Cost benchmarking of Network Rail's maintenance and renewals expenditure

Annual report 2023-24

05 December 2024

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Executive summary

Overview

The ORR holds Network Rail to account for its management of the mainline rail network in Great Britain. Understanding the drivers of Network Rail's expenditure, including the reasons for changes over time is central to assessing the scope for efficiency improvements. To achieve this, we use a range of analytical approaches including bottom-up assessments of Network Rail's business plans and performance, and top-down cost benchmarking using statistical (econometric) methods.

This report presents our latest cost benchmarking analysis of Network Rail. This compares total maintenance expenditure and conventional track renewals unit costs over time and across Network Rail's regions and maintenance delivery units (MDUs). We look at these costs because these are the largest costs that the company's regions incur and are comparable across regions.

Our analysis controls for the effect of exogenous factors such as network length and usage. This work complements our Annual Efficiency and Finance Assessments of Network Rail which provide detailed analysis of Network Rail's income and expenditure.

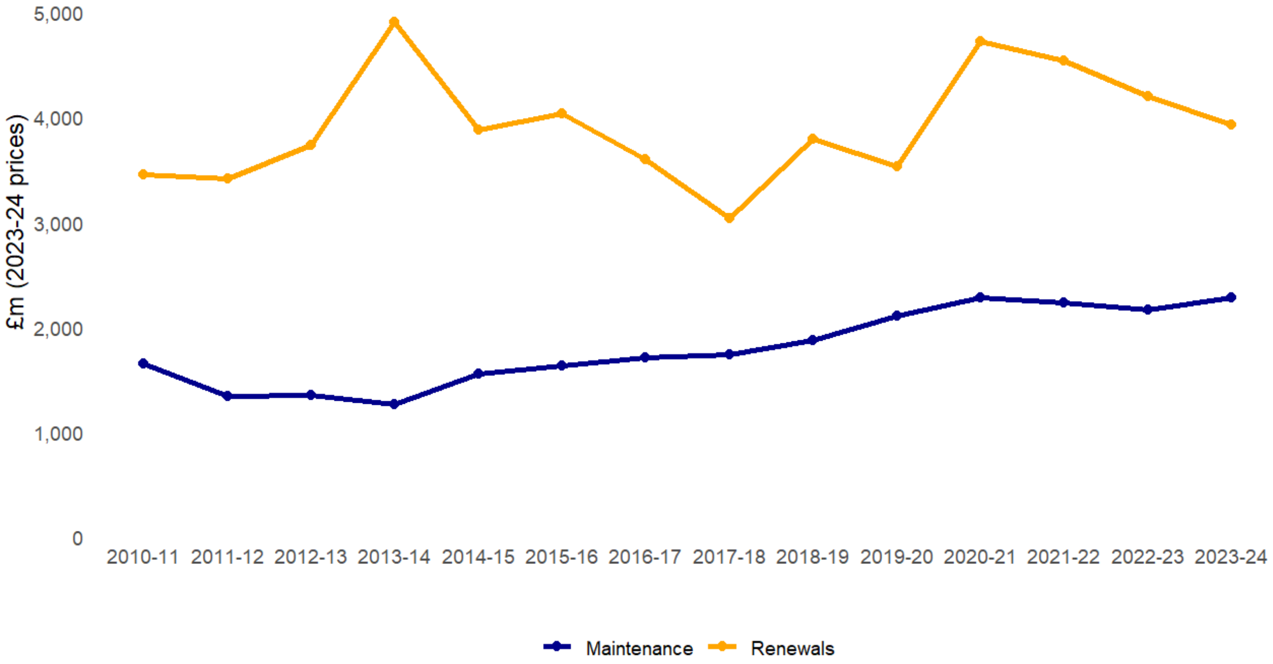
We have worked with Network Rail to successfully resolve some data issues that we identified in our previous year's work. This has improved the robustness of the results presented in this report. We will continue to develop our benchmarking analysis in CP7 and welcome views on this.

Key findings

Our key findings are summarised below. Overall, we are confident in the robustness of our statistical modelling. This has identified long-term trends in increasing maintenance and renewals costs, and variations at a regional level. In our analysis, all expenditure data is inflation-adjusted to 2023-24 prices, using the Consumer Price Index (CPI).

Key finding 1: There has been an average annual increase in total maintenance expenditure of 3% (in real terms) since 2010-11. Total renewals expenditure has also increased over the same period (at an average of around 2% per year) but has been more variable. This is illustrated in Figure 1. However, it is not possible to infer efficiency from the observed trend in total expenditure because this does not control for volume of work, traffic levels, input prices, headwinds and other external factors.

Figure 1: Maintenance and renewals expenditure, 2010-11 to 2023-24



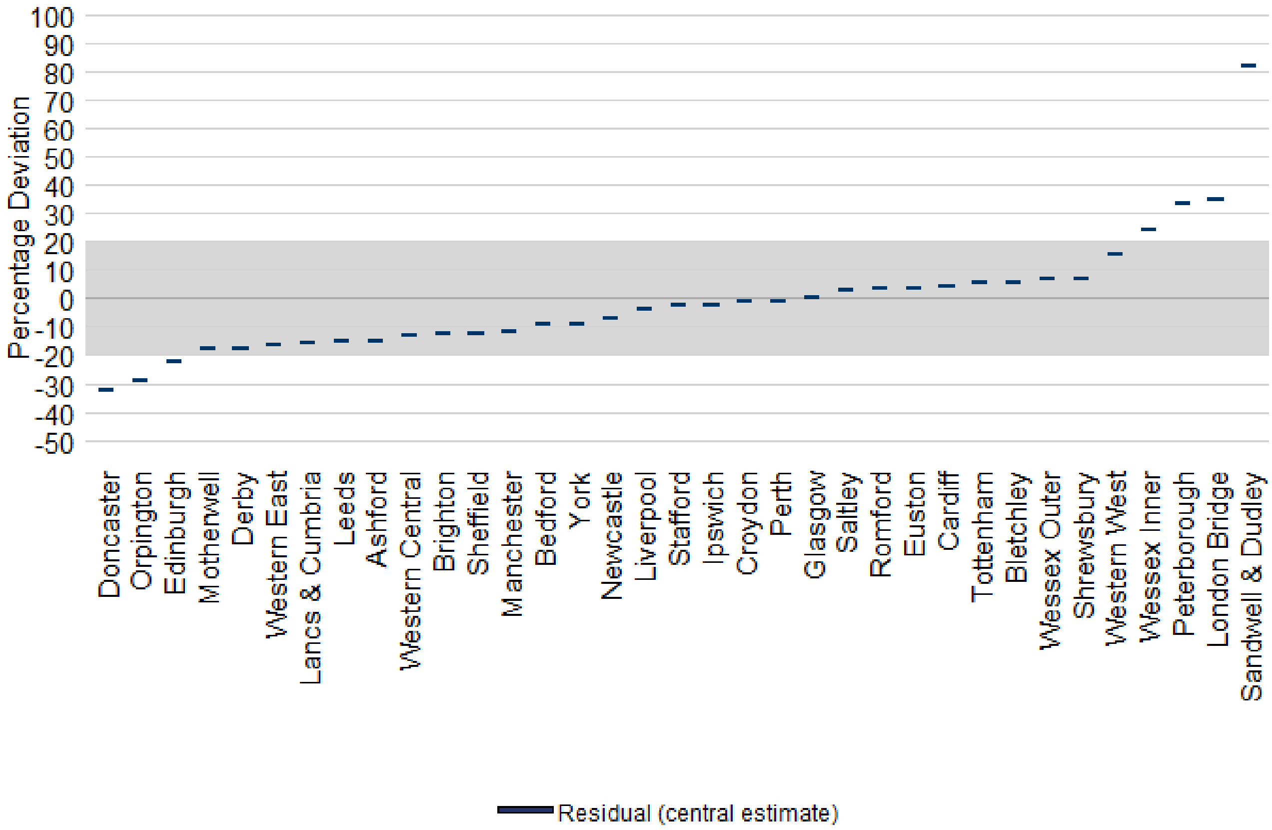
Key finding 2: Regional variation in maintenance expenditure is broadly consistent with what we would expect from our cost modelling (between -4% and +1% deviation from outturn). As shown in Figure 2, North West and Central is at the lower end of the range while Southern is at the top end of the range. Our analysis shows that, on average, regional maintenance expenditure in the last year was below our modelled long-term average, which could suggest a recent improvement to efficiency, other things equal.

Figure 2: Variation between outturn and expected (modelled) maintenance expenditure by Network Rail region, 2023-24

Note: To account for some uncertainty with the modelling we consider any region within +/-5% of our model prediction (shown in grey) is not an 'outlier'.

Key finding 3: Maintenance expenditure at seven of Network Rail's 35 MDUs lie outside the range we would expect from our cost modelling (three lie below and four above). This is illustrated in Figure 3. This analysis provides insight into the scope for productivity gains by lower performing MDUs, for example, through ways of working and technology adoption. We are continuing to work with Network Rail to understand the reason for the outliers.

