OFFICE OF RAIL AND ROAD

Cost benchmarking of Network Rail's maintenance and renewals expenditure

Annual report: year 4 of Control Period 6 (2022-23)

20 December 2023

Contents

Executive summary

1. The Office of Rail and Road holds Network Rail to account for its management of the rail network in Great Britain. Understanding the main drivers of Network Rail's expenditure (including the reasons expenditure changes from year to year) and assessing the scope for it to improve its efficiency are central to this work. To achieve this, we use different analytical approaches, ranging from a bottom-up assessment of Network Rail's business plans, projects and efficiency improvement measures to top-down cost benchmarking using statistical methods.

2. This report presents our latest cost benchmarking statistical analysis, which compares maintenance expenditure and conventional track renewals unit costs (in simple terms, renewals expenditure divided by work volume) over time and across Network Rail's regions, and maintenance delivery units (MDUs), after normalising[1] for the effect of the observable underlying differences between them.

3. The methodology in this year's report is broadly similar to the methodology in our year 3 of CP6 cost benchmarking report that we published in November 2022. Following last year's publication, we worked with Network Rail and its regions to resolve some data issues that we had identified. This has improved the quality of our data and the robustness of the results presented in this report.

4. Our cost benchmarking analysis has been used to inform our 2023 periodic review (PR23) decisions. Notably, it was one part of the evidence that informed our initial advice to the UK and Scottish governments in summer 2022, as they prepared their statements of available funding (SoFAs) and high-level output specifications for the next control period (control period 7 or CP7). Cost benchmarking analysis was also an important element of the evidence base that ORR used to inform its PR23 final determination on Network Rail's CP7 efficiency targets.

Key findings

Maintenance expenditure

Key finding 1: There has been an **average annual increase in maintenance expenditure of 4% per year (in real terms[2]) since 2010-11, after normalising**

[1] By normalising, we mean we take account of some of the underlying differences between regions that affect expenditure, e.g. length of the network.

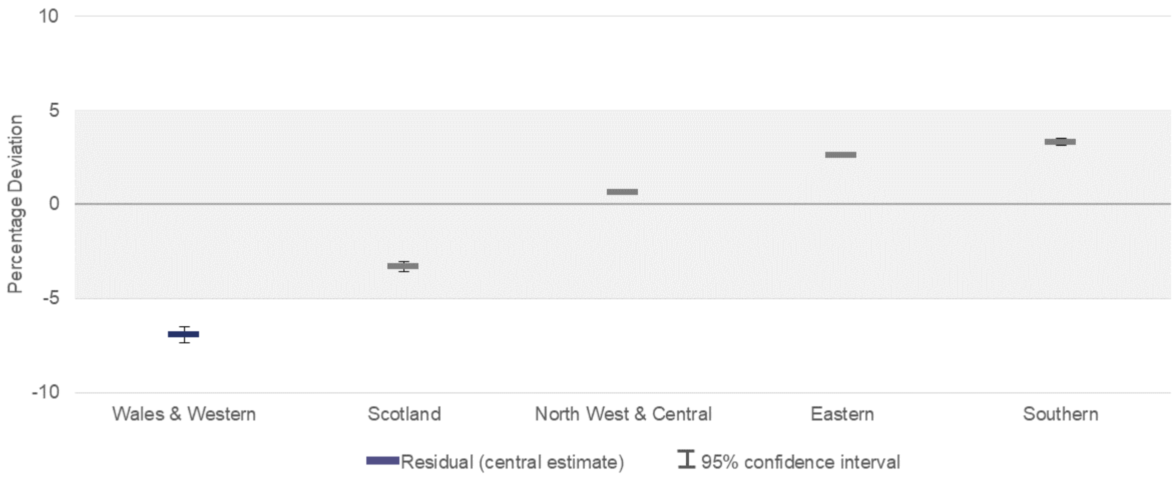
[2] In real terms means after adjusting for the effect of inflation (measured by the Consumer Price Index (CPI)).

for factors such as traffic and network complexity. This may be due to inefficiency, or other factors. However, maintenance expenditure decreased by 3% from 2021-22 to 2022-23, in real terms. This may be due to efficiency, or other factors.

Key finding 2: As shown in Figure 1 below, **maintenance expenditure at region level in 2022-23 is broadly in line with that predicted by our model (between -7% and +3% deviation). Wales and Western** is at the lower end of the range while **Southern** is at the top end of the range**.** This range is tighter than that implied in last year's analysis (-17% to +17%). We consider that our model has become a better predictor of maintenance expenditure as we improved the quality of our data since last year**.**

5. Figure 1 below presents our results, comparing the outturn and modelled maintenance expenditure by Network Rail's regions, in 2022-23.

Figure 1: Deviation between outturn and expected (modelled) maintenance expenditure by Network Rail region, 2022-23



Note: Given the uncertainty associated with this statistical model, we consider any region that is within +/−5% of our modelled prediction (as shown by the x-axis at zero) is not an 'outlier'. These regions are marked grey. The lines surrounding the central estimate of a given region's deviation between outturn and modelled cost indicate a 95% confidence interval. In other words, given the data available and the robustness of our model, there is a 95% probability that this estimated confidence interval contains the actual number representing the deviation between outturn and modelled cost.

Conventional track renewals unit costs

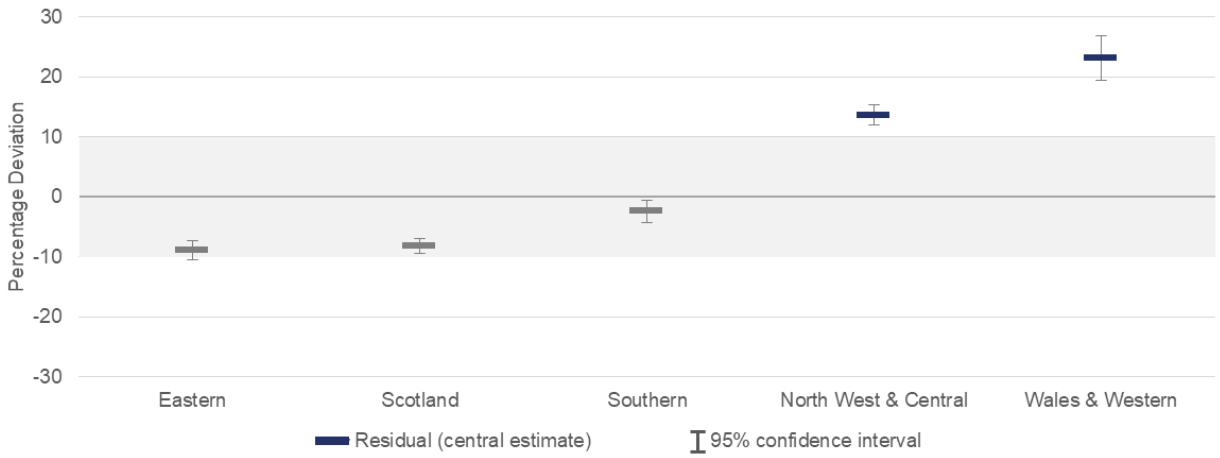
Key finding 3: There has been an **average annual increase in the average unit costs of conventional track renewals of 4% per year (in real terms) since 2014-15**, after normalising for factors such as traffic and network complexity. **In**

2022-23, the rate of growth in the average unit costs for conventional track renewals was 6% (which is higher than the long term trend). This is supported by our unit cost trend analysis which found that, overall, conventional track renewals unit costs in 2022-23 were 11% higher than the average for the first three years of CP6. This may be due to inefficiency, headwinds or some other factors including work mix or some project-specific factors (e.g. project location), which cannot be taken account of in a top-down analysis of this sort.

Key finding 4: As shown in Figure 2 below, conventional track renewals' average unit costs at the region level were between -9% and +23% of what our model would predict, in 2022-23. This range is larger than in last year's analysis (-3% to +7%). Compared to last year, **Eastern was still at the lower end of the range**, whilst **Wales and Western replaced Southern at the top end of the range**.

6. Figure 2 below presents our results, comparing the outturn and modelled unit costs for conventional track renewals by Network Rail's regions, in 2022-23.

Figure 2: Deviation between outturn and expected (modelled) unit costs for conventional track renewals by Network Rail region, 2022-23



Note: Given the uncertainty associated with this statistical model, we consider any region that is within +/−10% of our modelled prediction (as shown by the x-axis at zero) is not an 'outlier'. These regions are marked grey. The lines surrounding the central estimate of a given region's deviation between outturn and modelled cost indicate a 95% confidence interval. In other words, given the data available and the robustness of our model, there is a 95% probability that this estimated confidence interval contains the actual number representing the deviation between outturn and modelled cost.

7. It is important to note that the unit costs of renewals are influenced by a wide variety of project-specific factors, which cannot be taken account of in a top-down

analysis of this sort. So, the results above should be read as indicative of the relative position of different regions.

8. We will continue to work with Network Rail over the next few months to look into the potential underlying causes for these results, encouraging regions to share good practice, and to improve our model where possible.

1. Introduction

1.1 This report presents our latest cost benchmarking statistical analysis, which compares maintenance expenditure and conventional track renewals unit costs (in simple terms, renewals expenditure divided by work volume) over time and across Network Rail's regions and maintenance delivery units (MDUs), after normalising for the effect of the observable underlying differences between them[3].

1.2 Our previous reports demonstrated that it is possible to build a statistical model that can explain the majority of the variation in some types of expenditure between Network Rail business units as a function of a few key cost drivers.

1.3 The methodology in this year's report is broadly similar to the methodology in our year 3 of CP6 cost benchmarking report that we published in November 2022. We use historical data to establish a statistical relationship between expenditure and underlying cost drivers. We use the model to predict expenditure for the latest year as a function of observable cost drivers at the region or MDU level; and then compare that figure against actual expenditure. We refer to the difference between these two figures as the **unexplained difference**. The larger the unexplained difference, the more important it is to understand what is different about the business unit in question relative to others and relative to previous years, be it efficiency, inefficiency, headwinds (cost increases outside of Network Rail's control), tailwinds (cost reductions outside of Network Rail's control), data reporting or some other factor.

1.4 Our analysis aims to provide a comparison of expenditure across Network Rail's business units and to improve our understanding of underlying cost drivers. Together with other strands of ORR's work, such as our Annual Efficiency and Finance Assessment, it provides a deeper context for our overall assessment of Network Rail. This analysis is becoming an increasingly influential part of our reporting toolkit.

1.5 The methodology and most of the data that is the basis of this report formed the basis for the cost benchmarking analysis that we undertook on the CP7 plans that Network Rail submitted to us in March 2022, as part of PR23. Firstly, using

[3] For renewals, we have also analysed average unit costs (expenditure divided by work volume) separately by main asset classes and for different types of renewals activity. Whilst part of this analysis is discussed in the "Context" section of chapter 3, we are only publishing our detailed analysis on conventional track renewals as this compares better with last year's analysis.

Network Rail historical data and CP7 forecasts, we estimated both the maintenance expenditure and conventional track renewals average unit costs for CP7 for each region. We compared these estimates with Network Rail's forecasts to form a view on the reasonableness of those forecasts. Secondly, we used our previous cost benchmarking analysis, together with other studies (both in the literature and those commissioned by Network Rail), to inform our view about potential savings that Network Rail could make in CP7. The findings of that analysis were used as one element of the evidence that informed ORR's initial advice to the UK and Scottish governments in summer 2022, as they prepared their statements of available funding (SoFAs) and high-level output specifications (HLOSs) for the next control period (CP7).

1.6 Furthermore, we used cost benchmarking analysis to inform our PR23 final determination. Specifically, we assessed the forecasts of maintenance, renewals and support costs in Network Rail's Strategic Business Plans (the interim plan for Scotland) that it submitted to ORR in March 2023 which, alongside other evidence, informed our final determination on Network Rail's CP7 efficiency targets.

Reporting our results

1.7 The key focus of this analysis is the comparison of outturn maintenance expenditure and conventional track renewals average unit costs in 2022-23, against expected expenditure derived from our statistical models, which are calibrated on past data. Results are presented as percentage deviations from expected expenditure/average unit costs – a positive number means that outturn expenditure has been higher than that predicted by the model and vice versa. These results represent cost variances that cannot be statistically explained by observable business unit characteristics and therefore merit further investigation.

1.8 We present results at the level of Network Rail's regions and MDUs, and highlight the largest outliers.

1.9 We have discussed our key findings with Network Rail, and this has been helpful in sense checking our interpretation of the results and in identifying other potential factors at play.

