slightly more stretching catch-up efficiency challenge in ED2.

Bottom-up hybrid cost assessment: the CRU, PC4

The PC4 Final Decision, published in June 2017, sets out allowances for GNI, the gas transmission and distribution company in Ireland. The CRU, the Irish gas regulator, used a bottom-up hybrid approach to establish GNI's efficient opex costs. The CRU assessed GNI's historic costs for different cost categories (or 'functional area'), establishing a normalised run rate representing 'business as usual' opex by adjusting for one-off costs. The normalised run rate,

or ‘base’ costs for each cost category were then adjusted using adjusted up or down based on an assessment of GNI’s Business Plan Questionnaire (BPQ) submission.

The CRU supplemented its bottom-up analysis with assessment of top-down evidence based on benchmarking against GB gas distribution networks. This was used to consider whether there was scope to apply adjustments to the bottom-up estimates that would challenge GNI to improve their relative efficiency during PC4.

B.2. Approach to calculating catch-up efficiency challenges

In Section 3 we present estimates of the catch-up efficiency challenges set by regulators in a range of regulated industries. These are not estimates of catch-up efficiency achieved by the companies, but the challenges set by the regulator during price control reviews. Unlike ongoing efficiency, it is not standard practice for regulators to report catch-up efficiency as a single annual percentage figure. Therefore, we constructed estimates from available data, much of which is published by the regulator in its Final Decisions or Final Determinations.

The presentation and availability of this data differs across the Final Decisions. This means that we tailored our analytical method to fit the available data, in order to produce a broadly comparable estimate for each price control. We adopt a hierarchy of approaches (outlined below), in which we first attempted to implement our ‘gold standard’ approach which represents the catch-up pressures regulators put on regulated entities’ costs. We move on to the next best approach if this is not possible.

When we had to compromise on the ‘gold standard’ approach, our estimates are the best representation of the catch-up efficiency challenge that we have been able to construct within the timescales of this review. However, given the data limitations, it is possible that the stated values also include other theoretical aspects of the cost efficiency challenge (e.g. which arise from the regulator reducing submitted costs based on a lack of clear articulation of the need for a particular programme or capital project). We outline our hierarchy of methods below.

(1) Stated catch-up efficiency challenge

When the regulator explicitly states a catch-up efficiency challenge, we have used this figure. Figures were stated for RC3 (CRU – Water), PC4 (CRU – Gas), PC15, PC21 (both UR – Water), PR09 (Ofwat), RIIO-T2 (Ofgem) and GD17 (UR – Gas Distribution).

(2) ‘Gold-standard’ difference between the regression line and the benchmark

For top-down benchmarking, in which a catch-up challenge is based on a regression model and benchmark challenge, the ‘gold standard’ approach which we sought to estimate first was to:

- Calculate the industry average challenge as the percentage difference between the regression line and the benchmark. In the case of PR19 and PR14 (both Ofwat) this was reported.
- Calculate the ends of our range as the percentage difference between the most / least efficient firm and the benchmark.

We view this as the ‘gold standard’ as it attempts to isolate the portion of any disallowance which is related to catch-up efficiency, and should exclude disallowances which arise for other reasons (e.g. an unjustified business plan request). We were able to employ this approach to the English and Welsh PR19 and PR14 water and wastewater price controls (including the PR19 CMA appeal), and the RIIO-ED2 (Ofgem) price control.

(3) Average of the difference between the regression and the benchmark

In some cases, when top-down benchmarking was undertaken, the difference between the regression line and the benchmark has not been stated, but the efficiency challenge for each individual company (either as a percentage or as a value) has. In these instances, we:

- Calculate the industry average challenge as the mean of the individual catch-up efficiency challenges.

- Calculate the ends of our range as the difference between the most / least efficient firm and the benchmark. For the range, this should be the same as if we used the 'gold standard' approach.

This has been possible for the DPCR5, RIIO-ED1 and RIIO-GD2 price controls (all Ofgem).

(4) Cost reduction as a percentage of submitted costs

When the above approaches were not possible, we used values reported as an 'efficiency challenge'. This can either be a percentage reported in the determination or constructed as the difference between the allowed and submitted costs divided by the submitted costs. The industry average is calculated as the mean of the individual catch-up efficiency challenges and the range is calculated as the firm with the highest / lowest percentage change compared to their submitted costs.