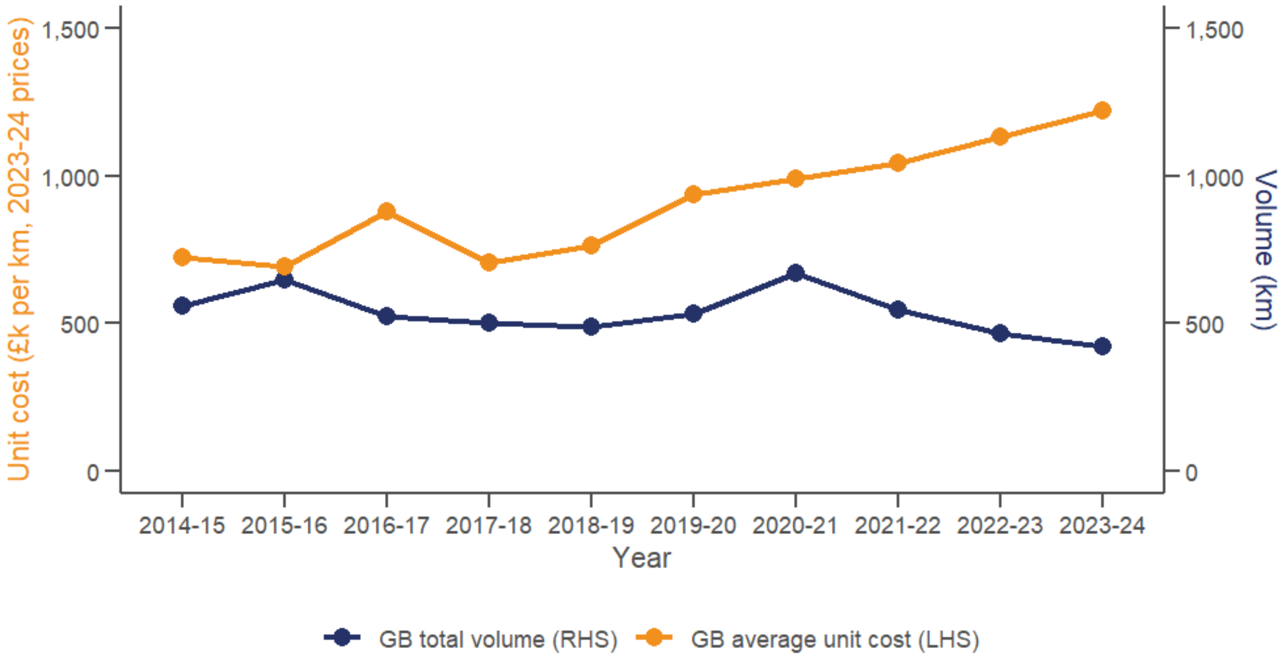
Figure 3: Variation between outturn and expected (modelled) maintenance expenditure for each maintenance delivery unit (MDU), 2023-2024



Note: To account for some uncertainty with the modelling, we consider any MDU within +/-20% of our model prediction (shown by the vertical axis at zero) is not an 'outlier'. These MDUs are within the grey section.

Key finding 4: There has been a 7% average annual increase in the unit cost of conventional track renewals since 2014-15 (in real terms) – this is illustrated in Figure 4. However, after controlling for factors such as track length and extent of electrification, the average annual increase in unit costs of conventional track renewals is 3% per year since 2014-15 (in real terms).

Figure 4: Trends in conventional track renewals – average unit cost and volumes, 2014-15 to 2023-24



Key finding 5: Average conventional track renewals unit costs were consistent with what we would expect from our cost modelling (between -7% and +6% of what our model would predict). As shown in Figure 5, Wales and Western is at the lower end and North West and Central is at the top end of the range for track renewals unit costs.

Figure 5: Variation between outturn and expected (modelled) unit costs for conventional track renewals by Network Rail region, 2023-24

Note: To account for some uncertainty with the modelling, we consider any region within +/-10% of our model prediction (shown by the vertical axis at zero) is not an 'outlier'. These regions are within the grey section.

1. Introduction

1.1 This report presents our cost benchmarking statistical analysis of Network Rail for the year April 2023 to March 2024 (‘2023-24’). Our analysis compares maintenance expenditure and conventional track renewals unit costs (renewals expenditure divided by work volume) over time and across Network Rail’s regions and maintenance delivery units (MDUs). Our analysis controls for exogenous factors such as track length and traffic density.

1.2 The statistical methods used in our analysis are explained in Annex B. This work compliments our Annual Efficiency and Finance Assessments which provide a comprehensive analysis of Network Rail’s income and expenditure.

Reporting our results

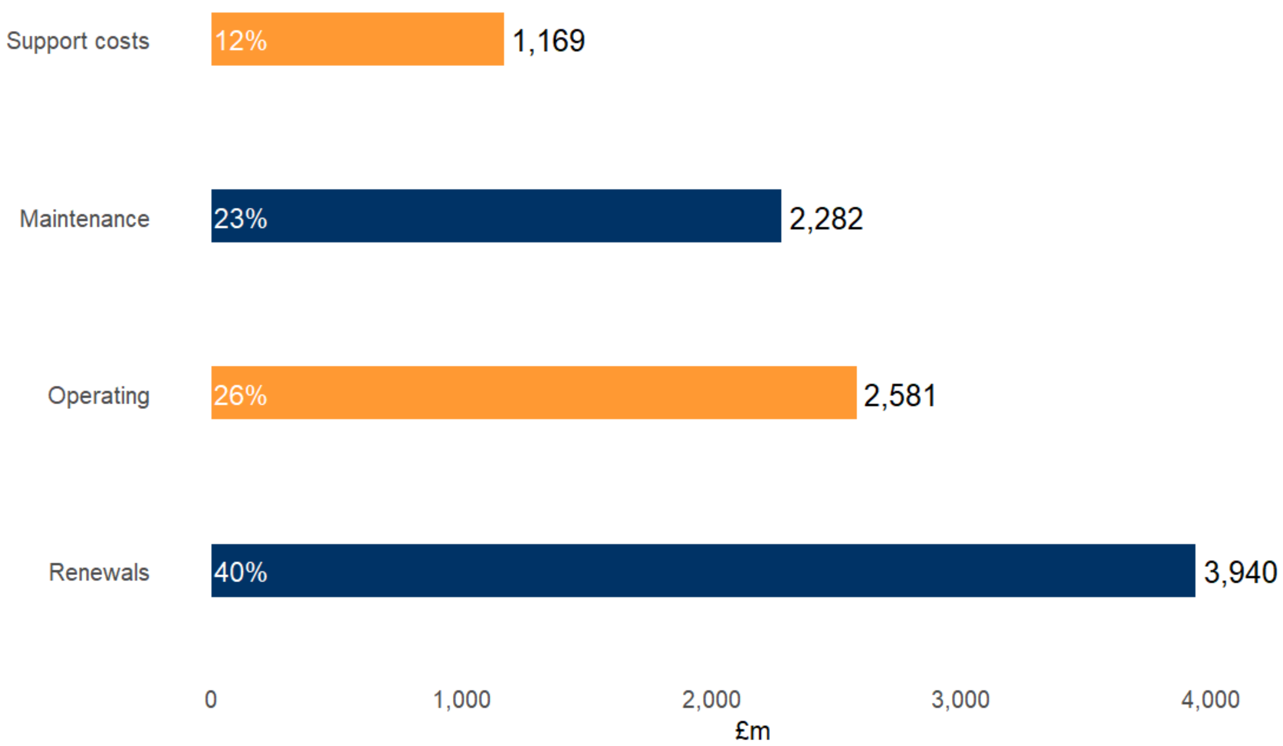
1.3 The key focus of this analysis is the comparison of outturn maintenance expenditure and conventional track renewals average unit costs in 2023-24, against expected expenditure derived from our statistical models, which are calibrated on past data. Results are presented as percentage deviations from 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.

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

Context

1.5 In this report, we cover maintenance and a proportion of renewals. As shown in Figure 6, maintenance represented 23% of Network Rail’s expenditure on core business activities (operations, support, maintenance and renewals (OSMR)) for 2023-24, with renewals representing 40%. Our analysis has focused on activities carried out at the regional level for which, on the renewals side, we can match costs and volumes. A smaller section of renewals spend is what we use in our statistical analysis. This is conventional track renewals and accounts for 13% of total renewals spend in 2023-24.