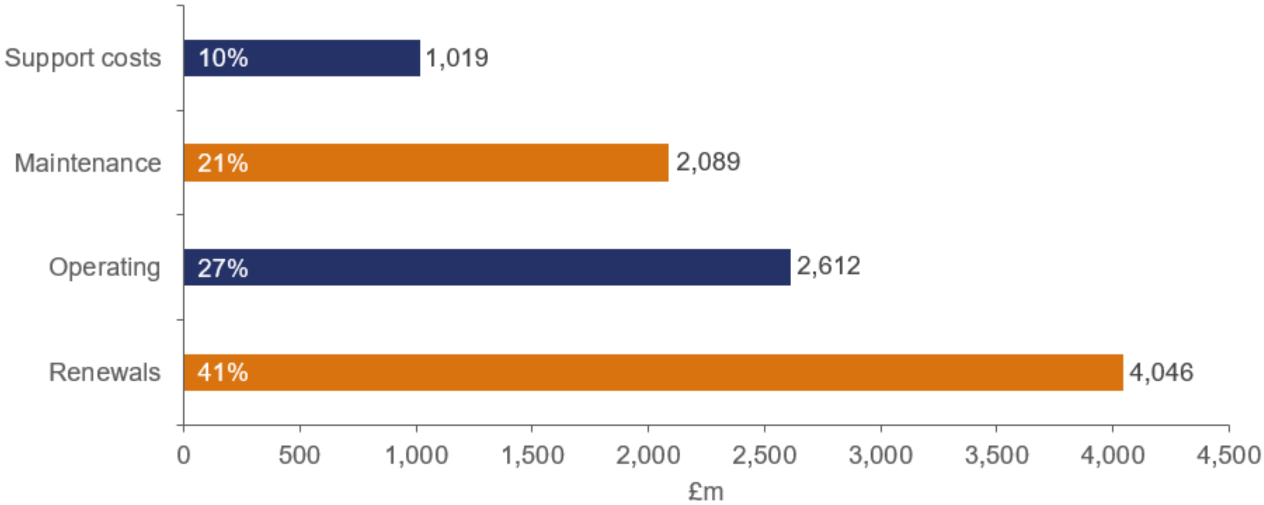
1.10 We have sought to reflect Network Rail's input in this report as much as possible. We will continue to engage with Network Rail to discuss its views on the methodology and the data that supports this analysis; on the factors that could explain our results; and on possible actions that it could undertake to continue to improve both its cost information and efficiency.

Quantitative context

1.11 Below we provide some high-level quantitative information by way of context for the analysis that follows.

1.12 In this report, we cover maintenance and a proportion of renewals. As shown in Figure 3, maintenance represented 21% of Network Rail's operations, support, maintenance and renewals (OSMR) expenditure for 2022-23, with renewals representing 41%. Our unit cost analysis of renewals has focused on 63% of renewals expenditure (i.e. covering activities carried out at region level where we could match costs and volumes). The proportion of renewals analysed in our statistical model (i.e. conventional track renewals) represents 12% of both the renewals expenditure for 2022-23 and average yearly renewals expenditure over 2014-15 to 2022-23.

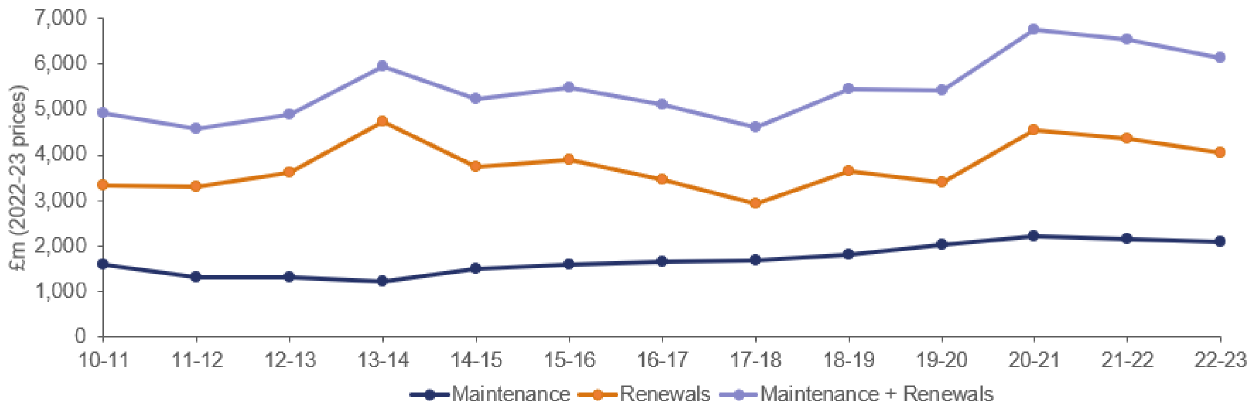
Figure 3: Breakdown of OSMR expenditure, 2022-23 (2022-23 prices)



Expenditure figures are taken from the 2023 Regulatory Financial Statements. Operating expenditure includes Schedule 4 & 8 payments, network operations costs, traction electricity and industry costs and rates.

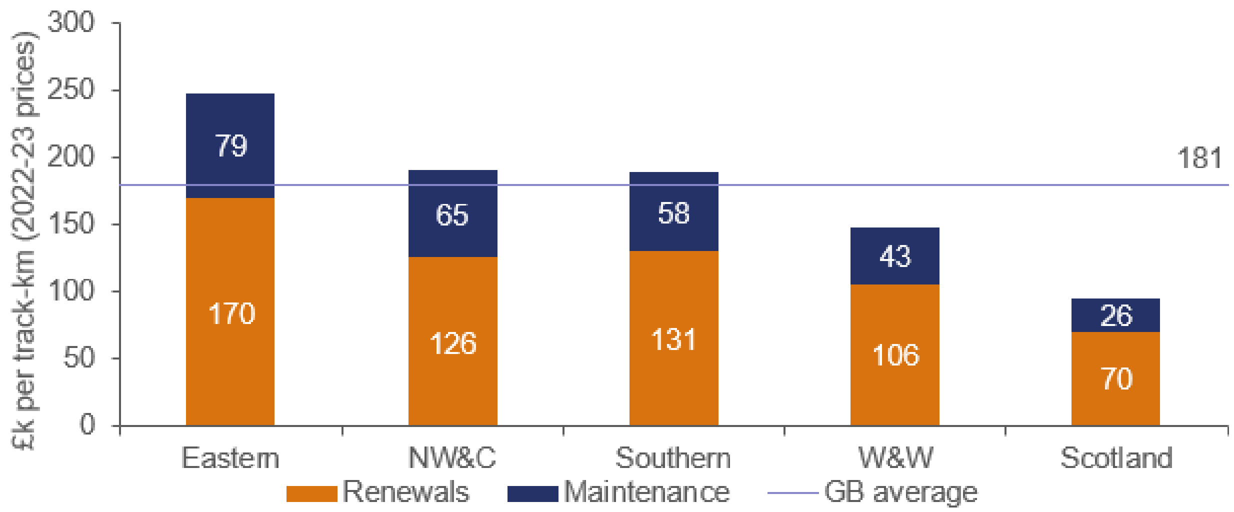
1.13 Figure 4 shows the trends in total maintenance and renewals expenditure, in 2022-23 prices. Maintenance expenditure has slightly fallen since 2021-22, after having been on a steady upward trend since 2013-14. Renewals expenditure has fluctuated considerably over the period from 2010-11 to 2022-23.

Figure 4: Maintenance and renewals expenditure, 2010-11 to 2022-23 (2022-23 prices)



1.14 Figure 5 shows the breakdown of average annual maintenance and renewals expenditure by region, normalised by network size (expressed in track-kms). There is considerable variation across regions. A key purpose of cost benchmarking is to control for the proportion of this variation that is due to observable factors, so that comparisons across regions are made on a more like-for-like basis.

Figure 5: Breakdown of average total maintenance and renewals expenditure per track-km, 2010-11 to 2022-23 (2022-23 prices)

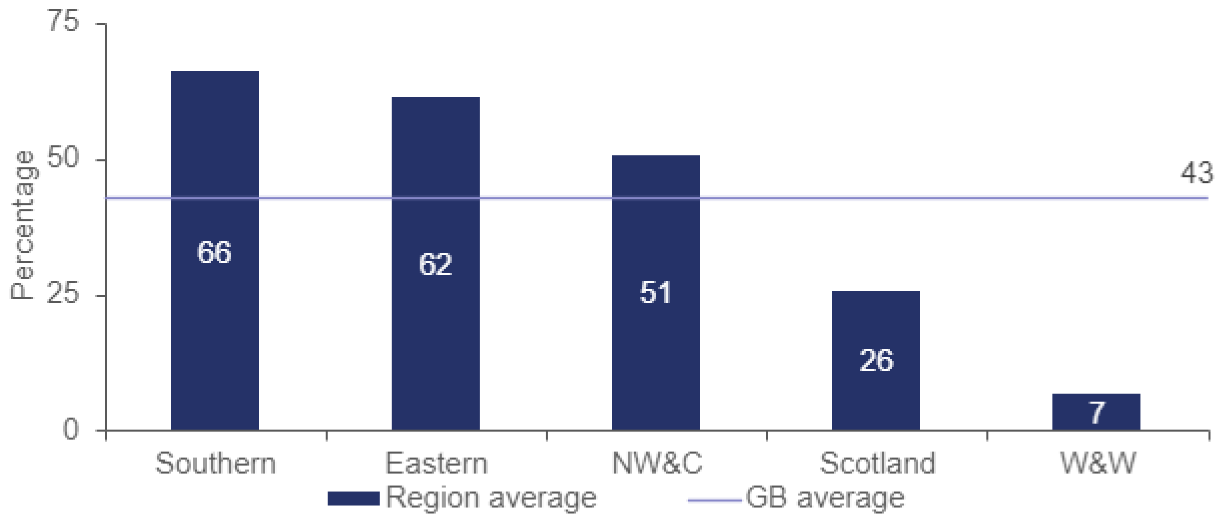


1.15 Figure 6 shows average annual traffic density across regions (split into passenger and freight traffic). We observe that according to this data, there appears to be no clear correlation between this variable and the expenditure per track-km (as shown in Figure 5 above).

Figure 6: Average traffic density (train-km per track-km), 2010-11 to 2022-23

1.16 Figure 7 shows the average proportion of electrified track for the period from 2010-11 to 2022-23. We observe that there is a high degree of variation in the proportion of electrified track between regions.

Figure 7: Average proportion of electrified track, 2010-11 to 2022-23

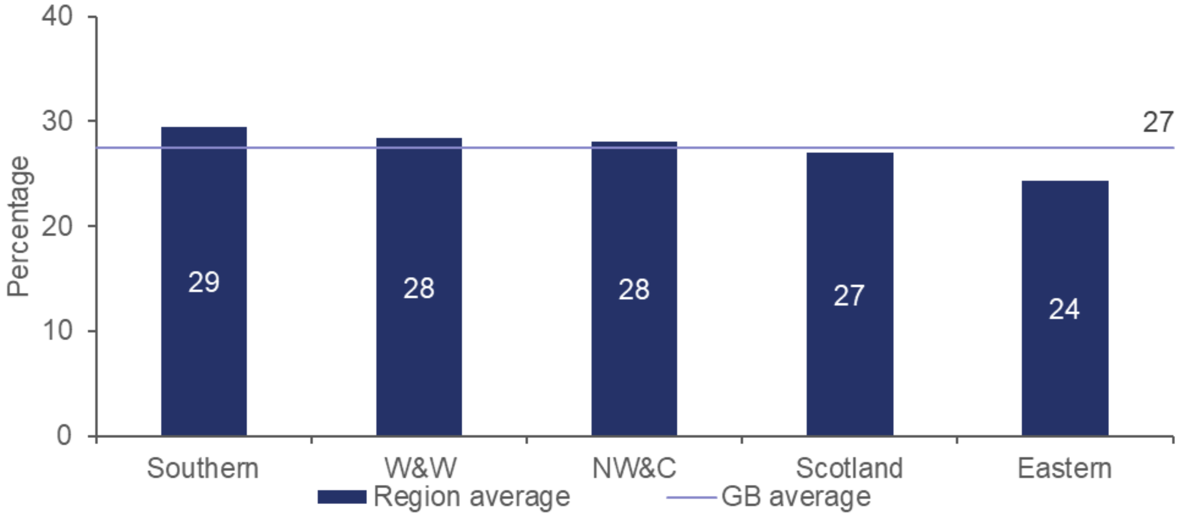


1.17 The network is classified into five criticality bands[4]. Figure 8 shows the proportion of track-km that is classified into either criticality band 1 or 2. We observe that

[4] Network Rail defines route criticality as a "measure of the consequence of the infrastructure failing to perform its intended function, based on the historic cost of train delay per incident caused by the track asset". Using this measure, each strategic route section (SRS) of the network has been assigned a route criticality band from 1 to 5. The lower the number of the criticality band, the more a delay is likely to cost

according to our data, there is no clear correlation between this variable and the expenditure per track-km (as shown in Figure 5 above).