We used this approach for the RIIO-GD1 and T1 (Ofgem), PR13 and PR18 (ORR), PR5 (CRU – Electricity), GT22 (UR – Gas Transmission), and GD23 (UR – Gas Distribution) price controls.

Bottom-up approach

Finally, for bottom-up catch-up efficiency we calculate the percentage that 'base' costs were reduced by. This was calculated for the Dublin Airport and Heathrow Airport price controls.

Other adjustments

We also had to make adjustments which cut across our methodologies. When a reduction has been reported for a period, then we calculate the compound annual growth rate to make our reported figures comparable, both across price controls and with ongoing efficiency. We had to make some simplifying assumptions to aid with the comparability and presentation of the results, for example ignoring glidepath adjustments.

B.3. TABLE OF EFFICIENCY CHALLENGES

Below we present a complete list of the catch-up efficiency challenges we calculated for each price control. We present both the average industry catch-up challenge and the range (i.e. the firms with the lowest and largest catch-up challenges for each price control).

Table B.1 Catch-up efficiency challenges applied in UK and Ireland

Country	Regulator	Sector	Price control	Period	Average	Most efficient	Least efficient
England & Wales	CMA	Water	PR19 (et al)	2020-25	0.3%	-	-
		Wastewater	PR19 (et al)	2020-25	0.4%	-	-
	Ofwat	Water	PR19	2020-25	0.9%	-3.4%	4.1%
		Wastewater	PR19	2020-25	0.4%	-2.7%	4.4%
		Water	PR14	2015-20	1.3%	-	-
		Wastewater	PR14	2015-20	2.0%	-	-
		Water (opex)	PR09	2010-15	-	0.0%	2.9%
		Water (capex, infra)	PR09	2010-15	-0.1%	-3.8%	3.3%
		Water (capex, non-infra)	PR09	2010-15	0.6%	-1.8%	2.9%
		Wastewater (opex)	PR09	2010-15	-	0.0%	2.2%
		Wastewater (capex, infra)	PR09	2010-15	-0.1%	-3.4%	2.0%
		Wastewater (capex, non-infra)	PR09	2010-15	0.1%	-2.8%	2.1%
GB	Ofgem	Electricity	ED2	2023-28	0.3%	-0.6%	2.4%
		Gas	GD2	2021-26	0.5%	-0.6%	2.2%
		Transmission	T2	2021-26	1.2%	-	-
		Electricity	ED1	2015-23	0.5%	-0.5%	1.4%
		Transmission	T1	2013-21	1.2%	0.8%	1.8%
		Gas	GD1	2013-21	1.1%	0.7%	2.0%
		Electricity	DPCR5	2010-15	0.3%	-0.3%	0.9%
	ORR	Rail	PR18	2019-24	1.5%	1.2%	1.8%
		Rail	PR13	2014-19	3.6%	-	-
UK	CAA	Aviation	H7	2022-26	0.3%	-	-

Country	Regulator	Sector	Price control	Period	Average	Most efficient	Least efficient
Ireland	CRU	Electricity	PR5	2021-25	0.7%	0.1%	1.4%
		Water	RC3	2020-24	4%	-	-
		Wastewater	RC3	2020-24	4%	-	-
		Gas	PC4	2017-22	0.8%	-	-
		Electricity	PR4	2016-20	2.2%	1.4%	2.8%
Northern Ireland	UR	Gas	GT22	2022-27	1.5%	1.4%	1.7%
		Gas	GD23	2023-28	2.0%	1.4%	2.9%
		Electricity	RP6	2017-24	0.0%	-	-
		Water	PC21	2021-27	1.1%	-	-
		Water	PC15	2015-21	2.3%	2.2%	-
		Gas Distribution	GD17	2017-22	-	1.9%	4.6%

Source: CEPA analysis of multiple Final Determinations; Note: '-' denotes when we have not been able to calculate a value either because we could not locate the data, or because there is only one firm in the industry.