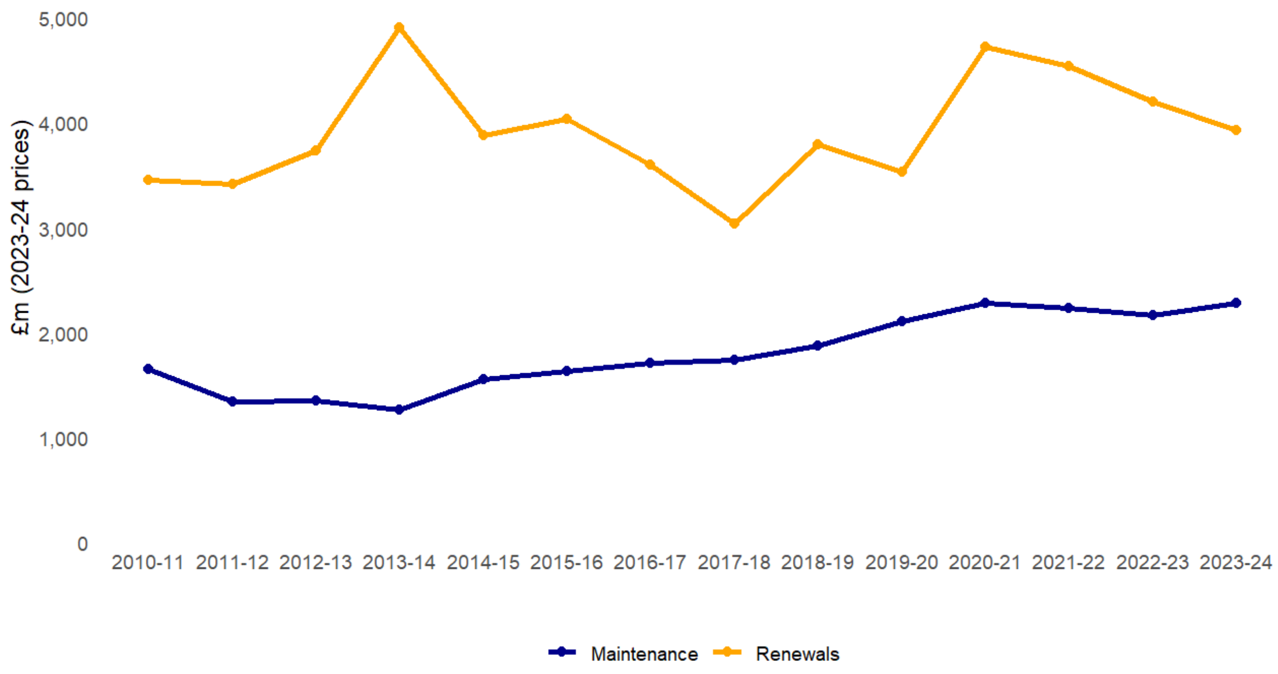
Figure 6: Breakdown of OSMR expenditure, 2023-24



Source: Network Rail's regulatory financial statements 2023-24

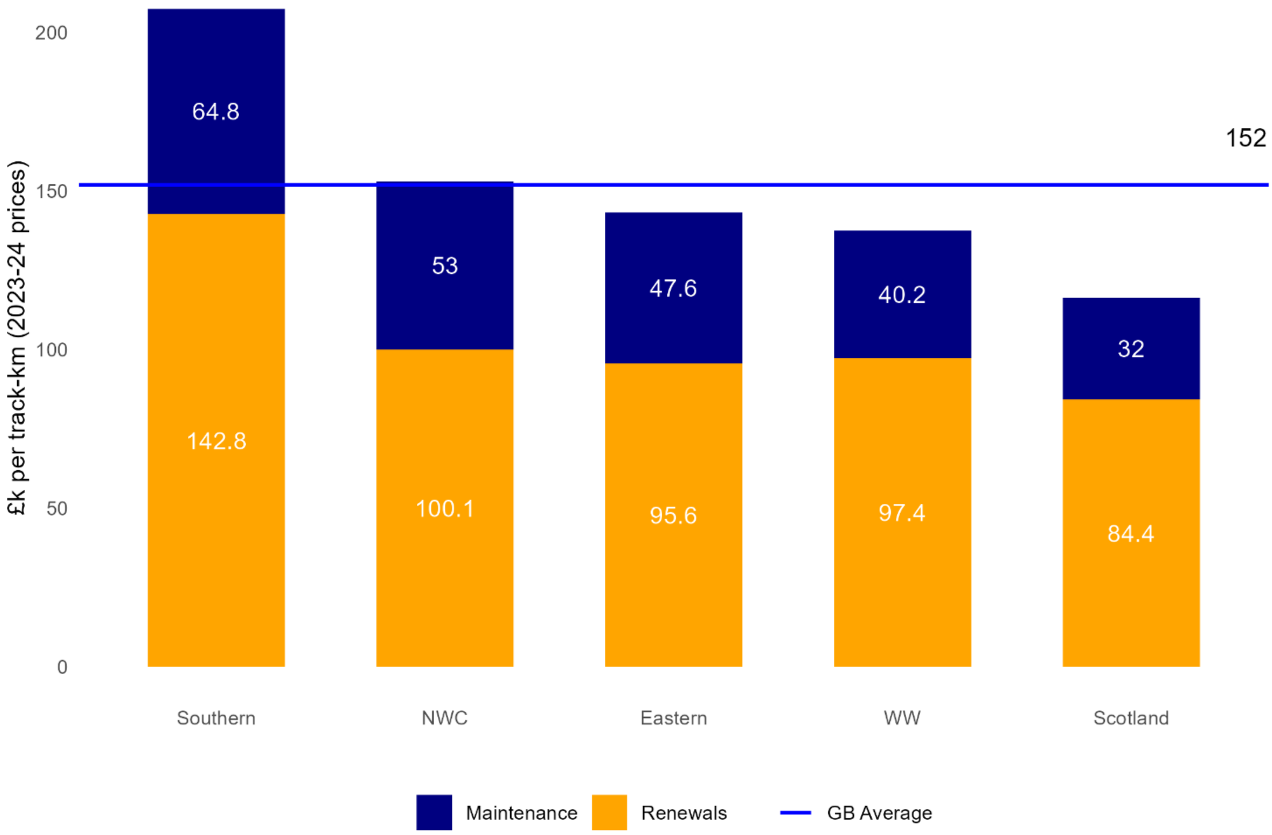
1.6 Figure 7 shows the trends in maintenance and renewals expenditure since 2010-11. Maintenance expenditure has gradually increased, and renewals expenditure has fluctuated considerably. The annual average growth is 3% for maintenance over this period, while the corresponding growth rate for renewals is 2%.

Figure 7: Maintenance and renewals expenditure, 2010-11 to 2023-24



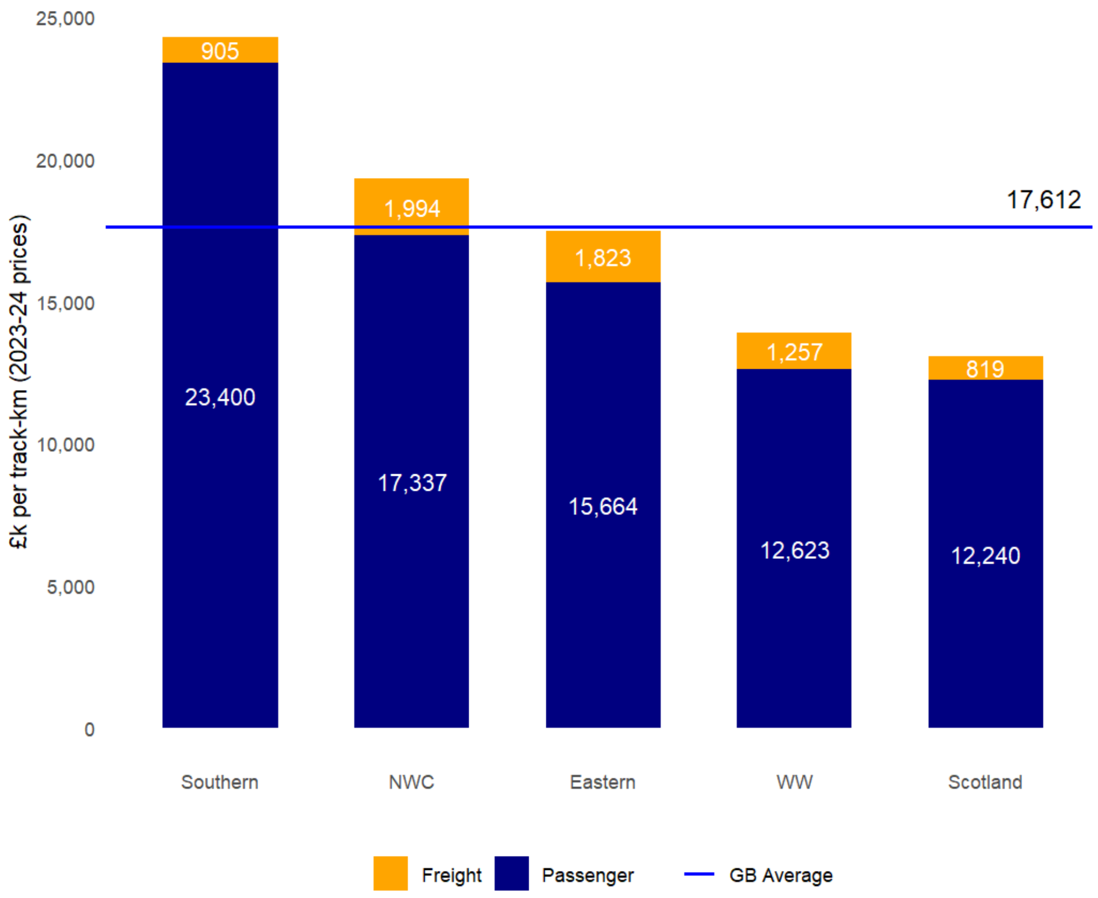
1.7 Figure 8 shows the breakdown of average annual maintenance and renewals expenditure by region, normalised by network size (expressed in track kilometres). There is considerable variation across regions. Average expenditure for regions is £152k per track-km between 2010-11 to 2023-24. Southern spend the most per track-km at £208k per track-km while Scotland spend the lowest at £116k per track-km. A key purpose of cost benchmarking is to control for the proportion of variation of variables such as this that is due to observable factors, so that comparisons across regions are made on a more like-for-like basis.