Figure 8: Criticality 1 and 2 track-km as a proportion of total track-km, average 2013-14 to 2022-23

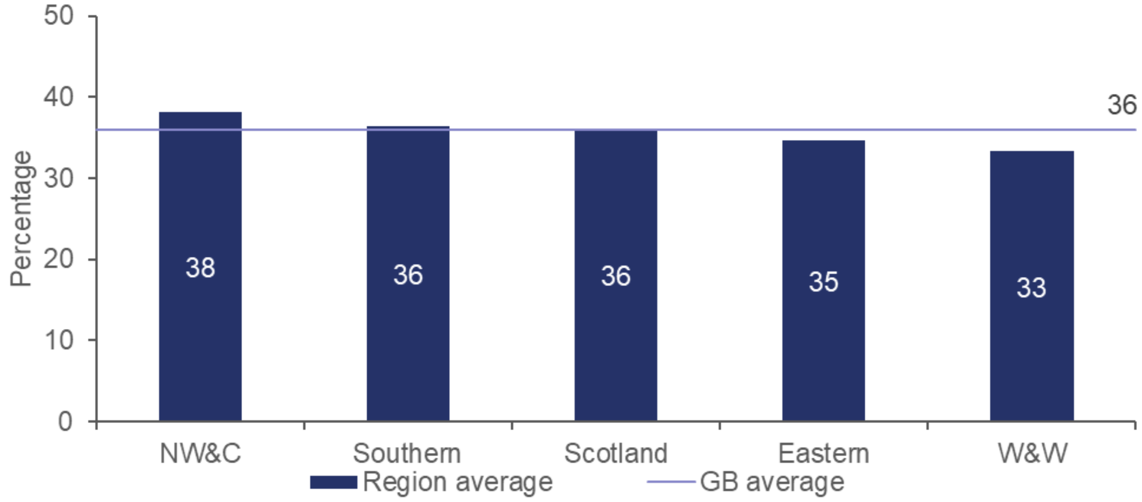


1.18 The network is also classified into seven track category bands[5]. Figure 9 shows the proportion of track-km that is classified into criticality bands 1A, 1 or 2. We observe that according to our data, there is no clear correlation between this variable and the expenditure per track-km (as shown in Figure 5 above).

should infrastructure fail. The classification of each SRS into criticality bands is used in the development of Network Rail's asset policy as a first step to matching the timing and type of asset interventions.

[5] Each track line is assigned a category from 1A to 6 based on a function related to its Equivalent Million Gross Tonnes per Annum (EMGTPA). The EMGTPA measures the annual tonnage carried over a section of track but takes into account variations in track damage caused by different types of rolling stock. Category 1A is the highest - 125mph or higher and Category 6 is the lowest – 20mph and below.

Figure 9: Category 1A, 1 and 2 track-km as a proportion of total track-km, average 2013-14 to 2022-23



1.19 Our analysis aims to control for the effect of cost drivers including those described above on maintenance expenditure and average renewals unit cost across Network Rail's business units.

2. Maintenance

Introduction

2.1 Maintenance expenditure relates to activities that sustain the condition and capability of the existing infrastructure to the previously assessed standard of performance.

2.2 Most maintenance activity on Network Rail's infrastructure is carried out by Maintenance Delivery Units (MDUs). MDUs are operating units within Network Rail's routes, responsible for the majority of the day-to-day upkeep of their designated part of the network. MDUs are not responsible for renewals.

2.3 Most maintenance is carried out, or procured, at the route or region level. Each MDU is part of a route, and each route is part of a region. In 2022-23, MDUs accounted for around 61% of total network maintenance expenditure. The remaining 39% was regionally or centrally-managed, covering activities such as structures examination, major items of maintenance plant and other HQ managed activities.

2.4 In our year 3 of CP6 report, we identified some data issues that affected our analysis of maintenance expenditure. These included the exclusion of a significant proportion of expenditure classified as "centrally-managed maintenance expenditure" as we could not effectively allocate it to individual routes. They also included issues related to expenditure classification and data recording. We stated that we would work with Network Rail and its regional teams to resolve those issues. As part of this, we said we would agree with Network Rail on a process that would allow regional teams to validate the data before we analyse it.

2.5 Following our publication of the report, we worked with Network Rail and its regions to put together a dataset at MDU and region level and this is the data we have used in the present analysis. Although, as discussed in paragraph 2.34, it has not yet been possible to fully resolve the issue of cost allocation at MDU level due to hosting[6], we consider this data to be the best we can have at the moment. The data has been subjected to quality assurance by both Network Rail and its regions, in addition to our own quality assurance. Network Rail quality assurance consisted of, among other things, ensuring that cost classification is consistent across regions.

[6] Hosting is a process whereby one MDU undertakes maintenance activities on some infrastructure (e.g. overhead line) on behalf of other MDUs, but the costs are charged to the MDU doing the work rather than the MDU where the asset is located.

2.6 In our year 3 of CP6 report, we undertook the analysis based on data for the control period 4 (CP4) ten routes and then we compared regions after aggregating these route level results to the current five regions. This was because, at the time, we did not consider that the size and the quality of the data that we had at region level was good enough to produce robust results. Notably, a significant proportion of the maintenance expenditure classified as “centrally-managed” was excluded from the model as we were unable to effectively allocate it to the ten routes. We recognised that the CP4 ten routes do no longer match the current organisational structure of Network Rail and stated our aim to use regional data in our future analysis. In the present report, we have used the maintenance expenditure data as reported at the level of Network Rail’s five regions. Analysing data at region level constitutes a significant improvement as we no longer have to exclude some expenditure.

2.7 The findings of this analysis at region level are then compared with those from our MDU-level analysis. We consider that the region level analysis is more robust than the MDU-level analysis, but the MDU-analysis is more local and granular (although it continues to be affected by data allocation issues due to hosting). Whilst the two types of analysis broadly agree in their conclusions, there are some differences which we discuss at the end of this chapter.

Region level analysis

2.8 The analysis is based on data for financial years 2010-11 to 2022-23 for the existing five regions. The data and the region-level maintenance expenditure model specification are described in Annex B.

2.9 From Annex B, Table 2, we observe that **there has been an average annual increase in maintenance expenditure of 4%[7] per year (in real terms) since 2010-11, after normalising for factors such as traffic and network complexity**. This may be due to inefficiency, or other factors.

Regional results

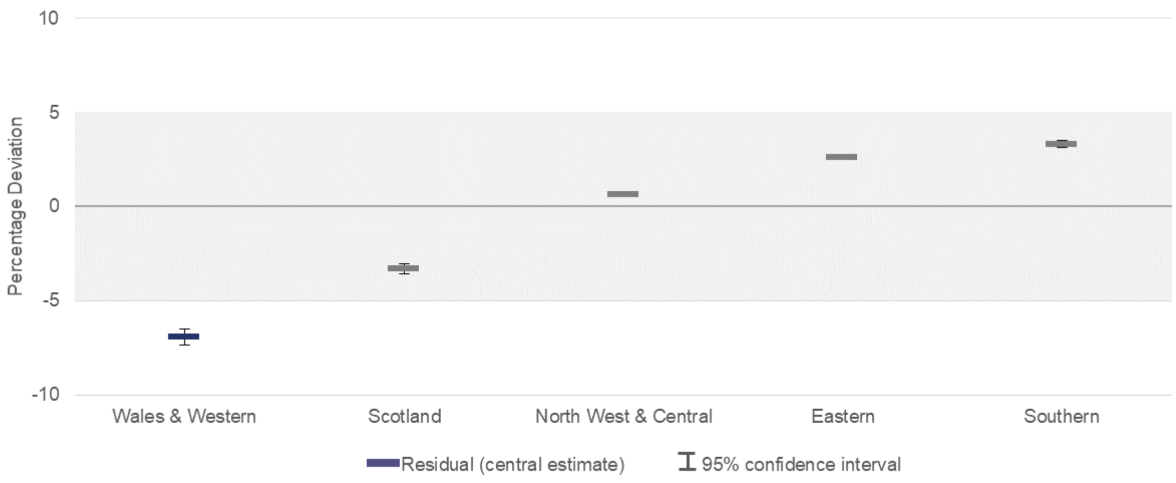
2.10 The main output of this analysis is the estimate of the maintenance expenditure that each region is expected to incur, given its characteristics (e.g. traffic, network complexity, etc). Then we compare these estimates against the outturn maintenance expenditure in 2022-23. We order the regions according to the

[7] Calculated from the coefficient of the “Year” variable as ($e^{0.04}$ -1).

amount of unexplained variation (i.e. the difference between outturn and predicted expenditure).

2.11 Figure 10 below shows, for each region, the proportion of unexplained cost variance in 2022-23. A negative number means that the region spent less than expected (according to our statistical model) while a positive number means that the region spent more than expected (according to our statistical model).

Figure 10: Deviation between outturn and expected (modelled) maintenance expenditure, 2022-23- Regional comparisons



Note: Given the uncertainty associated with this statistical model, we consider any region that is within +/−5% of our modelled prediction (as shown by the x-axis at zero) is not an 'outlier'. These regions are marked grey. The lines surrounding the central estimate of a given region's deviation between outturn and modelled cost indicate a 95% confidence interval. In other words, given the data available and the robustness of our model, there is a 95% probability that this estimated confidence interval contains the actual number representing the deviation between outturn and modelled cost.

2.12 Figure 10 shows that **maintenance expenditure at the region level, was between -7% and +3% of that predicted by our model for 2022-23**. **Wales and Western is at the lower end of the range** while **Southern is at the top end of the range**. However four out of five regions are within 5% of our model's prediction.

2.13 This range is tighter than that implied in last year's analysis (-17% to +17%). However, we consider that these results are not directly comparable to those in last year's report because the present analysis has modelled all the maintenance expenditure at region level, while last year we excluded a significant proportion of expenditure that was classified as "centrally-managed". This reduction in the size of the range is an indication that our model has become a better predictor of maintenance expenditure, as it models the totality of maintenance expenditure at region level.

2.14 The **Southern** region's actual maintenance expenditure was 3% above the model's prediction in 2022-23. Given the uncertainties in our model, we consider that Southern's maintenance expenditure (like that of Eastern, North West and Central and Scotland) is in line with our model's prediction (i.e below 5% difference).

2.15 **Wales and Western** is at the lower end of the range (-7%). Although not comparable because of the data issues as explained above, in last year's report, Wales and Western spent 3% less than our model's prediction. The region stated that last year's result was the outcome of the work they had undertaken to reduce costs. For example, the region said that it re-aligned the accounting classification of some minor maintenance works expenditure to be consistent with practice in other regions. According to the region, this resulted in reduced maintenance expenditure, which seems to have continued this year.

2.16 Other possible factors that could account for differences between regions arising from wider discussions with Network Rail include factors that our model does not capture, such as the proportion of work carried out in and around the London area; and the need to carry out work at night and weekends (over and above that implied by higher traffic volumes alone).

2.17 We will continue to work with Network Rail over the next few months to look into the potential underlying causes for these results, and to improve our model where possible.

MDU-level analysis

Introduction

2.18 During 2017-18 to 2019-20, Network Rail reduced the number of MDUs from 37 to 35. Woking closed in 2017-18 and activities previously undertaken by Woking moved to Clapham and Eastleigh, which then became Wessex Inner and Wessex Outer from 2018-19. Similarly, in 2019-20, Bristol, Plymouth, Reading and Swindon MDUs were restructured into Western Central, Western East and Western West.

2.19 To maintain comparability with historical data, we analysed maintenance expenditure using the 37 MDUs structure in our cost benchmarking reports for year 1 and year 2 of CP6. However, we have always sought to analyse the MDUs using the actual structure, as far as the data can be accurately reported at that structure. Last year, we undertook the analysis for 36 MDUs. This is because while we were able to re-allocate data from Woking, Eastleigh and Clapham to

Wessex Inner and Wessex Outer, we were unable to do the same for Western Central, Western East and Western West, so we continued to use Bristol, Plymouth, Reading and Swindon as part of the MDU structure, instead. We stated that we would continue to explore ways to effectively allocate this data to the new MDUs.

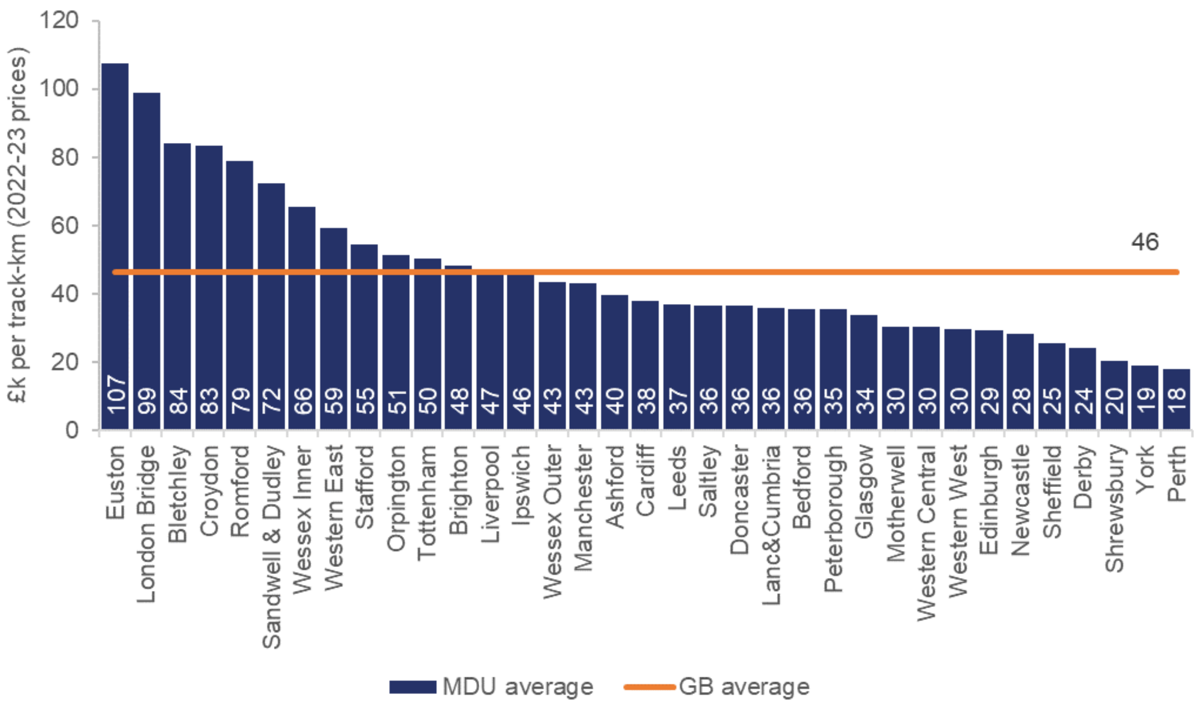
2.20 This year we have undertaken the analysis for 35 MDUs as we have been able to re-allocate data from Bristol, Plymouth, Reading and Swindon to Western Central, Western East and Western West. Annex E maps the 35 MDUs to Network Rail's five regions.