Appendix C ACADEMIC LITERATURE

ORR asked us to review the evidence on efficiency gains which have been achieved in practice by companies in other relevant, regulated sectors. In this section we set out our review of three recent studies which attempt to estimate historic productivity growth in the UK water and wastewater sector, and the GB electricity networks.

One of the challenges of directly estimating outturn productivity growth in a sector subject to price cap regulation is that outputs are generally not purchased at market prices. In such circumstances, the conventional growth accounting approach to calculating TFP growth by comparing the value of outputs against the value of inputs is very challenging. In that context, some studies attempt to measure changes in an output index, where that index is a combination of different output vectors (e.g. number of connected customers, network length, peak load).

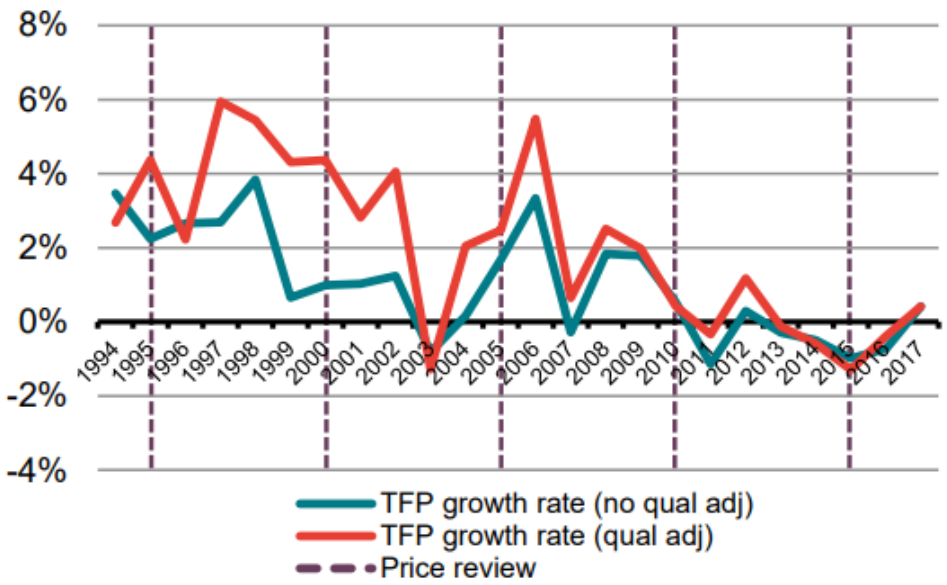
C.1. PRODUCTIVITY GROWTH IN THE WATER SECTOR

In the run up to the PR19 price review, Water UK[74] commissioned Frontier Economics to quantify the productivity gains achieved by the water and sewerage companies in England since privatisation in 1989.[75]

Frontier found that annual productivity growth for the water and sewerage sector has averaged 1.0% since privatisation without adjustments for the aspects of water company service that improve the quality of its outputs (e.g. the quality and cleanliness of drinking and bathing water); or 2.1% when adjusting (on what it describes as "a conservative basis") for output quality. It found that productivity growth was high during the immediate post-privatisation period, which was then followed a period of intermediate growth in the first five years of the 2000s, with a significant drop in growth since 2007 following the GFC.

This trend is shown in Figure C.1 and Table C.2 below.

Figure C.1: Frontier Economics estimate of annual productivity change, 1994–2017



Source: Frontier Economics (2017)

[74] Water UK is a membership body representing the UK water industry, including all the UK water and wastewater companies.

[75] Frontier Economics (September 2017) "Productivity improvement in the water and sewerage industry" available online.

Table C.2: Frontier Economics estimate of average annual TFP growth over price review periods

Period	TFP growth (no quality adjustment)	TFP growth (with 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 ongoing")	-0.1%	0.1%
1994 – 2017	**1.0%**	**2.1%**

Source: Frontier Economics (2017)

Frontier highlights some important limitations with its method:

- First, it notes that the measures used to capture quality improvements reflected the focus of investment in the earlier period under review (e.g. the safety of drinking water and reliability of service; the impact of sewage treatment works on river and bathing waters). The emphasis of quality investment in later years focussed on other dimensions (e.g. leakage rates from pipes; the frequency of sewer flooding; pollution incidents; risk of severe drought restrictions) which are not well captured by the measures included in the study, due to the shortage of comparable data on these dimensions covering the whole period.
- Second, it states that its estimates of productivity growth since 2015 should be viewed more cautiously as they are influenced by some data inconsistencies due to changes in data reporting. Quality adjustments were made on a more conservative basis in this period due to lack of data.
- Third, it notes that quality improvements were particularly significant in productivity growth in the 5 years from 1997 to 2002. This may reflect some natural and expected lag between investment and quality outcomes being achieved.