Figure 8: Average regional maintenance and renewals expenditure £k per track-km, 2010-11 to 2023-24



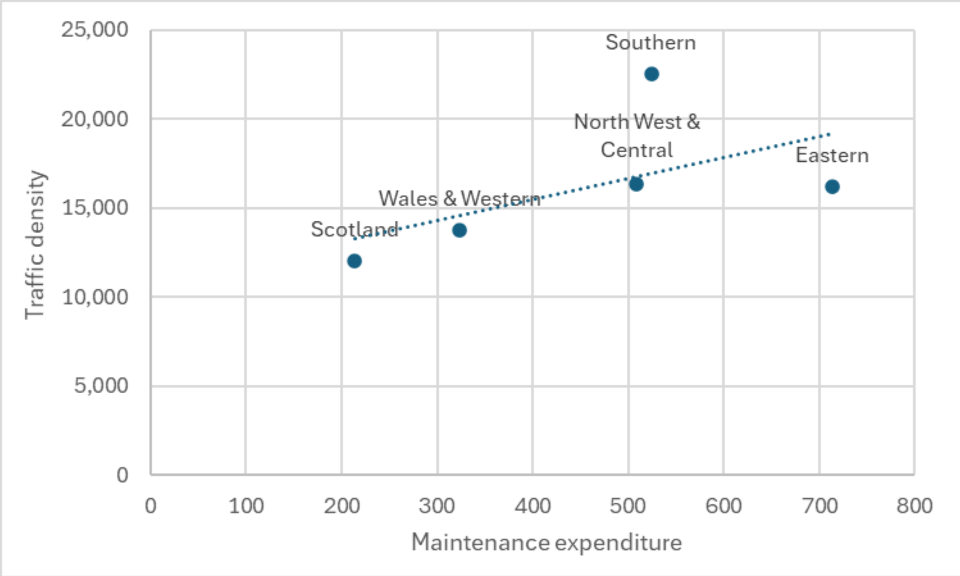
1.8 Figure 9 shows average annual traffic density across regions (split into passenger and freight traffic). There appears to be a clear correlation between this variable and the maintenance and renewals expenditure per track-km. Regions which have the highest traffic density also have high expenditure per track-km (as shown in Figure 8 above).

Figure 9: Average traffic density (train-km per track-km), 2010-11 to 2023-24



1.9 As mentioned above, there is a general correlation between increasing traffic density and maintetance expenditure. This is illustrated more clearly in Figure 10. The drivers of regions' predicted maintenance expenditure are examined in Chapter 2.

Figure 10: Maintenance expenditure (£m) and total traffic density in 2023-24



2. Maintenance

Introduction

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

2.2 Maintenance Delivery Units (MDUs) are responsible for the majority of Network Rail's day-to-day maintenance activities. MDUs (which account for 59% of total network maintenance expenditure) sit within Network Rail's regional organisational structure. The remaining 41% of maintenance activities are regionally or centrally managed, covering more complex activities such as structures examinations and major items of maintenance plant.

2.3 We have worked with Network Rail and its regions to put together a dataset at MDU and region level and this is the data that we have used in this analysis. The data has been subjected to quality assurance by Network Rail centrally and by its regions, in addition to our own quality assurance. We are continuing to work with Network Rail to resolve some known issues relating to where one MDU undertakes some maintenance activities on behalf of another, but the costs are not properly reallocated. This is referred to as hosting.

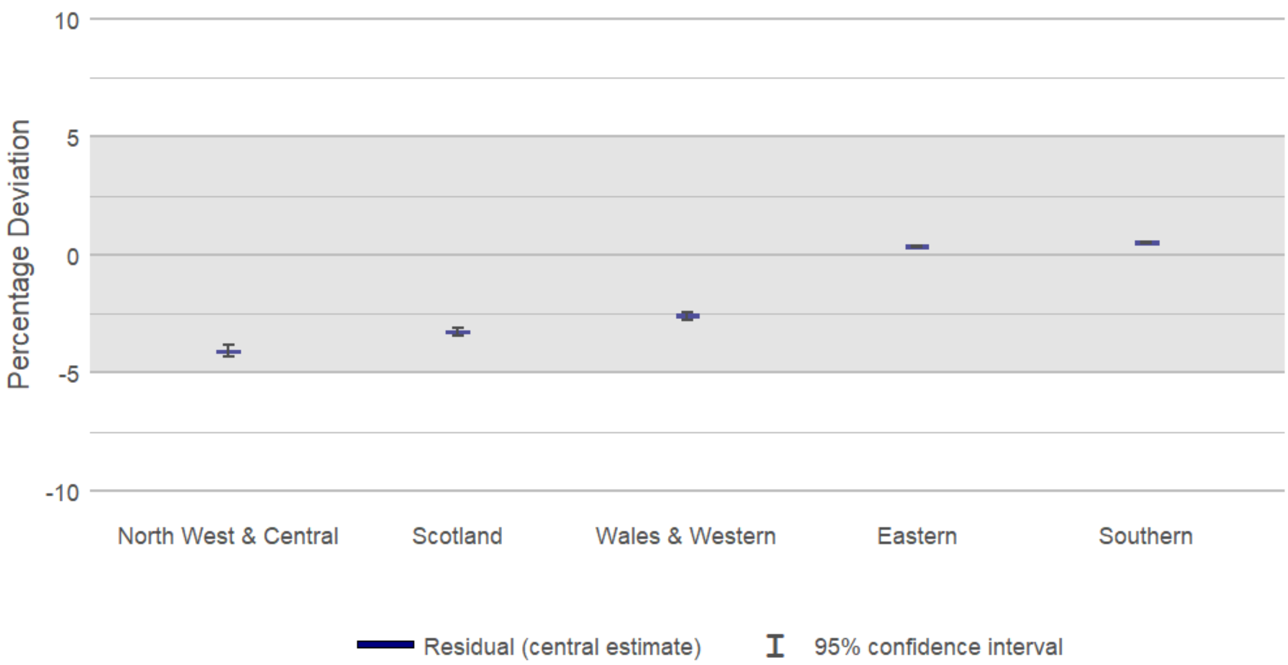
Regional analysis

2.4 After controlling for factors such as traffic and network complexity, our analysis shows that there has been an average 4% annual increase in maintenance expenditure (in real terms) since 2010-11. This may be due to inefficiency or other factors which this statistical analysis cannot separately identify. Our model specification for analysing regional variations in maintenance expenditure is described in Annex B.

Regional results

2.5 Figure 10 shows the proportion of unexplained cost variance for each region in our statistical analysis for 2023-24. A negative number means that a region spent less than predicated and vice versa.

Figure 11: Deviation between outturn and expected (modelled) maintenance expenditure for each region, 2023-24



Note: To account for some uncertainty with the modelling, we consider any region within +/-5% of our model prediction (shown by the x-axis at zero) is not an 'outlier'. These regions are within the grey section. The lines surrounding the central estimate of a given region's deviation between outturn and modelled cost indicate a 95% confidence interval.

2.6 Figure 11 shows that maintenance expenditure at the region level, was between -4% (North West and Central) and +1% (both Southern and Eastern) of that predicted by our model for 2023-24. All five regions were within 5% of our model's prediction, and as such none are considered outliers. Our analysis shows that, on average in 2023-24, regional maintenance expenditure was below our modelled long-term average, which suggests an improvement to efficiency.