2.21 On average, MDUs accounted for around 51% of total network maintenance expenditure during the 9 years covered by this analysis. The remaining 49% is centrally-managed and it covers activities such as structures examination, major items of maintenance plants and other HQ managed activities.

MDU context

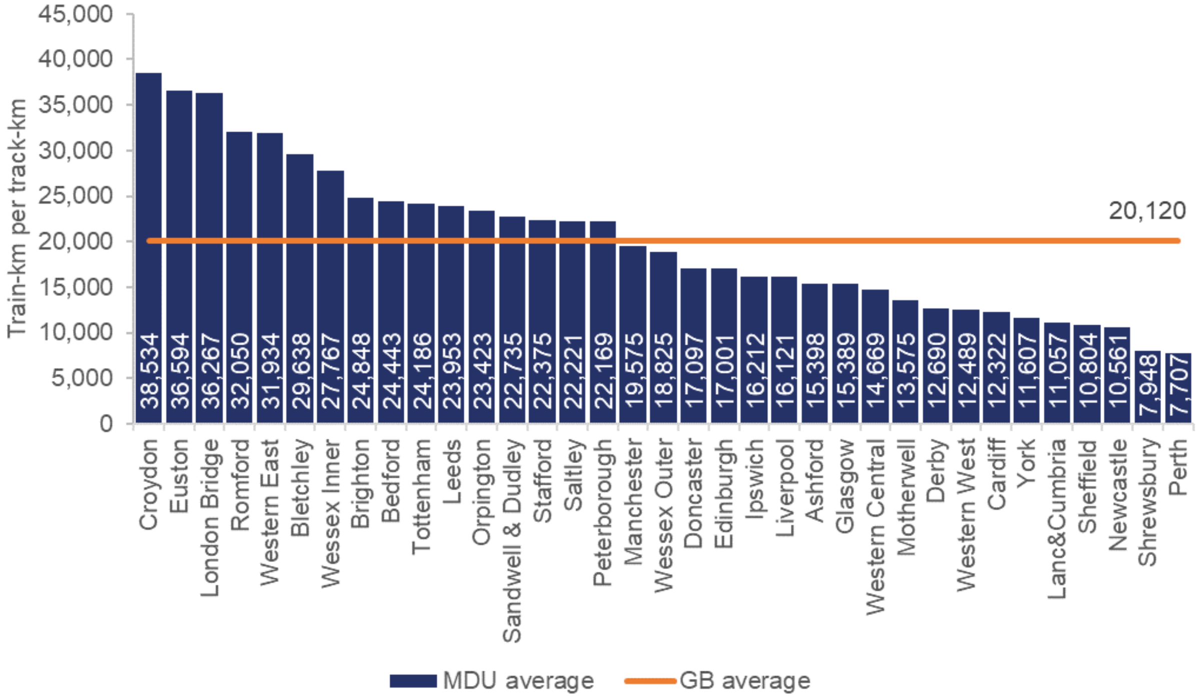
2.22 **Maintenance expenditure**: Figure 11 below shows that MDUs spent, on average, c. £46k per track-km each year. Euston spent the most, at £107k per track-km, whilst Perth spent the lowest amount, at £18k per track-km.

Figure 11: Average maintenance expenditure per track-km, 2014-15 to 2022-23 (2022-23 prices)



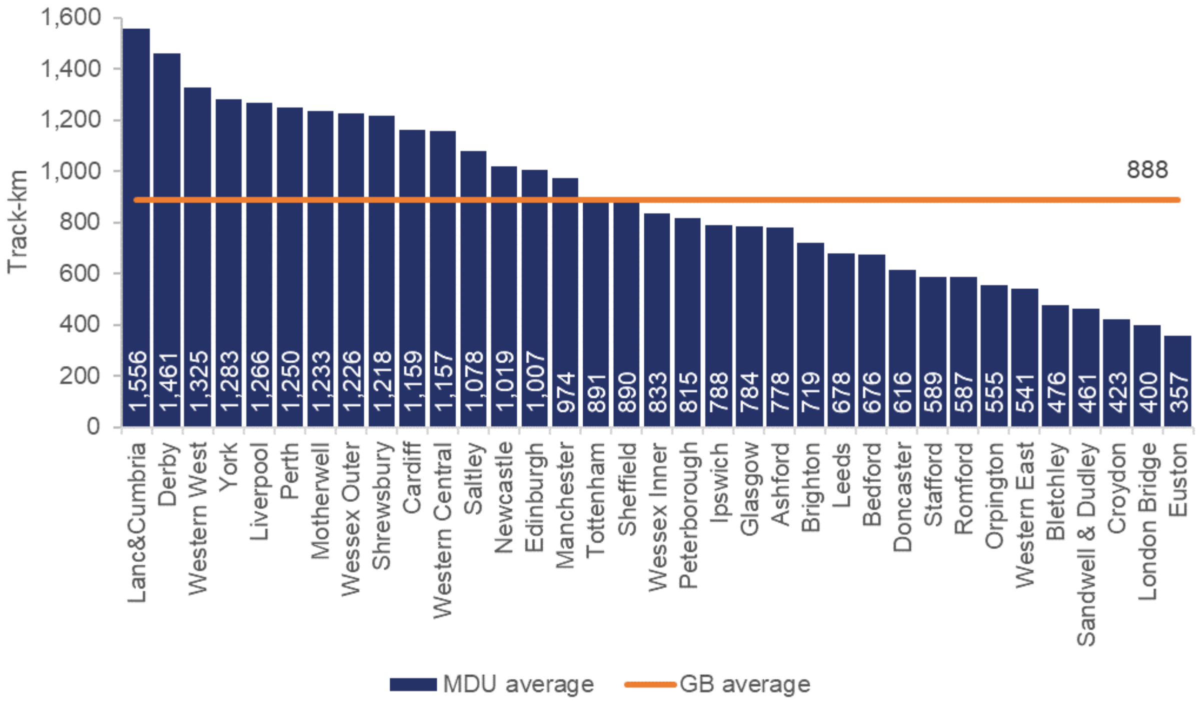
2.23 **Traffic Density**: Figure 12 below shows that traffic density (passenger and freight traffic per track-km) varied widely across MDUs. Croydon had 38,534 train-km per track-km, on average, per year. On the other hand, Perth had 7,707 train-km per track-km per year. The average GB-wide track density was 20,120 train-km per track-km per year.

Figure 12: Average traffic density (train-km/track-km), 2014-15 to 2022-23



2.24 **Network size (track-km):** as shown in Figure 13 below, Lancashire & Cumbria (Lancs & Cumbria) is responsible for the longest section of network with 1,556 track-km, whilst Euston maintains the shortest with 357 track-km. The average length of track covered by an MDU over the period 2014-15 to 2022-23 is 888 track-km.

Figure 13: Average track-km, 2014-15 to 2022-23



2.25 **Average number of tracks (track-km/route-km)** across all MDUs in 2022-23 was 2.22. Peterborough had the highest average number of tracks at 4.46, followed by Euston and Bedford at 3.23 and 3.14, respectively. Perth MDU had the lowest average number of tracks at 1.32, followed by Glasgow at 1.48.

2.26 **Average electrification** across all MDUs was 53% between 2014-15 and 2022-23. Shrewsbury, Western West, Derby, Perth and Sheffield all had virtually no electrified track (<1%), while Cardiff, and Saltley, had low proportions of electrified track (<10%). On the other hand, Croydon was almost fully electrified, followed by Euston, Orpington, London Bridge, Peterborough, and Romford, all with above 95% of track electrified.

2.27 The network is classified into five **criticality bands**. The MDU with the highest percentage of its track length within criticality bands 1 & 2 (combined) in 2022-23 is London Bridge[8] at 92%, followed closely by Stafford also at 92%. Shrewsbury and Perth have no track in criticality bands 1 & 2.

[8] Data for London Bridge was taken from 2019-20 onwards only due to poor quality of data before this period.

MDU Analysis

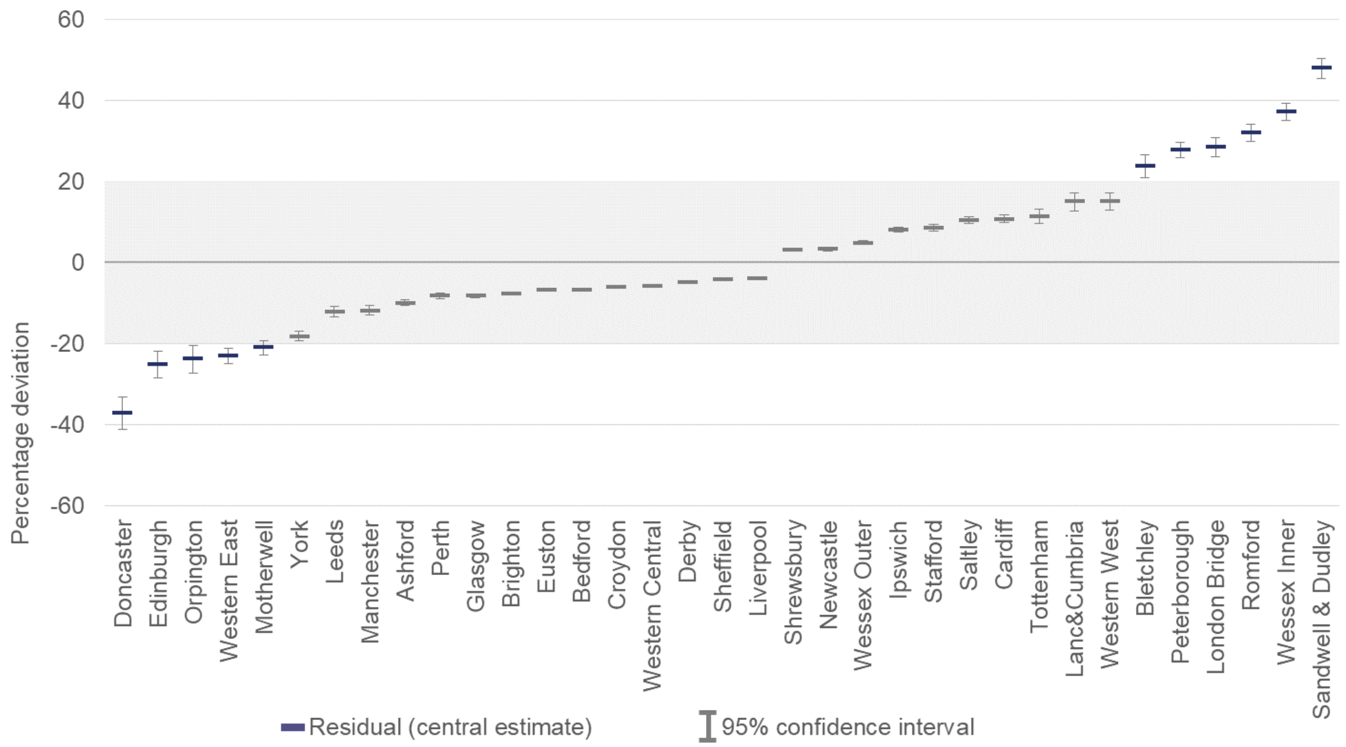
2.28 The MDU analysis is based on data for Network Rail's existing structure with 35 MDUs for financial years 2014-15 to 2022-23. The data and the MDU model specification are described in Annex B.

MDU results

2.29 The main output of this analysis is the estimate of the maintenance expenditure that each MDU is expected to incur, given its characteristics (e.g. traffic, network complexity, etc). Here, we compare these estimates against the outturn maintenance expenditure in 2022-23. We then order the MDUs according to the size of the unexplained variation.

2.30 Figure 14 below shows the proportion of unexplained cost variance for each MDU in 2022-23. A negative number means that the MDU spent less than expected (according to our statistical model), whilst a positive number means that the MDU spent more than expected.

Figure 14: Deviation between outturn and expected (modelled) maintenance expenditure, 2022-2023



Note: Given the uncertainty associated with this statistical model, we consider any region that is within +/−20% of our modelled prediction (as shown by the x-axis at zero) is not an 'outlier'. These regions are marked grey. The lines surrounding the central estimate of a given region's deviation between outturn and modelled cost indicate a 95% confidence interval. In other words, given the data available and the robustness of our model, there is a 95% probability that this estimated confidence interval contains the actual number representing the deviation between outturn and modelled cost.

2.31 Given that there is uncertainty in any statistical model, we classify MDUs into three broad bands based on the deviation between outturn maintenance expenditure and expected, or modelled, maintenance expenditure:

(a) MDUs for which outturn spend is **lower than expected** by 20% or more;

(b) MDUs for which outturn spend is **higher than expected** by 20% or more; and

(c) MDUs for which outturn spend is **within +/- 20% of that expected** by the model.