Additionally, we note that on the inputs side Frontier uses the 'modern equivalent asset valuations' (MEAV) approach to create a proxy for 'physical capital invested' over time and therefore create a 'capital inputs' index. However, the MEAV approach may overstate costs and understate productivity growth, particularly if capital assets were originally constructed at lower costs than their modern equivalent valuation in the regulatory accounts.

Overall, these factors combine to suggest that the method used may understate productivity growth in the later period of its study.

C.2. PRODUCTIVITY IN THE ELECTRICITY NETWORKS

The University of Cambridge Energy Policy Research Group (EPRG) recently conducted independent research into productivity growth in the electricity distribution and transmission sector, taking into account the effects of quality of

service and environmental targets on measured productivity growth.[76] The research is based on data collected from Ofgem and covers the period from 1991/92 to 2018/19.

EPRG estimates the growth in historic TFP using data envelopment analysis (DEA)[77] to construct a Malmquist index, which decomposes productivity growth into various components, such as efficiency change, technical change and scale change. The construction of the Malmquist requires a range of modelling choices and assumptions. For example:

- Each output variable that is included in the output index needs to be specified and weighted. The authors use energy distributed, customer numbers and network length as output variables within the baseline model used in the research.
- The input index also needs to be specified. This requires a range of assumptions around the construction of a consistent index of capex and opex costs for each of the DNOs. The authors also include inputs around customer minutes lost (CML) as an input variable within some of the model specifications in their analysis.
- A range of TFP estimates are then calculated by dividing the output index by the index of input costs.

Based on the range of assumptions set out above, the authors estimate a wide range of productivity growth estimates for the electricity distribution sector, as shown in Table C.3 below. For example:

- Under the baseline model, they find TFP growth of 0.8% per annum over the period from 1991/92 to 2018/19.
- The rate of TFP growth varies between regulatory periods. Under the baseline model, measured productivity is 3.7% p.a. in DPCR 4 falling to -5.5% per annum over the DPCR5 price control and then recovering slightly to -0.5% per annum over the first four years of the RIIO-ED1 price control period.
- When non-monetised 'quality' factors are considered (such as customer minutes lost (CML), losses and emissions costs and customer satisfaction), the authors find that TFP growth in the first four years of the RIIO-ED1 period increases to 3.8% per annum.

Table C.3: Average annual TFP growth over Distribution Price Control Review periods, Models 1 to 7

DPCR	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
DPCR 0	0.2%	-0.2%	0.1%				
DPCR 1/2	2.1%	2.1%	3.2%				
DPCR 3	5.3%	5.4%	7.0%				
DPCR 4	3.7%	4.6%	0.4%				
DPCR 5	-5.5%	-6.1%	-3.2%	-6.5%	-4.1%	1.3%	11.3%
RIIO-ED1	-0.5%	5.8%	4.0%	5.7%	3.8%	3.8%	3.8%
Whole period	**0.8%**	**1.8%**	**1.9%**	**-0.5%**	**-0.2%**	**3.0%**	**5.3%**

Source: Ajayi, V., Anaya, K., and Pollitt, M. (November 2021), p.33.

Overall, the results are highly dependent on the model specifications and assumptions used, and therefore the definition of 'measured productivity' needs to be considered carefully. The findings also illustrate how conventional

[76] Ajayi, V., Anaya, K., and Pollitt, M. (November 2021) *Incentive regulation, productivity growth and environmental effects: the case of electricity networks in Great Britain*. University of Cambridge Energy Policy Research Group Working Paper No. 2126, available online.

[77] DEA is a non-parametric method commonly used in the academic literature to measure productivity.

measures of productivity growth which focuses on cost efficiency may not capture all productivity improvement delivered by regulated utility companies over time, such as improvements in output quality.