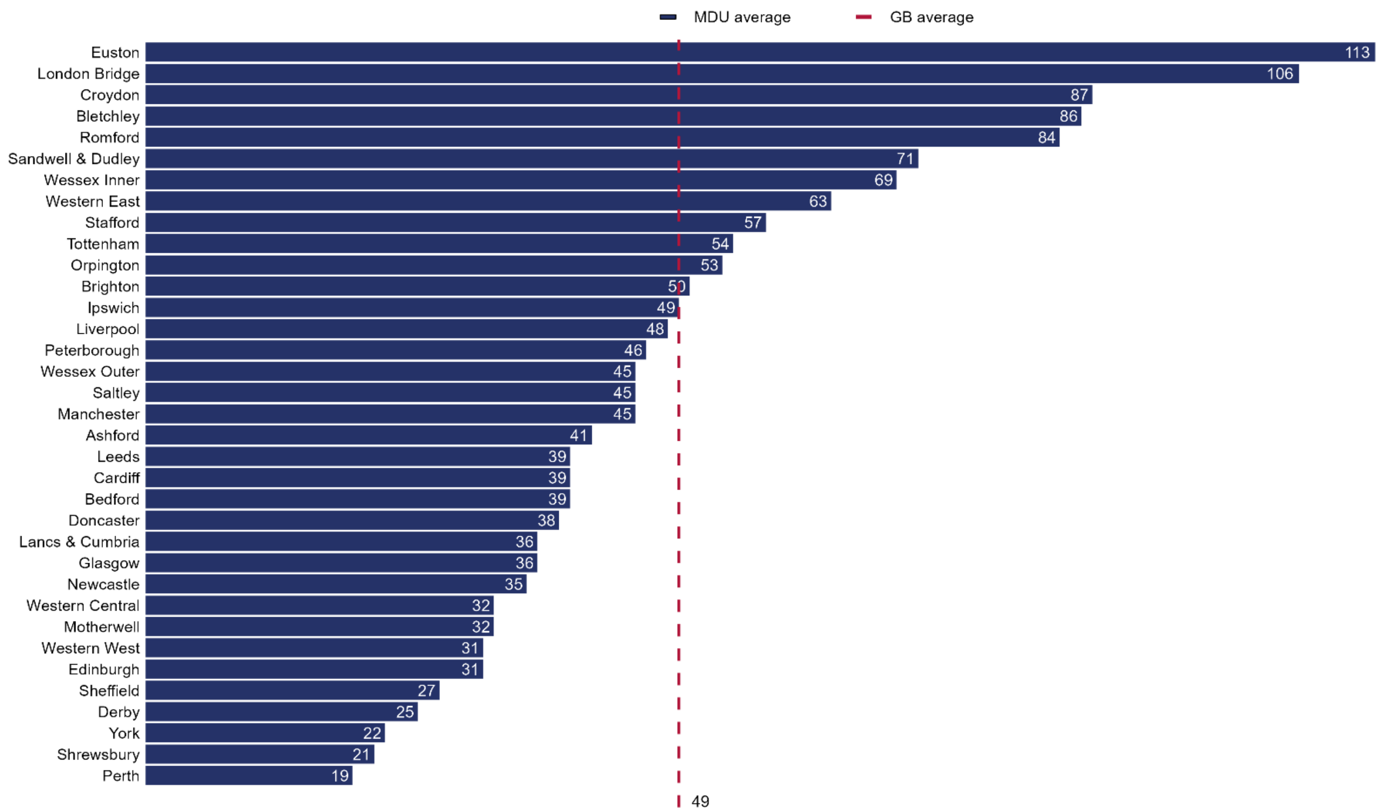
Maintenance Delivery Unit expenditure

Context

2.7 Since 2017-18, Network Rail has reduced the number of MDUs from 37 to 35. We have taken this into account in our analysis. We detailed this reallocation of data in last year's report.

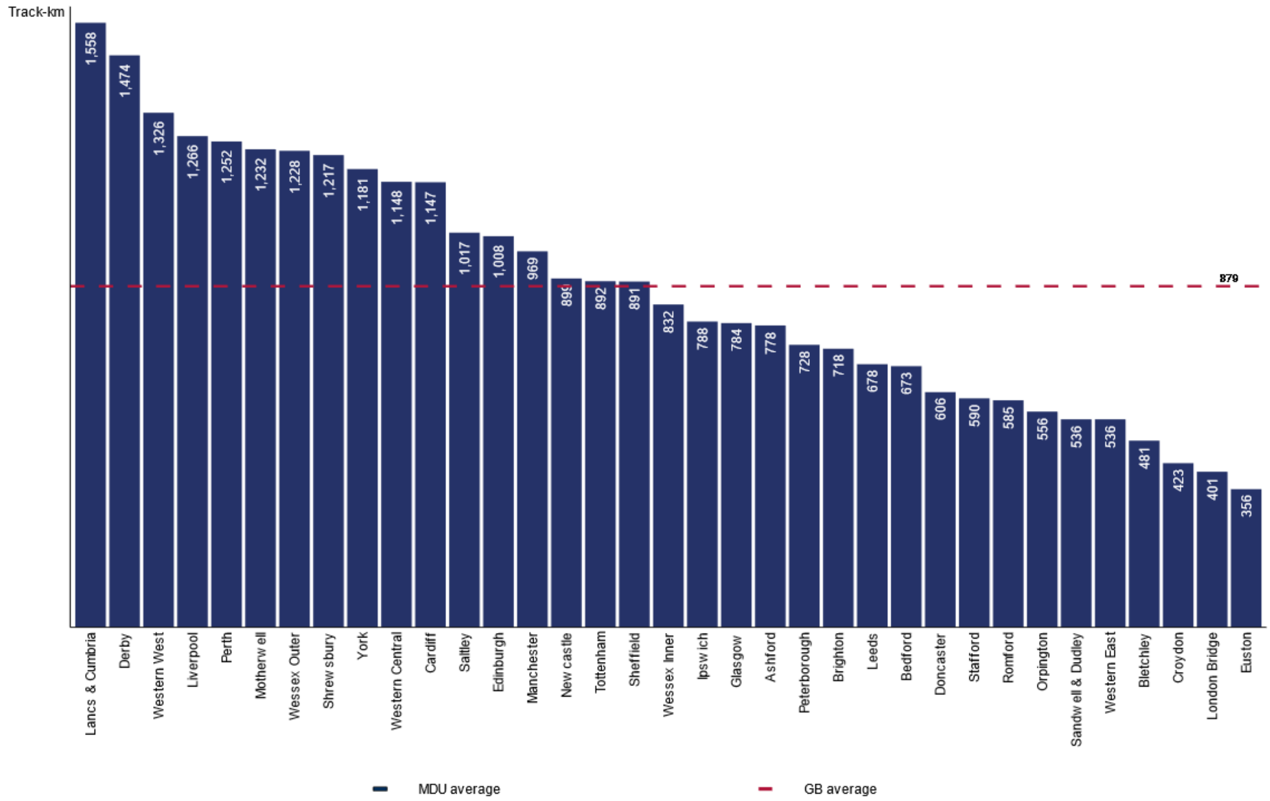
2.8 **Maintenance expenditure**: As shown in Figure 12, on average, MDUs spent £49k maintaining each kilometre of track. Euston MDU spent the most (£113k per track-km) and Perth spent the lowest (£19k per track-km).

Figure 12: Average MDU maintenance expenditure (£k) per track-km, 2014-15 to 2023-24 (2023-24 prices)



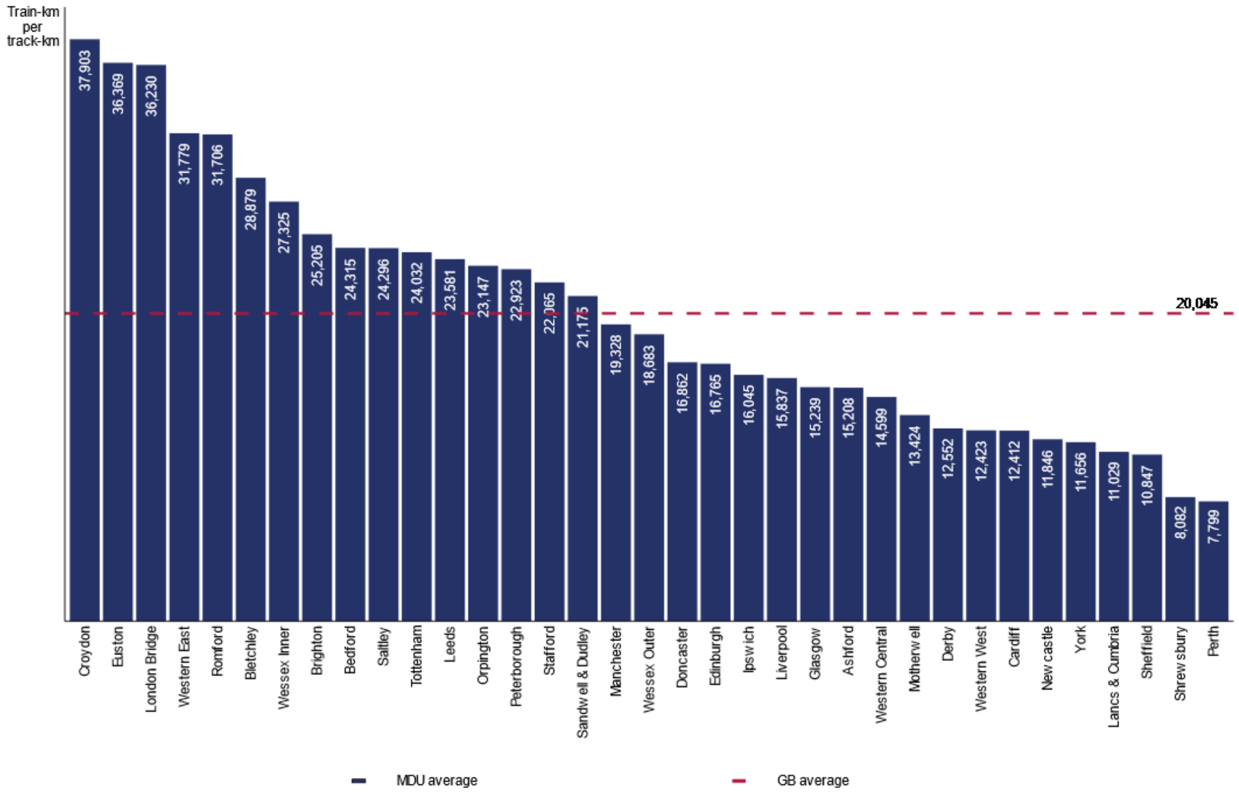
2.9 **Network size (track-km):** as shown in Figure 13 below, Lancashire & Cumbria (Lancs & Cumbria) is responsible for the longest section of network with 1,558 track-km, whilst Euston maintains the shortest with 356 track-km. The average length of track covered by an MDU over the period 2014-15 to 2023-24 is 879 track-km.