2.32 The analysis shows that, in 2022-23, the **Doncaster, Edinburgh, Orpington, Western East** and **Motherwell** MDUs are in the first category (<-20%). **Sandwell & Dudley, Wessex Inner, Romford, London Bridge, Peterborough** and **Bletchley** are in the second category (>+20%). At the extremes, **Doncaster** spent 37% less than predicted by our model whereas **Sandwell & Dudley** spent 48% above our model's prediction. The ordering of MDUs is broadly similar to that generated from last year's analysis, including the range of unexplained differences this year (-37% to +48%), which is almost identical to the one generated by last year's analysis for 2021-22 (-38% to +47%). The largest difference is that Wessex Inner went from being in the lower-than-expected category in 2021-22 to being one of the highest in the higher-than-expected category in 2022-23. This is likely due to a change in how the data is reported. When working to resolve the data issues that we identified in our year 3 of CP6 report, Network Rail discovered that maintenance expenditure for Wessex Inner had previously been understated.

2.33 This analysis shows that, for a minority of MDUs, there is a large proportion of unexplained variance between outturn expenditure and that suggested by our statistical model. One general explanation that the regions provided was hosting as described above. The regions stated that hosting arrangements are common and may therefore help to explain some of the outliers.

2.34 In last year's report, we said that we would work with Network Rail to explore ways in which this inconsistency in data recording due to hosting can be overcome. Following the publication, we discussed this with Network Rail but did not find a credible solution. While Network Rail recognises that this affects the comparisons in our analysis, it said stated that Network Rail's current data recording systems cannot allow them to effectively separate out the expenditure linked to hosting. We will continue to work with Network Rail to find a solution to this.

Consistency between regional and MDU results

2.35 In Figure 15 below, we compare the region level results to those implied by the MDU analysis. To do this, we map MDUs to regions, and then sum outturn and expected (modelled) cost from the MDU data/model up to region level.

2.36 Note that we do expect some differences in the regional and MDU level results as the two models are different in terms of the costs modelled and the cost drivers controlled for. However, this comparison helps us to draw out some insights regarding the robustness of the two analyses, by looking at whether the results for individual business units point in the same direction and by comparing the scale of unexplained differences.

Figure 15: Comparison of region and MDU deviations from expected (modelled) maintenance expenditure, 2022-23

2.37 Figure 15 shows that the results at both MDU and region level point in the same direction, with a relatively small difference in the scale, apart from in Scotland, where although the results point in the same direction, there is a large difference in scale. In our last year's report, results at MDU and region level pointed in the same direction only in three regions (Scotland, Southern and North West and Central). We consider this different result to be due to improvement in the data quality at region level as discussed above.

3. Renewals

Introduction

3.1 Renewals relate to activities to replace, in whole or in part, network assets that have deteriorated such that they can no longer be maintained economically. Renewal of an asset restores the original performance of the asset and can add additional functionality as technology improves.

3.2 In PR08, PR13 and PR18, we modelled maintenance and renewals expenditure together. The potential advantages of this approach include that it can capture potential interdependency between maintenance and renewals activities. For example, renewing an asset in one year may reduce maintenance requirements in subsequent years.

3.3 In practice, these two activities are different in nature and may be driven by different factors. Maintenance activities are less variable over time than renewals, which tend to be undertaken less often and as larger one-off projects to renew specific assets or specific parts of the network.

3.4 Therefore, in our year 1 of CP6 report, we estimated separate models for maintenance and renewals. Whilst this change greatly improved our modelling of maintenance expenditure, it also highlighted that our approach to the modelling of renewals needed further improvement. Notably, the renewals model could not account for natural annual fluctuations in expenditure arising from the lumpy nature of the renewals work (e.g. fluctuations due to differences in work mix, decisions to defer some works, etc.) which, if not accounted for, could be misinterpreted as poor/good performance. Also, different types of work are likely to be delivered at different costs.

3.5 In our year 2 and year 3 of CP6 reports, we addressed those shortcomings by comparing renewals unit costs (in simple terms, expenditure divided by work volume) and did this separately by main asset class and for different types of renewals activity.

3.6 We have followed the same approach for this year's analysis as it allows for more meaningful comparisons. It can also deal with a situation where there are large fluctuations in expenditure from year to year, as average unit costs for a given asset and work type should remain relatively stable, even if volumes of work fluctuate significantly.

3.7 We have analysed the average unit costs (expenditure divided by work volume) for CP5, years 1 to 3 of CP6 and year 4 of CP6, by asset class and by different types of renewals activity.

3.8 When making these comparisons, it is important to bear in mind that unit cost of renewals work is heavily influenced by a range of project-specific factors (e.g. location, scope, standards), which cannot be fully accounted for in this type of analysis.

3.9 Moreover, there are limitations when comparing CP5 to CP6 data, due to changes in the structure of the data reported. However, the mapping we have used aims to address this as far as possible, so that we can make some reasonable comparisons. There are also limitations when comparing unit costs over a single year. This is because there can be lags in the reporting of renewals activities, whereby the expenditure and volumes for a given activity are reported in different years[9]. While this mismatch can be partially addressed by calculating average unit costs across multiple years, this cannot be done for a single year of data.

3.10 Part of this unit cost analysis is discussed in the "Context" section of this chapter. However, we are only publishing our detailed analysis on conventional track renewals, as this better compares with the analysis presented in previous years' reports.

3.11 This chapter also describes the statistical model we have estimated to explain conventional track renewals unit costs at a route level as a function of key cost drivers. These results are then aggregated at a region level. Unlike in our maintenance expenditure analysis, where Network Rail provided us with data only at a region level, Network Rail was able to supply us with renewals data at the level of the existing 13 routes.

3.12 To adjust this data to the level of the ten CP4 routes, we aggregated the East Coast and North & Eastern routes into the LNE route, and we aggregated the Central, North West and West Coast Mainline South routes into the LNW route. All other routes stayed the same. Analysing the renewals data at the CP4 ten routes level has allowed us to overcome the issues with the size of our dataset by doubling the number of data points. This is important as the robustness of cost benchmarking analysis heavily depends on the size of the data used in the analysis.

3.13 Although we conducted our analysis at the level of the CP4 ten routes, we present only the regional comparisons in the main report. This allows us to be consistent

[9] We are aware this is a common issue with Signalling data.

with Network Rail's current organisational structure and Network Rail is regulated at a region level.

Context

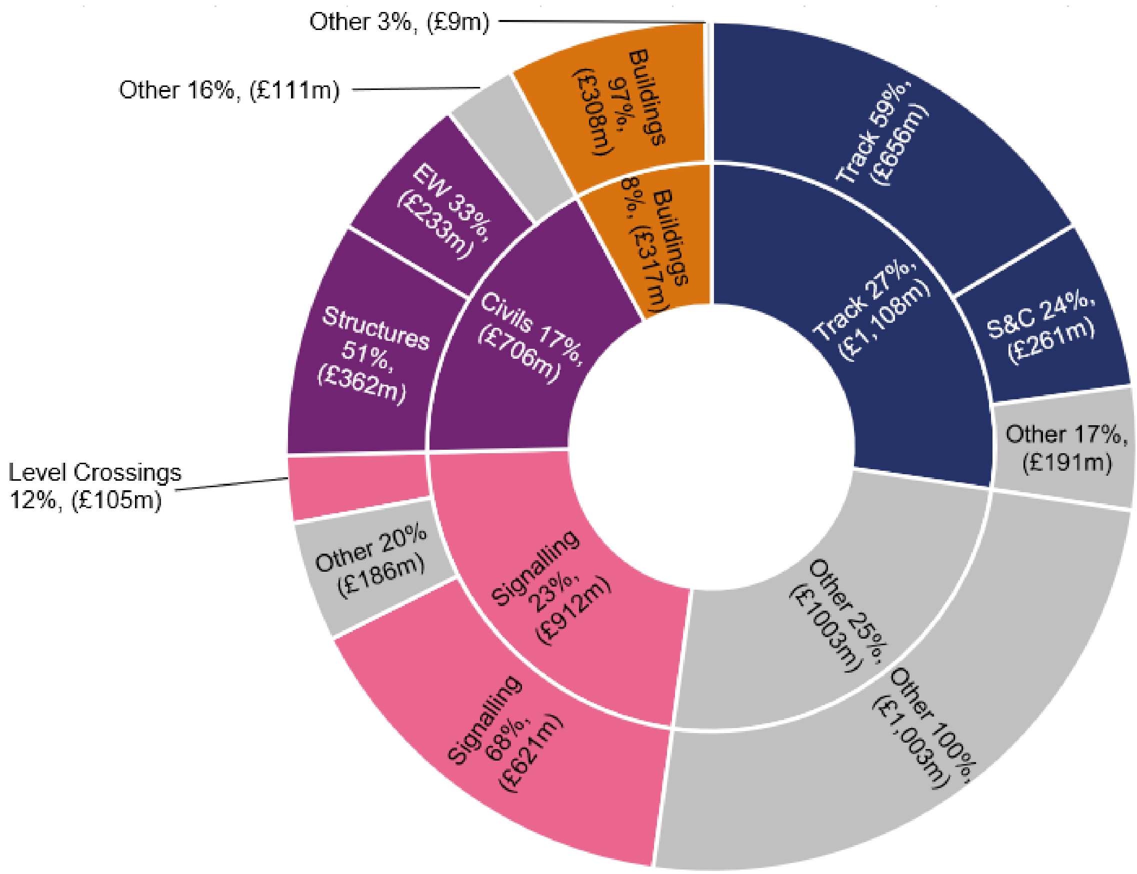
Renewals across asset classes

3.14 We conducted the average unit cost analysis on the components of Track (Track and Switching and Crossings), Signalling (Signalling and Level Crossings), Civils (Structures and Earthworks) and Buildings for which we could match costs and volumes. However, some assets renewal categories do not have unit costs. Therefore, this analysis accounts for 63% of renewals expenditure at a region level in 2022-23 (including centrally-managed expenditure).

3.15 **Breakdown of Network Rail's renewals expenditure by asset class:** Figure 16 shows the breakdown of renewals expenditure by asset class in 2022-23. The breakdown of average yearly expenditure for 2014-15 to 2022-23 is broadly the same. The 'Other' categories represent expenditure not captured in our analysis[10].

[10] For the 'Other' categories we were unable to accurately match expenditure and volumes at the work type level for this data. The 'Other' category in the inner ring of the chart includes expenditure on Electrical Power and Fixed Plant, Telecoms, Wheeled Plant and Machinery and IT, Property and Other renewals. EW stands for Earthworks; S&C stands for Switches and Crossings.

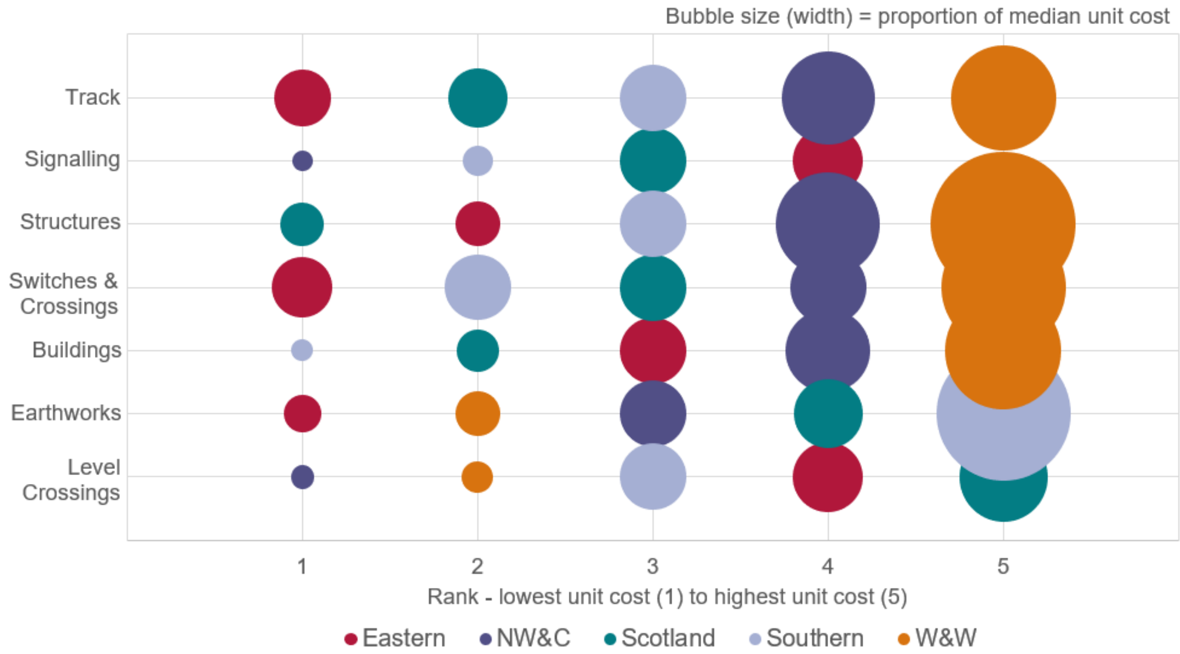
Figure 16: Breakdown of renewals expenditure by asset class (including centrally-managed expenditure), 2022-23 (2022-23 prices).



3.16 As indicated by the inner ring, expenditure on Track, Signalling, Civils and Buildings accounted for 75% of renewals expenditure. Asset classes are further split into sub-asset class or work type in the outer ring of Figure 16. For instance, the Switches & Crossings sub-asset class accounted for 24% of Track renewals expenditure.