C.3. PRODUCTIVITY IN THE ELECTRICITY DISTRIBUTION NETWORKS

In the run up to the RIIO-ED2 price review, NERA was commissioned by the Energy Networks Association[78] (ENA) to provide advice on the scope for ongoing productivity improvements in the electricity distribution sector.

NERA estimates outturn TFP growth observed in the electricity distribution sector over the period from 2010/11 to 2019/20. NERA's analysis shows that TFP growth in the electricity distribution sector over this period ranged from between -0.1% to 0.4% per annum. This range reflects the impact of different assumptions and methodological choices.

NERA bases its approach on the development of a weighted index of outputs which are not dependent on either revenue or market prices. The output variables are: number of customers; total network length (km); network-wide peak demand (MW); energy delivered (GWh); customers interrupted, excluding exceptional events (CI); customer minutes lost, excluding exceptional events; and installed capacity of distributed generation (MW).

The growth of output from each year to the next is then calculated as the weighted combination of the growth rate in each constituent output category[79]:

$$\frac{Output\ Index_t}{Output\ Index_{t-1}} = \left(\frac{Output\ 1_t}{Output\ 1_{t-1}}\right)^{weight\ 1} \times \left(\frac{Output\ 2_t}{Output\ 2_{t-1}}\right)^{weight\ 2} \times \dots$$

Once the output index is defined, the growth in TFP can be calculated by dividing the output index by another index of total expenditure (i.e., an index of inputs).

While this approach succeeds in developing a measure of TFP which is independent of market revenues, the analysis depends on a wide range of analytical choices and assumptions.

The first of these relates to the choice of input and output variables. NERA defines the 'inputs' as total costs, calculated as the sum of capital and operating costs. These are defined as follows:

- **Capital costs** are modelled as annuitised payments on the MEAV, as it is the existing asset base rather than capital expenditure in a given year that is used to provide distribution services. Underlying these calculations are the assumptions of (a) a real vanilla weighted average cost of capital (WACC) of 3.57%;[80] (b) all DNOs have the same WACC; and (c) an asset life of 45 years.
- **Operating costs** are taken from statutory accounts, excluding exceptional items and net of depreciation and amortisation. Pass-through costs are subtracts to exclude items not covered within totex. The costs are deflated using factor price indices and notional cost structures from ED1.

Other important assumptions are:

- Each output variable that is included in the output index needs to be specified and weighted. NERA applies an econometric approach involving cost regressions to specify the weighting of each output variable within the output index.
- As all output variables cannot be included in the same econometric model due to limitations relating to collinearity and the sample size, NERA develops a range of different model specifications which each inform a different output index.

[78] The ENA is a membership organisation which represents the companies which operate the electricity, gas and energy networks / systems in the UK and Ireland.

[79] This type of index is called a Törnqvist index.

[80] This is the arithmetic average of the ED1 WACC from 2015/16 to 2019/20.

The final TFP growth estimates along with the model specifications used to derive them based on the approach outlined above is illustrated in Table C.4 below:

Table C.4: Output variables, weights and results from Törnqvist indices constructed by NERA

Weight on variable	Model 1	Model 2	Model 3	Model 4	Model 5[81]
Customer numbers	54.2%		97.5%		91.7%
Network length	45.8%			93.1%	
Peak demand		86.2%			
Distributed generation		13.8%	2.5%		
Customers interrupted				6.9%	8.3%
Average TFP growth	**-0.07%**	**0.03%**	**0.36%**	**0.16%**	**0.29%**

Source: NERA (2021)

While this analysis is a useful contribution to the literature on productivity growth in the electricity distribution sector, it is highly dependent on the construction of the input and output indices as well as the analytical assumptions used to convert them into an estimate of TFP. For example, NERA notes that models which include distributed generation or customer interruptions lead to higher estimated rates of TFP growth, suggesting that a part of historical productivity growth has been achieved through outputs which are not captured in conventional scale variables. Moreover, as we note in relation to Frontier Economics' work on water sector productivity, the MEAV approach to creating a proxy for capital expenditure may overstate costs and understate productivity growth, particularly if capital assets were originally constructed at lower costs.

[81] Model 5 also includes dummy variables for each DNO to allow for DNO-specific fixed effects.

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