Figure 13: Average track-km, 2014-15 to 2023-24



2.10 **Traffic Density**: Figure 14 below shows that traffic density (passenger and freight traffic per track-km) varied widely across MDUs. Croydon had 37,903 train-km per track-km, on average, per year. On the other hand, Perth had 7,799 train-km per track-km per year. The average GB-wide track density was 20,046 train-km per track-km per year.

Figure 14: Average traffic density (train-km/track-km), 2014-15 to 2023-24

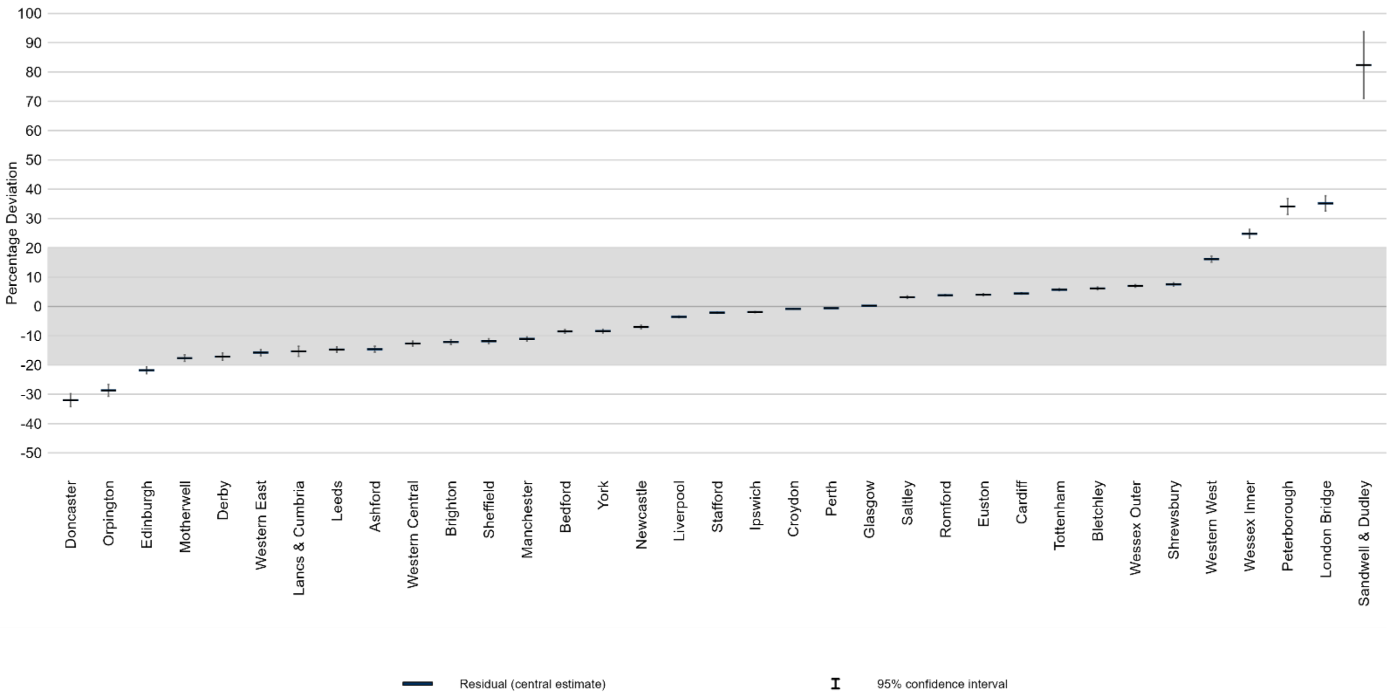


MDU results

2.11 The main output of this analysis is the estimate of maintenance expenditure that each MDU is expected to incur, given its characteristics (e.g. traffic, network complexity, etc). We compare these estimates to actual expenditure in 2023-24 to identify unexplained variations.

2.12 Figure 15 shows the proportion of unexplained cost variance for each MDU in 2023-24. 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 15: Deviation between expected (modelled) and actual MDU expenditure, 2023-2024



Note: To account for some uncertainty with the modelling, we consider any MDU within +/-20% of our model prediction (shown by the x-axis at zero) is not an 'outlier'. These MDUs are within the grey section. The lines surrounding the central estimate of a given region's deviation between outturn and modelled cost indicate a 95% confidence interval.

2.13 Given that there are uncertainties and limitations in any econometric approach, 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.

2.14 Our analysis found that the majority (28 out of 35) of MDUs' expenditure was consistent with our model predictions. However, Doncaster, Orpington and Edinburgh MDUs spent less than expected and Sandwell & Dudley, London Bridge, Peterborough and Wessex Inner spent more. At the extremes, Doncaster spent 32% less than predicted by our model whereas Sandwell & Dudley spent 82% above our model's prediction.

2.15 The ordering of MDUs is broadly similar to that generated from last year's analysis, however the range of unexplained differences (-32% to +82%) this year is much larger compared to the one generated by last year's analysis for 2022-23 (-37% to +48%). This is largely due to the residual for Sandwell & Dudley - which was also the largest outlier last year - which has increased significantly.

2.16 After speaking with North West and Central, one reason may be that this MDU covers track with high complexity which is not adequately accounted for in our model. A general problem 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.

2.17 This was the case for both Peterborough and Doncaster which are at opposite ends of the spectrum in our model. The Eastern region has suggested that this may be due to hosting issues and that variances roughly offset each other.

2.18 Last year, Sandwell & Dudley also came out at the top of our model as spending more than predicted. North West and Central has suggested that this may be due to the operational complexity around Birmingham New Street station.

2.19 Three out of seven MDUs within the Southern region were outside the expected band of +/- 20% this year. The Southern region explained that this was likely due to an increase in premium and contractor costs, and an increase in one-off schemes, although they could not explain why Orpington had a maintenance expenditure that was lower than we would expect.

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. 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 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,year 3 and year 4 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 4 of CP6 and year 5 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 (we are aware this is a common issue with signalling data). 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 This chapter also describes the model we have estimated to explain conventional track renewals unit costs at a region level as a function of key cost drivers.

3.11 We present the regional comparisons in the main report. This allows us to be consistent with Network Rail's current organisational structure and Network Rail is regulated at a regional level.

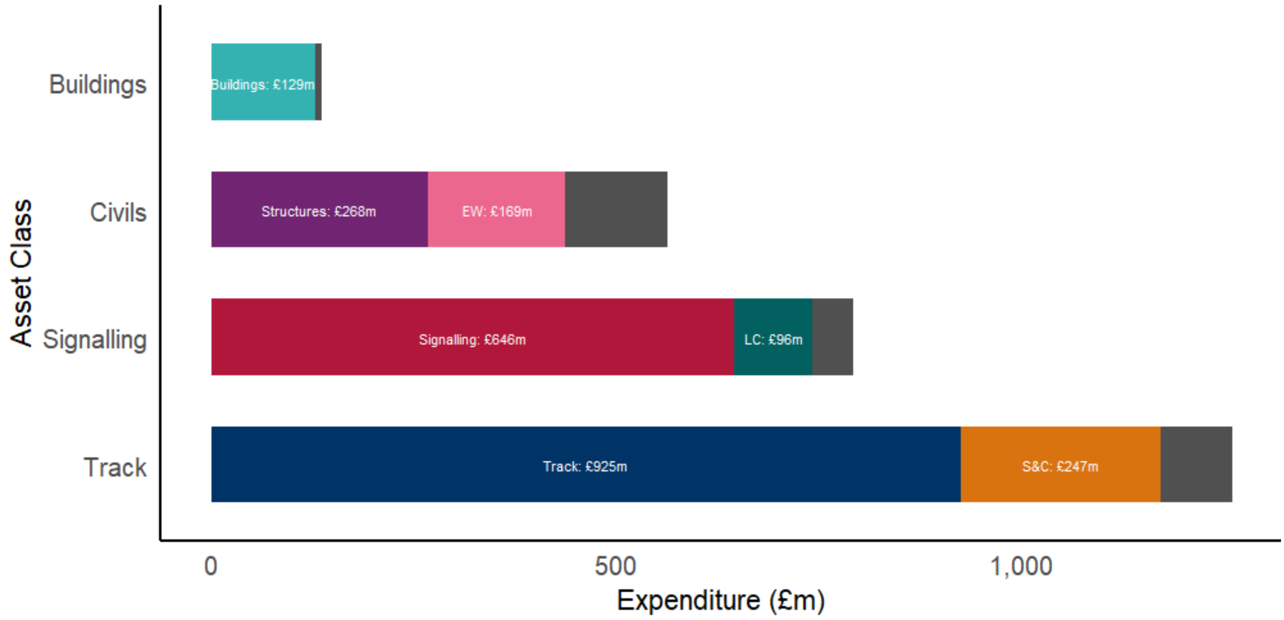
Context

Renewals across asset classes

3.12 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 asset renewal categories do not have unit costs. Therefore, this analysis accounts for 75% of renewals expenditure at a region level in 2023-24 (excluding centrally managed expenditure).

3.13 Breakdown of Network Rail's renewals expenditure by asset class: Figure 16 shows the breakdown of renewals expenditure by asset class in 2023-24. The breakdown of average yearly expenditure for 2014-15 to 2023-24 is broadly the same. The 'Other' (grey) categories represent expenditure not captured in our analysis.[1]

Figure 16: Breakdown of renewals expenditure by asset class (excluding centrally managed expenditure), 2023-24 (2023-24 prices).