3.17 **Variation in average renewals unit costs:** Figure 17 shows the 2022-23 average renewals unit costs, by asset and sub-asset class, and by region, with regions ranked for each asset according to their average unit cost. A rank of 1 represents the region with the lowest unit cost for a given asset class and a rank of 5 represents the region with the highest. The size (width) of the bubbles shows how large each region's average unit cost is relative to the median region in each asset and sub-asset class. **Wales and Western** and **North West and Central** have some of the highest average unit costs across the majority of asset classes. In comparison, **Eastern** and **Scotland** have some of the lowest average unit costs across the asset classes.

Figure 17: Average unit cost rankings per asset class, 2022-23



The bubble for Wales & Western Signalling has been removed due to the value being a large outlier (5.3).

3.18 For more details about the variations in renewals average unit costs, see Annex C, Table 3 where we present the renewals average unit costs by asset type for CP5, the first three years of CP6 and the year 4 of CP6 (2022-23).

Conventional track renewals

3.19 There are three main types of track renewals:

(a) conventional track renewals (work intended to fully replace the existing track asset utilising conventional track renewal methodologies);

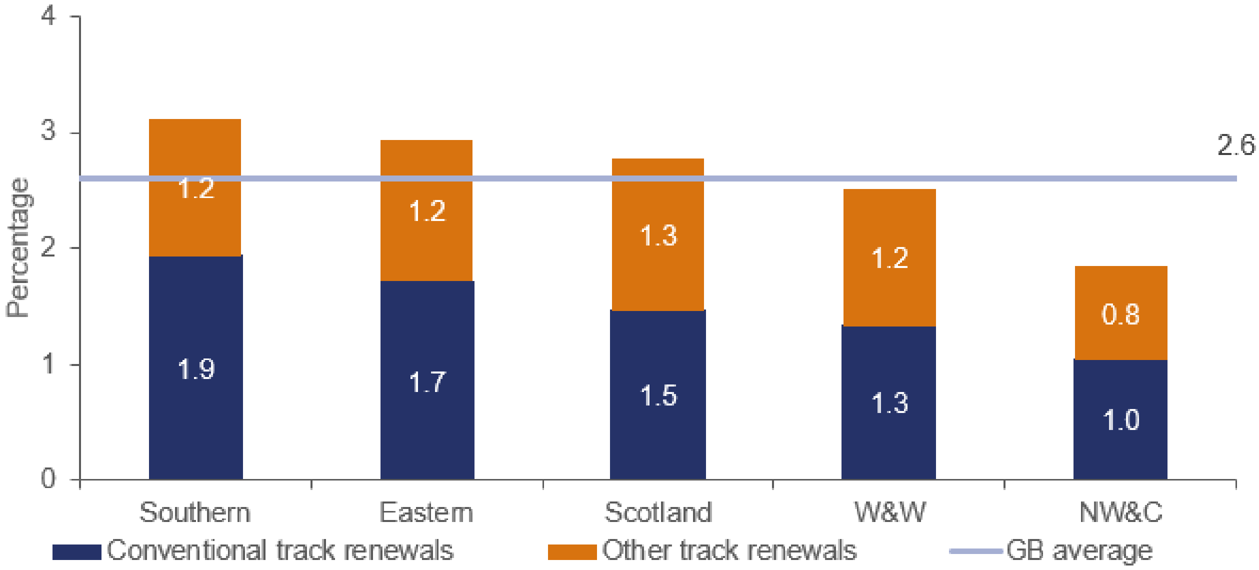
(b) track refurbishment (work intended to extend the life of the existing track asset rather than fully renew it); and

(c) high-output track renewals (work intended to replace the existing track asset through utilisation of the specialised high-output machines). The high-output technology is only appropriate for simple stretches of track without switches and crossings, platforms or viaducts.

The following paragraphs discuss conventional track renewals, which is the main focus of this chapter.

3.20 **Proportion of track renewed:** Figure 18 shows the volume of track renewed as a proportion of total region track-kms[11]. In 2022-23, Network Rail renewed 2.6% of its track. The Southern region renewed its track at the highest rate (3.1%, 1.9% of conventional track renewals and 1.2% of other types of track renewal), whilst North West and Central renewed at the lowest rate (1.8%, 1.0% of conventional track renewals and 0.8% of other types of track renewal).

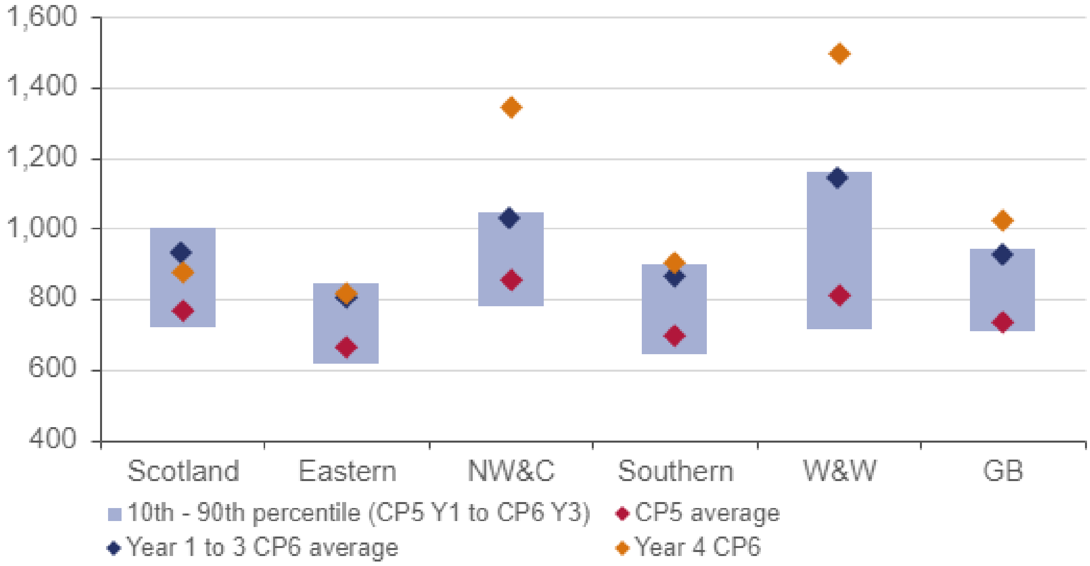
Figure 18: Average proportion of track renewed, 2022-23



3.21 **Conventional track renewals average unit cost:** Figure 19 shows the average unit costs for conventional track renewals by region for CP5; year 1 to 3 of CP6; and year 4 of CP6 (2022-23). **Average unit costs across all regions are 11% higher in year 4 of CP6 relative to the first three years of CP6.** Wales and Western has the highest average unit cost (£1,500k per track-km) in year 4 of CP6, whilst Eastern has the lowest average unit cost (£821k per track-km).

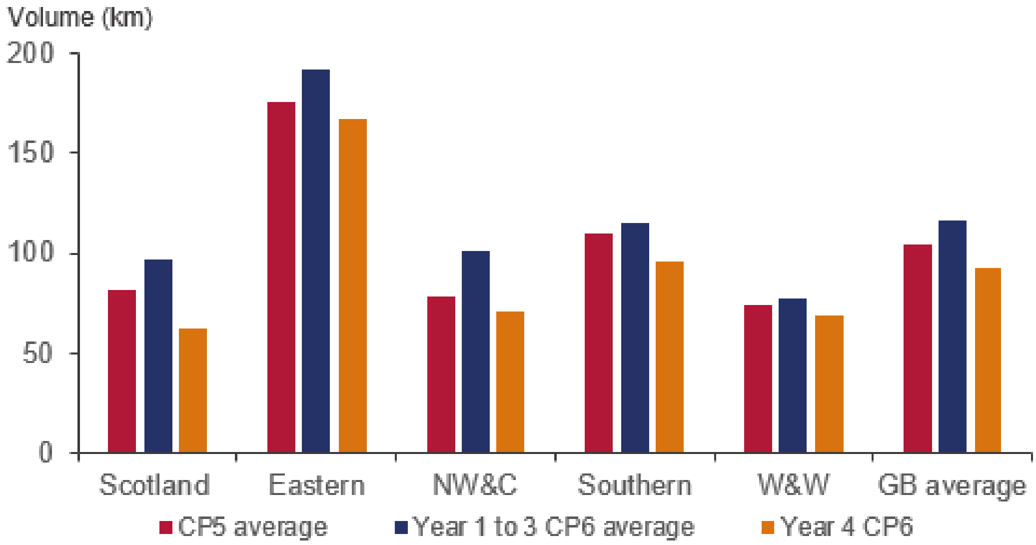
[11] Proportion of conventional track renewed per route is calculated as conventional track renewals costs divided by track-km. Proportion of other track renewals per route is calculated as the sum of high-output renewals and track refurbished, divided by track-km.

Figure 19: Conventional track renewals average unit costs (2022-23 prices)



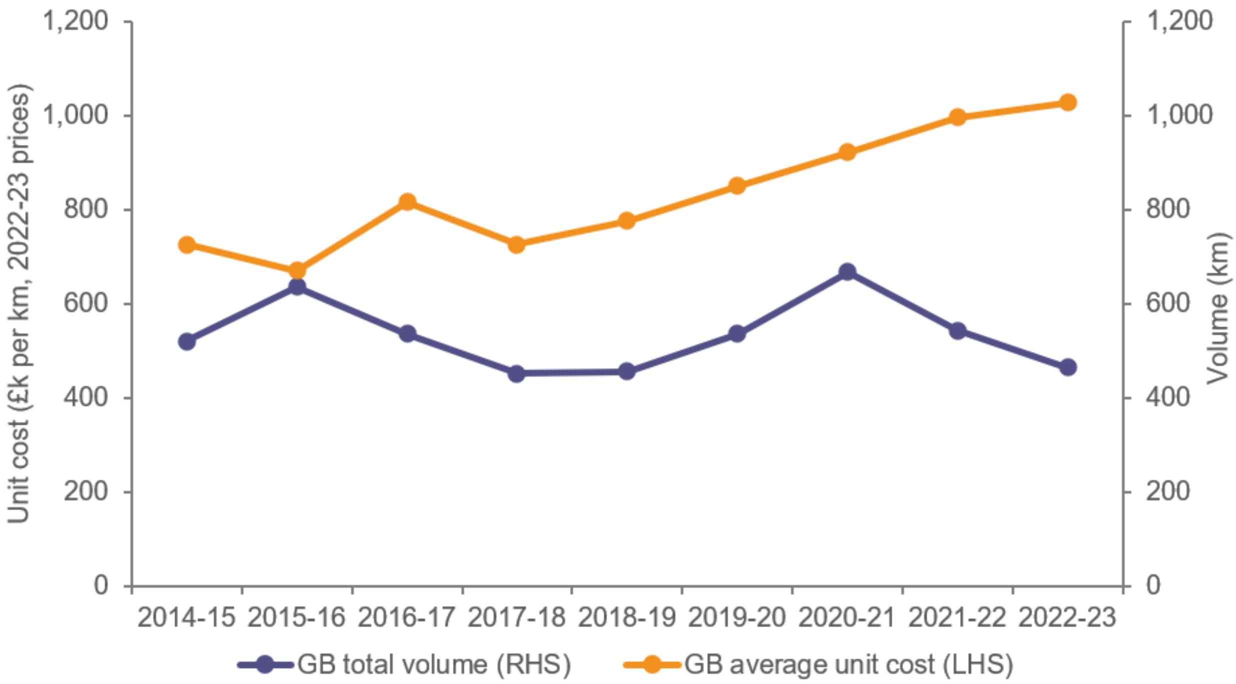
3.22 **Conventional track renewals volumes:** Figure 20 shows the average volumes for conventional track renewals by region for CP5 and year 1 to 3 of CP6, and volumes for year 4 of CP6 (2022-23). Volumes decreased in year 4 of CP6 relative to the average annual volumes in year 1 to 3 of CP6. Eastern completed the most conventional track renewals in 2022-23 (167km) whilst Scotland completed the fewest (62km).

Figure 20: Conventional track renewal volumes



3.23 **Trends in conventional track renewals unit costs and volumes (GB total):** Figure 21 shows the trend in the average unit cost and volumes for conventional track renewals for GB as a whole. Real terms unit costs have been on an upward trend since 2017-18. This could be due to inefficiency, changes in work mix or other factors. Volumes have also risen every year since 2017-18, until 2021-22, where they fell by 19% as compared to 2020-21, and then fell a further 14% from 2021-22 to 2022-23. Trends in unit costs and volumes are less clear prior to 2017-18.

Figure 21: Trends in Conventional track renewals – average unit cost and total volumes, 2014-15 to 2022-23 (2022-23 prices)



Analysis

Data

3.24 The analysis is based on data for financial years 2014-15 to 2022-23, recorded at the level of the ten routes that were introduced by Network Rail in CP4. The data and the conventional track renewals model specification are described in Annex B.

3.25 From Annex B, Table 2, we observe that **there has been an average annual increase in the average unit costs of conventional track renewals of 4%**[12] **per year (in real terms) since 2014-15, after normalising for factors such as**

[12] Calculated from the coefficient of the "Year" variable as ($e^{0.04}$ -1).

traffic and network complexity. In 2022-23, the rate of growth in the average unit costs for conventional track renewals increased to 6%[13] compared to the above long term trend. This may be due to inefficiency, headwinds or some other factors including work mix or some project-specific factors (e.g. project location), which cannot be taken account of in a top-down analysis of this sort.