3.14 Expenditure on Track, Signalling, Civils and Buildings accounted for 75% of renewals expenditure. Asset classes are further split into sub-asset class or work types. Figure 16 shows asset classes on the vertical axis and sub-asset classes within the bars on the chart. For instance, the Switches & Crossings sub-asset class (orange section of the bottom bar) accounted for £247m of track renewals expenditure in 2023-24, which is around 23% of track renewals expenditure.

[1] For the 'Other' categories we were unable to accurately match expenditure and volumes at the work type level for this data. The 'Other' category 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.

Conventional track renewals

3.15 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.

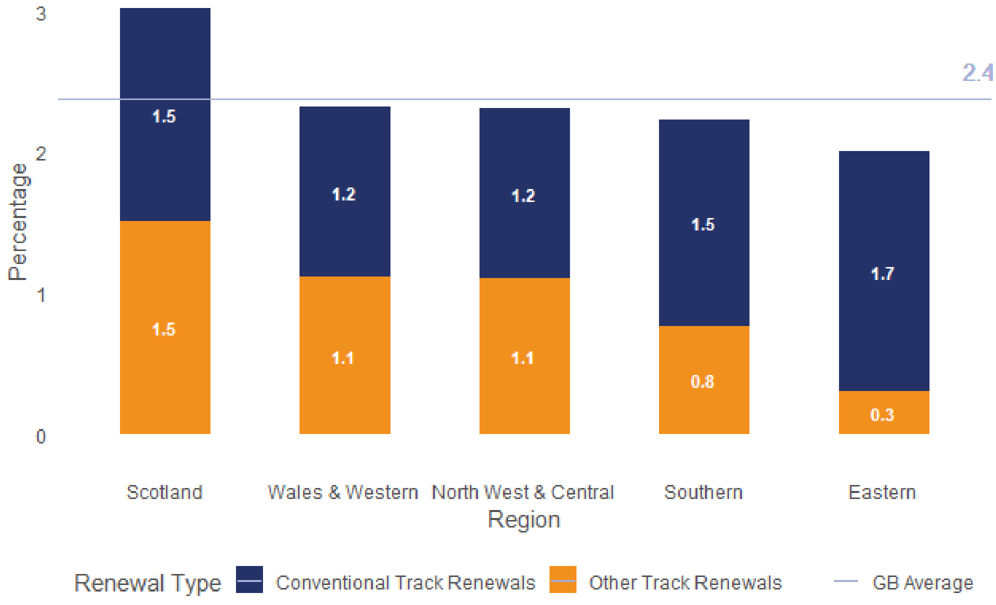
3.16 In the remainder of this chapter we focus on conventional track renewals.

Proportion of track renewed

3.17 Figure 17 shows the volume of track renewed as a proportion of total region track-km[2]. In 2023-24, Network Rail renewed 2.4% of its track. The Scotland region renewed its track at the highest rate (3%, 1.5% of conventional track renewals and 1.5% of other types of track renewal), whilst Eastern renewed at the lowest rate (2%, 1.7% of conventional track renewals and 0.3% of other types of track renewal).

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

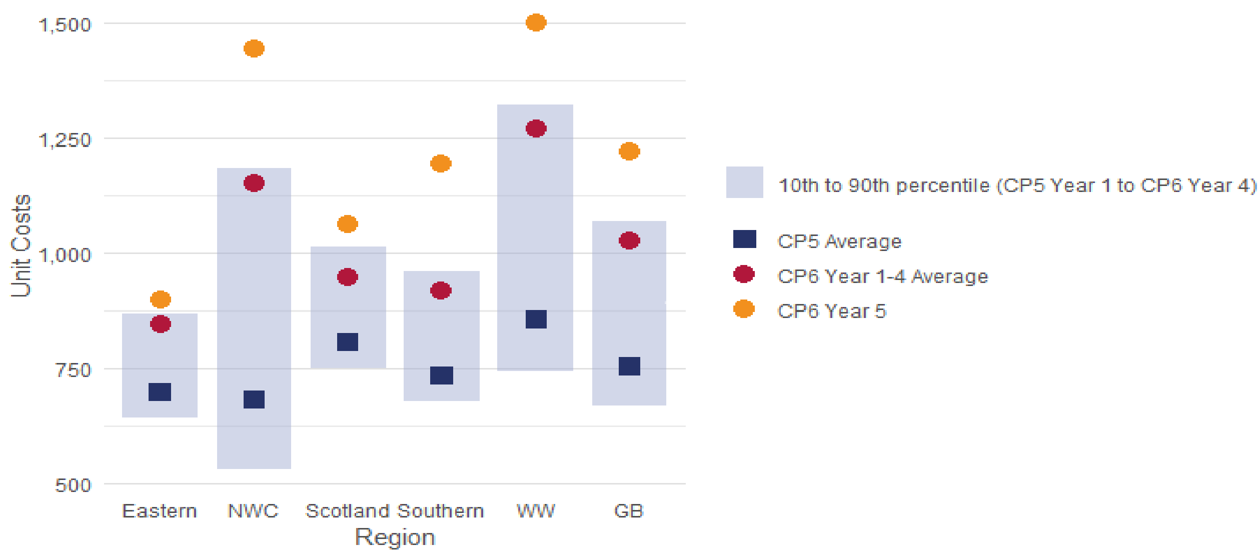
Figure 17: Average proportion of track renewed, 2023-24



Conventional track renewals average unit cost

3.18 Figure 18 shows the average unit costs for conventional track renewals by region for CP5; year 1 to 4 of CP6; and year 5 of CP6 (2023-24). Average unit costs across all regions are 19% higher in year 5 of CP6 relative to the first four years of CP6. Wales and Western has the highest average unit cost (£1,500k per track-km) in year 5 of CP6, whilst Eastern has the lowest average unit cost (£899k per track-km).

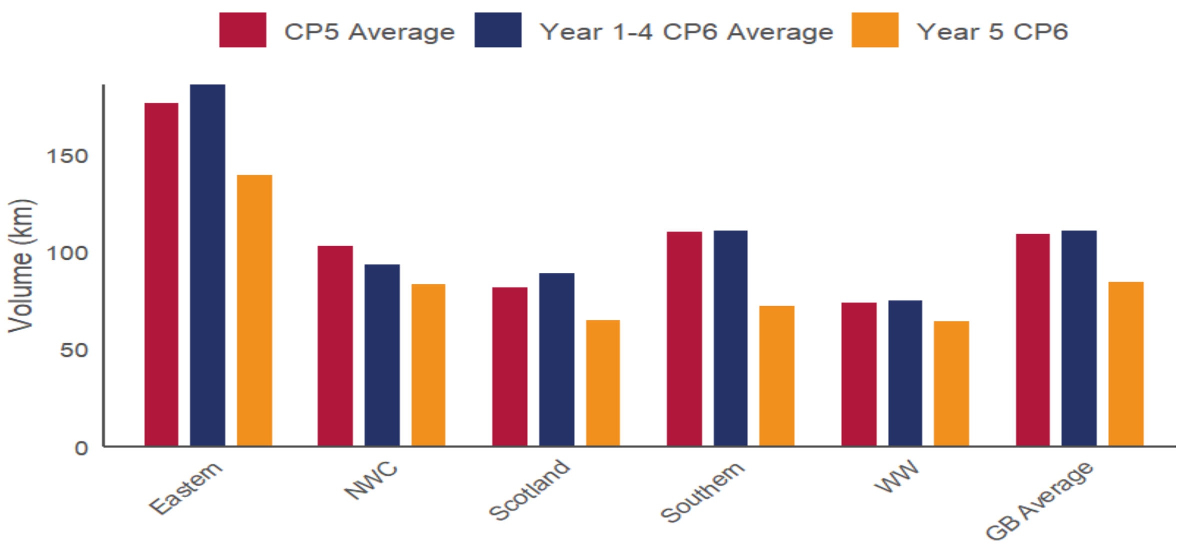
Figure 18: Conventional track renewals average unit costs (£k) (2023-24 prices)



Conventional track renewals volumes

3.19 Figure 19 shows the average volumes for conventional track renewals by region for CP5 and years 1 to 4 of CP6, and volumes for year 5 of CP6 (2023-24). Volumes decreased in year 5 of CP6 relative to the average annual volumes in year 1 to 4 of CP6. Eastern completed the most conventional track renewals in 2023-24 (139km) whilst Wales and Western completed the fewest (64km).