Regional results

3.26 This section compares outturn conventional track renewals unit costs against expected spend as predicted by our model, given each region's characteristics. Whilst the underlying analysis was conducted using route level data, we have aggregated our route level results to the region level and that is what we present in this section[14]. We order the regions according to the amount of unexplained variation (i.e. the difference between outturn and predicted unit costs).

3.27 We note that the unit cost of conventional track renewals is influenced by a wide variety of project-specific factors, which cannot be taken account of in a top-down analysis of this sort. So, the results we present here should be read as indicative of the relative position of different regions, rather than as precise estimates of what the average unit costs should be in each case.

3.28 Figure 22 below shows, for each region, the proportion of unexplained cost variance in 2022-23[15]. A negative number means that the region spent less than expected (according to our statistical model) whilst a positive number means that the region spent more than expected.

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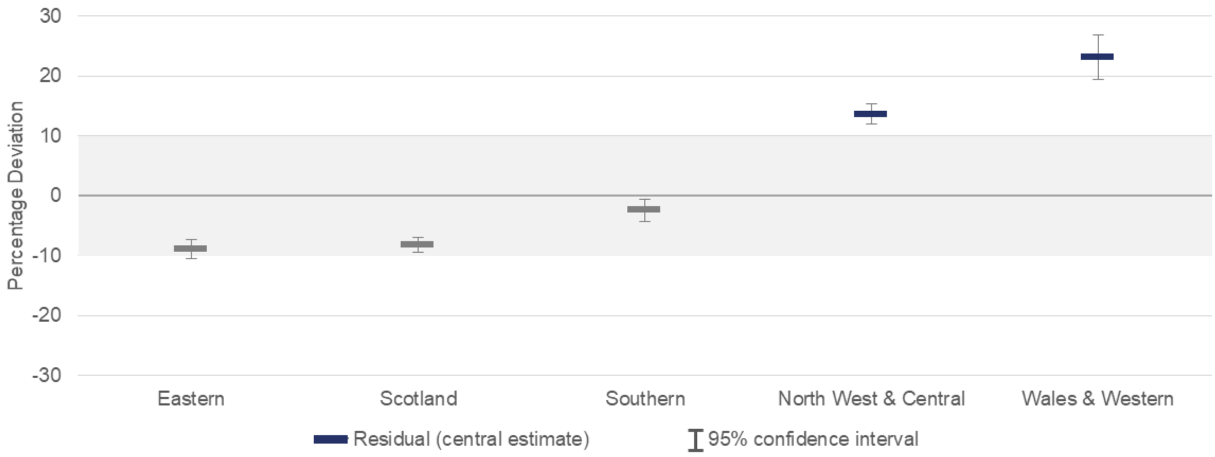
[13] Calculated from the coefficient of the "Dummy for 2022-23" variable" as ($e^{0.06}$ -1).

[14] This allows the interpretation of these findings to be consistent with Network Rail's current organisational structure as reflected in the five regions..

[15] This is obtained as an average of the average unit costs for the relevant routes, weighted by renewals volume.

Figure 22: Deviation between outturn and expected (modelled) unit costs for conventional track renewals by Network Rail region, 2022-23



Note: Given the uncertainty associated with this statistical model, we consider any region that is within +/−10% of our modelled prediction (as shown by the x-axis at zero) is not an 'outlier'. These regions are marked grey. The lines surrounding the central estimate of a given region's deviation between outturn and modelled cost indicate a 95% confidence interval. In other words, given the data available and the robustness of our model, there is a 95% probability that this estimated confidence interval contains the actual number representing the deviation between outturn and modelled cost.

3.29 Figure 22 shows that **conventional track renewals' average unit costs at the region level are between -9% and +23% of what our model would predict. This range is significantly wider than in last year's analysis (-3% to +7%).**

3.30 Compared to last year, **Eastern is still at the lower end of the range (-9%)**, whilst **Wales and Western has replaced Southern at the top end of the range (+23%)**. This is largely consistent with our unit cost analysis where we found that, in 2022-23, conventional track renewals unit costs for **Eastern** and **Wales and Western were 2% and 31%,higher than their respective average unit costs for the first three years of CP6**. Looking at all the regions together, the unit cost analysis showed that, **in 2022-23, Network Rail's conventional track renewals unit costs were 11% higher than the average unit costs for the first three years of CP6.** This may be due to inefficiency, headwinds or some other factors including work mix or some project-specific factors (e.g. project location), which cannot be taken account of in a top-down analysis of this sort.

3.31 In our year 3 of CP6 report, Wales and Western's average conventional track renewals unit costs appeared to be 3% less than our model's prediction. The Wales and Western region explained that its track renewals work was negatively impacted by industrial action in 2022-23. The region stated that the industrial action meant it continued to incur its normal sunk costs/overheads, but could not deliver all the volume which pushed up the unit costs. While it is possible that the industrial action in 2022-23 affected Wales and Western delivery of its renewals volumes, it is unlikely this explains the whole of the movement, and it is not clear whether this region was more affected by this issue than the other regions. We will continue to discuss the effect of industrial action on the data with Network Rail.

3.32 In last year's report, **North West and Central**'s conventional track renewals average unit costs were almost as expected by our model. The present analysis shows that in 2022-23, North West and Central had the second highest unit costs relative to model prediction (+14%). This finding is consistent with our unit cost analysis where North West and Central's average unit costs on conventional track renewals in 2022-23, were 31% higher than its average unit costs for the first three years of CP6. The region cited several project-specific factors (including location and possessions design) that could explain its high average conventional track renewals unit costs relative to model prediction. The region also said that in 2022-23, it delivered a smaller work bank than it had planned, which pushed up the unit costs.

3.33 It is important to note that the unit costs of renewals are influenced by a wide variety of project-specific factors, which cannot be taken account of in a top-down analysis of this sort. So, the results above should be read as indicative of the relative position of different regions.

3.34 We will continue to work with Network Rail over the next few months to look into the potential underlying causes for these results, encouraging regions to share good practice, and to improve our model where possible.

Annex A: Cost benchmarking

What is cost benchmarking?

4.1 Cost benchmarking involves comparing expenditure across organisations or business units, after controlling for the effect of observable underlying differences. By ‘controlling for’ we mean that we separate out the effect that differences in observable cost drivers are expected to have on overall expenditure. We do this by identifying statistical patterns in past data using statistical models.

4.2 Cost benchmarking results can be used for a number of purposes. These include: to set efficiency targets (for example as part of a periodic review), to identify unexplained cost differences and underlying sources of good or bad practice; to set prices (or access charges in the case of rail infrastructure); or to forecast future costs as the result of changes in outputs.

4.3 During a control period, cost benchmarking results can be used in part as a reputational tool to help drive improved performance within Network Rail, and in part as an indication of where ORR should focus its detailed analysis, monitoring and engagement.

4.4 Cost benchmarking, like any other statistical model, is only as good as the data it is based on. Measurement error (for example, by wrongly attributing cost incurred in one area to another), omitted variables (the absence of important cost drivers from the model), or too small a sample size, can all weaken the robustness of cost benchmarking results.

4.5 More generally, it is important to underline that cost benchmarking is a high-level tool. It is useful in identifying significant discrepancies across organisations/business units, and in producing reasonable, though not highly precise, expenditure forecasts. We should also not expect cost benchmarking to provide in-depth insights into the reasons behind such discrepancies. Therefore, while we consider that cost benchmarking analysis is an important policy informing tool, its results should be used as part of a wider evidence base.

Use of cost benchmarking in ORR

4.6 Cost benchmarking has been used by ORR to help set efficiency targets for Network Rail in the 2008 and 2013 periodic reviews (PR08 and PR13 respectively). In both cases, we compared Network Rail, as a whole, against a number of European peers. Whilst we used this international comparison to inform our determinations, we also recognised that there are limitations in this type of analysis, especially in the absence of high quality and consistent data across countries.

4.7 From PR18, ORR decided to focus on Network Rail's regions. As part of that our cost benchmarking approach also shifted towards comparing Network Rail's business units (i.e. its regions, routes and MDUs), building on internal analysis undertaken by Network Rail during PR13.

4.8 In our PR18 final determination, we committed to updating this evidence base annually and stated our intention to make greater use of comparative regulation in control period 6 (CP6), with cost benchmarking playing an important role.

4.9 Our cost benchmarking analysis has been used to inform our PR23 decisions. Notably, it was a part of the evidence that informed our initial advice to the UK and Scottish Governments in summer 2022, as they prepared their statements of available funding (SoFAs) and high-level output specifications for the next control period (control period 7 or CP7). Cost benchmarking analysis was also one element of the evidence base that ORR used to inform its PR23 final determination on Network Rail's efficiency targets, in CP7.

Annex B: Data and model specification

5.1 This Annex discusses the data used in our analysis and the three models' specification before presenting the models' statistical results.

5.2 In all three models, all expenditure data is inflation-adjusted to 2022-23 prices, using the Consumer Price Index (CPI).

Region data based maintenance model

5.3 The analysis is based on data for financial years 2010-11 to 2022-23 for the existing five regions.

Dependent variable

5.4 The dependent variable is annual maintenance expenditure at the region level. For years 2010-11 to 2018-19, we collected the data from Statement 8a of Network Rail's Regulatory Financial Statements (RFS) where this data was reported at the level of the CP4 ten routes. As each CP4 route can be matched to a current region, we were able to aggregate this route-level data to the existing five regions. For years 2019-20 to 2022-23 we collected the data from Statement 3 of the RFS where it is reported at region level. This change has allowed us to overcome the data issues that we had identified in last year's report (done using route level data), where we excluded a significant proportion of maintenance costs from our analysis, as we could not effectively allocate them to individual routes.

MDU data based maintenance model

Dependent variable

5.5 The analysis is based on data for Network Rail's existing structure with 35 MDUs. The dependent variable is annual maintenance expenditure by MDUs, from 2014-15 to 2022-23. This excludes centrally-managed expenditure (covering activities such as structures examination, major items of maintenance plant and other HQ managed activities).

5.6 In our cost benchmarking reports for year 1 and year 2 of CP6, we analysed maintenance expenditure using Network Rail's former structure with 37 MDUs. Last year we based our analysis on a structure with 36 MDUs. To move from the 37 to the 36 and then the 35 MDUs structure, we re-allocated data from Woking, Eastleigh and Clapham to Wessex Inner and Wessex Outer, and data from Bristol, Plymouth, Reading and Swindon to Western Central, Western East and Western West. For 2017-18 to 2021-22, we calculated the expenditure for Wessex Inner and Wessex Outer separately as a proportion of the total expenditure for Wessex

Inner and Wessex Outer, and then applied those proportions to the total for Woking, Eastleigh and Clapham for the years 2014-15 to 2016-2017.

5.7 On the other hand, we have data for Western Central, Western East, and Western West from 2019-20 onwards. We calculated the average share of each of these MDUs expenditure as a proportion of their total expenditure. To obtain data for Western Central, Western East and Western West covering the years 2014-15 to 2018-19, we used data which we have for Bristol, Plymouth, Reading and Swindon covering years 2014-15 to 2018-19 and applied the above calculated proportions to the total annual expenditure of Bristol, Plymouth, Reading and Swindon from 2014-15 to 2018-19[16].

Conventional track renewals unit cost model

5.8 The analysis is based on data for financial years 2014-15 to 2022-23, recorded at the level of the ten routes that were introduced by Network Rail in CP4. From 2019-20 onwards, Network Rail supplied us with data at the level of the 13 routes. To adjust this data to the level of the ten CP4 routes, we aggregated the East Coast and North & Eastern routes into the LNE route, and we aggregated the Central, North West and West Coast Mainline South into the LNW route. All other routes stayed the same.

5.9 Analysing the renewals data at the CP4 10 routes level has allowed us to overcome the issues with the size of our dataset by doubling the number of data points. This is important as the robustness of cost benchmarking analysis heavily depends on the size of the data used in the analysis.

Dependent variable

5.10 The dependent variable is annual average unit costs at the route-level for conventional track renewals. We obtain this variable by dividing total annual expenditure on conventional track renewals by the amount of track-km renewed using conventional track renewals methods. For years 2014-15 to 2018-19, expenditure data comes from Statement 9b in Network Rail's Regulatory Financial Statements and volume data comes from Network Rail's published Annual Returns. For years 2019-20 and onwards, both expenditure and volume data were provided to us directly by Network Rail for the purpose of this analysis.

[16] This probably introduced some errors in the analysis, but it was the only way forward as we try to report our analysis in a structure that matches Network Rail's current structure. Since the allocation is done for the earlier years in our analysis, this may not have a significant impact on our comparisons for the latest year.

Independent variables

5.11 Table 1 below summarises the explanatory (or independent) variables we retained in the final models. See our year 3 of CP6 report for more details about the expected direction of the relationship to expenditure and the reasoning behind this.

Table 1: Independent variables used in our models

	Variable	Maintenance (Region)	Maintenance (MDU)	Renewals (Route)
Characteristics	Track-km (length of track)	✓	✓	
	Average number of tracks (track-km/route-km)		✓	
	Proportion of electrified track (electrified track-km/track-km)	✓	✓	✓
	Switches and Crossings (S&C) Density (number of S&C/track-km)		✓	✓
	Criticality 1 & 2 density (criticality 1 & 2 km/track-km)	✓	✓	
	Proportion of track category 1A, 1 & 2 (category 1A, 1 & 2 km/track-km)			✓
Usage	Total (passenger + freight) train-km			✓
	Passenger train-km		✓	
	Freight train-km		✓	
	Passenger traffic density (train km/track km)	✓		
	Freight traffic density (train km/track km)	✓		
Output	Average length of Possession (Days)	✓	✓	✓
	Lagged Enhancement Expenditure (£ million)	✓		
	Lagged Maintenance expenditure (£ million)	✓		
	Number of track-km renewed using conventional methods (km)			✓
	Number of track-km renewed using high-output technology (km)			✓
	Number of refurbished track-km (km)			✓
Input	Wage levels (£ per week or £k per month)	✓	✓	
	Average rainfall (mm per year)	✓	✓	✓

Exogenous Factors	Year-specific dummy variable (applies to 2020-21)	✓	✓	✓
	Year-specific dummy variable (applies to 2022-23)			✓
	Year	✓	✓	✓

Estimation approach

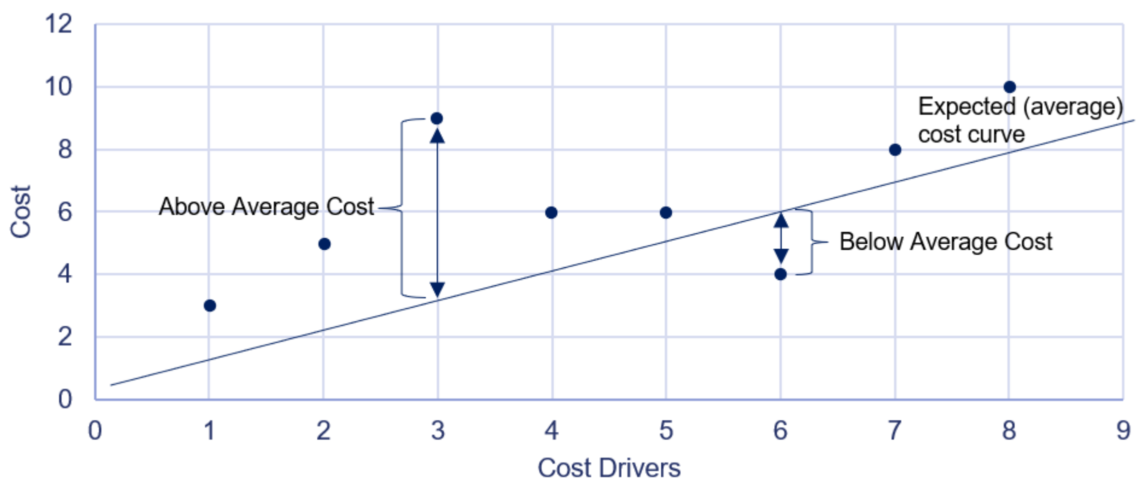
5.12 We have adopted the same functional form as in last year's report, namely the Cobb Douglas log-log formulation (i.e. where the dependent variable and most explanatory variables are entered in natural logarithms). With this functional formulation, most coefficients can be interpreted as constant elasticities that measure the percentage change in cost resulting from a percentage change in the relevant cost driver.

5.13 Similar to last year's analysis, we have used the ordinary least squares (OLS) method to estimate our models. This approach has the advantage of being simple to implement and its results easy to understand.

5.14 With OLS, we estimate a line that passes through the centre of the observed data points. This means that, given the information available, the OLS line defines the average cost that a business unit should incur given the cost drivers we control for in our model. The distance between the OLS line and observed/outturn points is the residual. We use these residuals to describe the region/ MDUs' performance relative to the average of the peer group, after controlling for differences in relevant cost drivers.

5.15 This is illustrated in Figure 23 below. Observations above the line imply that the business unit in question spent more than expected, while those observations below the line mean that the business unit spent less than expected. The larger the distance between the individual observation and the line (i.e. the residual) the more important it is to find out what is different about the business unit in question relative to others and relative to previous years, be it efficiency, headwinds, tailwinds, data reporting or some other factor.

Figure 23: Theoretical OLS regression line and cost performance (for illustration only)



5.16 For more details about the conceptual frame of the OLS and how to interpret its results, see our year 3 of CP6 report. Table 2 below presents the results of our OLS model estimates.

Table 2: OLS coefficient estimates results for regional maintenance expenditure, MDU maintenance expenditure and conventional track renewals unit cost models

Variable	Maintenance Coefficient	MDU Coefficient	Renewals Coefficient
Track-km	0.50***	0.37***	-
Conventional track-km	-	-	0.36***
Refurbished track-km	-	-	-0.02
High output track-km	-	-	0.02***
Passenger traffic density	0.33**	-	-
Freight traffic density	0.01	-	
Train-km	-	-	0.19*
Passenger train-km	-	0.33***	-
Freight train-km	-	0.12***	-
Average number of tracks	-	-0.10*	
Switches and crossings density	-	0.23***	-0.32
Average rainfall	-0.02	0.15***	0.37***
Number of possessions days	0.04**	-	-
Average days per possession	-	0.09***	0.02***
Average wage levels	0.32*	0.47***	-
Proportion of electrified track	0.11	0.46***	0.31*
Proportion of track criticality 1 & 2	0.49**	-0.06	-
Proportion of track category 1A, 1 & 2	-	-	0.50*
Lagged maintenance expenditure	0.40***	-	-
Lagged enhancement expenditure	0.07***		-

Variable	Maintenance Coefficient	MDU Coefficient	Renewals Coefficient
Year (average annual unexplained growth rate in maintenance expenditure)	0.04***	0.03***	0.04**
Dummy for 2020-21 (deviation from the annual growth rate due to COVID-19)	0.11***	0.11***	0.10**
Dummy for 2022-23	-	-	0.06
Constant	-8.55***	-9.84***	2.27
Number of observations	60	315	90
R^2	0.98	0.64	0.56

*** Statistically significant at the 99% confidence level
** Statistically significant at the 95% confidence level
* Statistically significant at the 90% confidence level

Annex C: Renewals unit costs

6.1 This Annex presents renewals average unit costs per asset type. It compares the renewals average unit costs for CP5, the first three years of CP6 and the year 4 of CP6 (2022-23).

6.2 When making these comparisons, it is important to bear in mind that the unit cost of renewals work is heavily influenced by a range of project-specific factors (e.g. location, scope, standards), which cannot be fully accounted for in this type of analysis. Moreover, there are limitations when comparing CP5 to CP6 data, due to the changes in the structure of the data reported. Similarly, there are limitations in comparing one year of renewals data with an average of many years, such as a control period. This is because there are sometimes lags in reporting of renewals volumes, which means sometimes expenditure is reported in a given year, but the volumes could be delivered in subsequent years[17]. While this mismatch can be reduced by averaging across years, this cannot be done for a single year of data. However, the mapping we have used (which was informed by detailed discussions with our engineers) aims to address this as far as is possible so that we can make some reasonable comparisons.

6.3 Table 3 below presents the renewals average unit costs by asset class and by region for CP5, the first three years of CP6 and the year 4 of CP6 (2022-23). It also presents the average percentage change in renewals unit costs from the first three years of CP6 average to year 4 of CP6.

Table 3: Region average unit costs per asset class (2022-23 prices)

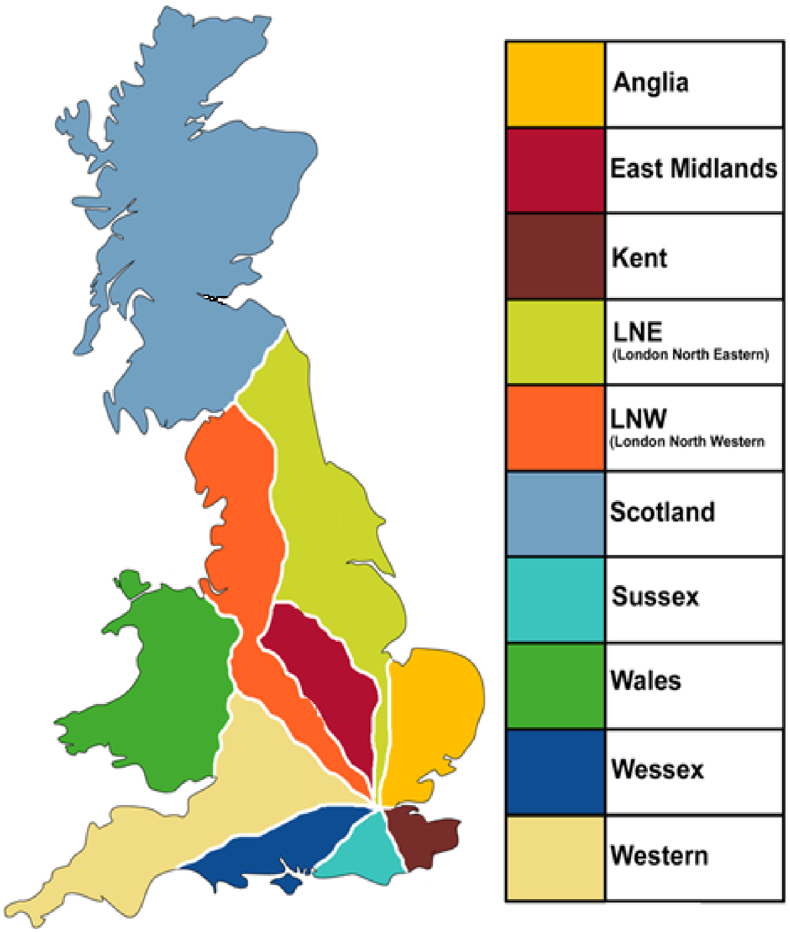
Asset class	Region	Average unit cost for CP5	Average unit cost for CP6 Y1 to Y3	Average unit cost for CP6 Y4	% change from CP6 Y1 to Y3 to CP6 Y4
Track (£k per km)	Scotland	484	679	657	-3%
	Eastern	588	696	628	-10%
	NW&C	787	804	1,042	29%
	Southern	643	803	742	-8%
	W&W	525	883	1,177	33%
	GB	**594**	**757**	**806**	**6%**
S&C (£k per km)	Scotland	276	425	333	-22%
	Eastern	296	319	304	-5%
	NW&C	488	372	379	2%
	Southern	274	321	332	3%

[17] This is common with signalling renewals.

Asset class	Region	Average unit cost for CP5	Average unit cost for CP6 Y1 to Y3	Average unit cost for CP6 Y4	% change from CP6 Y1 to Y3 to CP6 Y4
	W&W	288	525	627	19%
	GB	**309**	**354**	**357**	**1%**
Signalling (£k per SEU)	Scotland	321	1,049	920	-12%
	Eastern	545	399	965	142%
	NW&C	369	1,643	282	-83%
	Southern	665	837	420	-50%
	W&W	334	575	4,887	750%
	GB	**416**	**675**	**553**	**-18%**
Level Crossings (£k per unit)	Scotland	1,727	2,889	2,000	-31%
	Eastern	2,428	857	1,569	83%
	NW&C	2,049	901	521	-42%
	Southern	1,938	5,676	1,500	-74%
	W&W	2,102	1,172	697	-41%
	GB	**2,180**	**1,188**	**1,064**	**-10%**
Structures (£k per m2)	Scotland	2.6	3.5	1.4	-61%
	Eastern	2.7	2.0	1.4	-32%
	NW&C	2.9	3.5	3.3	-6%
	Southern	4.9	5.1	2.1	-59%
	W&W	3.7	3.1	4.6	48%
	GB	**3.1**	**3.0**	**2.0**	**-32%**
Earthworks (£k per 5-chain)	Scotland	40	41	57	38%
	Eastern	30	42	31	-25%
	NW&C	107	92	55	-40%
	Southern	94	204	112	-45%
	W&W	41	50	37	-25%
	GB	**51**	**72**	**53**	**-27%**
Buildings (£k per m2)	Scotland	1.5	0.9	1.4	59%
	Eastern	0.7	1.1	2.2	91%
	NW&C	1.9	5.7	2.8	-51%
	Southern	2.1	1.2	0.7	-38%
	W&W	2.0	6.6	3.8	-42%
	GB	**1.52**	**1.6**	**1.5**	**-3.7%**

Annex D: Network Rail’s geographic routes and regions

CP4 ten routes covered in this analysis



CP6 structure with 14 routes

Annex E: Mapping of Network Rail's regions, routes and MDUs

Region	CP4 ten routes	Maintenance delivery unit (MDU)
Eastern	London North Eastern (LNE)	Doncaster, Leeds, Newcastle, Peterborough, Sheffield, York
	East Midlands (EM)	Bedford, Derby
	Anglia	Ipswich, Romford, Tottenham
North West & Central	London North Western (LNW)	Bletchley, Euston, Lancashire & Cumbria, Liverpool, Manchester, Saltley, Sandwell & Dudley, Stafford
Scotland	Scotland	Edinburgh, Glasgow, Motherwell, Perth
Southern	Wessex	Wessex Inner, Wessex Outer
	Sussex	Brighton, Croydon
	Kent	Ashford, London Bridge, Orpington
Wales & Western	Wales	Cardiff, Shrewsbury
	Western	Western Central, Western East, Western West

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