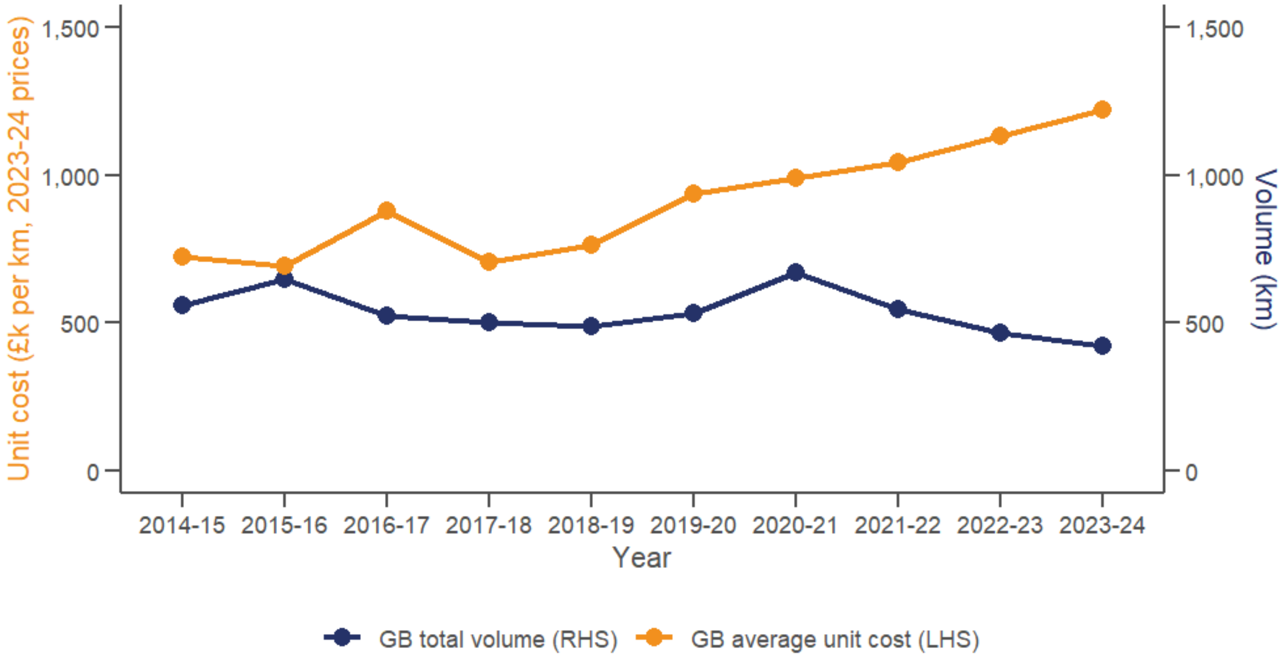
Figure 19: Conventional track renewal volumes



Trends in conventional track renewals unit costs and volumes (GB total)

3.20 Figure 20 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 2014-15. The annual average growth rate over this period was 7%. This could be due to inefficiency, changes in work mix or other factors. Since 2021-22 volumes have been falling, with the latest year falling by 9%, which amplifies the upward trend in unit costs in recent years.

Figure 20: Trends in Conventional track renewals – average unit cost and total volumes, 2014-15 to 2023-24



Analysis

Data

3.21 The analysis is based on data for financial years 2014-15 to 2023-24, recorded at the level of the five regions. The data and the conventional track renewals model specification are described in Annex B.

3.22 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 3%[3] per year (in real terms) since 2014-15, after controlling for factors such as track length and extent of electrification. This may be due to inefficiency 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

3.23 This section compares outturn conventional track renewals unit costs against expected spend as predicted by our model, given each region's characteristics.

[3] Calculated from the coefficient of the "Year" variable.

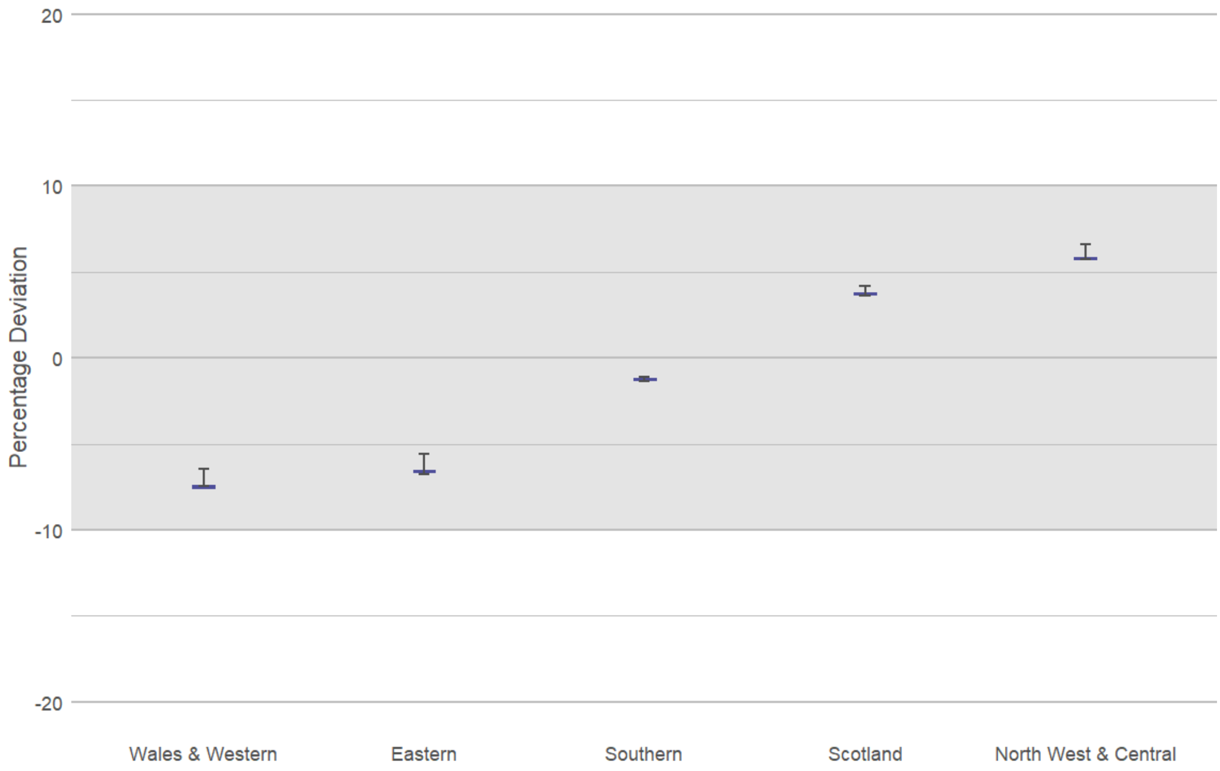
We order the regions according to the amount of unexplained variation (i.e. the difference between outturn and predicted unit costs).

3.24 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.

3.25 Figure 21 below shows, for each region, the proportion of unexplained cost variance in 2023-24[4]. 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.

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

Figure 21: Deviation between outturn and expected (modelled) unit costs for conventional track renewals by Network Rail region, 2023-24



Note: Given the uncertainty associated with this statistical model, we consider any region within +/-10% of our model prediction (shown by the x-axis at zero) is not an 'outlier'. These regions are within the grey section. The lines surrounding the central estimate of a given region's deviation between outturn and modelled cost indicate a 95% confidence interval.

3.26 Figure 21 shows that conventional track renewals' average unit costs at the region level are between -7% and +6% of what our model would predict. This range is significantly narrower than in last year's analysis (-9% to +23%).

3.27 Compared to last year, Wales and Western is at the lower end of the range (-7%), whilst North West and Central has replaced Wales and Western at the top end of the range (+6%). This is largely consistent with our unit cost analysis where we found that, in 2023-24, conventional track renewals unit costs for Eastern and North West and Central were 12% and 25% higher than their respective average unit costs for the first four years of CP6.

3.28 Looking at all the regions together, the unit cost analysis showed that, in 2023-24, Network Rail’s conventional track renewals unit costs were 19% higher than the average unit costs for the first four 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.

3.29 We will continue to work with Network Rail to look into the potential causes for these results, encouraging regions to share good practice.

Annex A: Cost benchmarking

What is cost benchmarking?

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.

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.

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. 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.

5. Cost benchmarking is a high-level tool. It is useful in identifying significant discrepancies across organisations/business units, and in producing indicative expenditure forecasts. We should also not expect cost benchmarking to provide in-depth insights into the reasons behind such discrepancies. Therefore, the results should be used as part of a wider evidence base.

Use of cost benchmarking by ORR

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.

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.

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.

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 funds available (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

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

2. In all three models, all expenditure data is inflation-adjusted to 2023-24 prices, using the Consumer Price Index (CPI).

Region data based maintenance model

3. The analysis is based on data for financial years 2010-11 to 2023-24 for the existing five regions into which Network Rail is divided for business planning and delivery.

4. Dependent variable

5. The dependent variable is annual maintenance expenditure at the region level. For years 2019-20 to 2023-24 we collected the data from Statement 3 of the RFS where it is reported at region level.

MDU data based maintenance model

Dependent variable

6. 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 2023-24. This excludes centrally managed expenditure (covering activities such as structures examination, major items of maintenance plant and other HQ managed activities).

7. 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. In year 3, this was 36 MDUs and last year we based our analysis on a structure with 35 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.

8. 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[5].

Conventional track renewals unit cost model

9. The analysis is based on data for financial years 2014-15 to 2023-24, recorded at the level of the five regions of Network Rail.

Dependent variable

10. The dependent variable is annual average unit costs at the region-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.

Independent variables

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.

[5] 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.

Table 1: Independent variables used in our models

	Variable	Maintenance (Region)	Maintenance (MDU)	Renewals (Region)
Characteristics	Track-km (length of track)	X	X	
	Average number of tracks (track-km/route-km)		X	
	Proportion of electrified track (electrified track-km/track-km)	X	X	X
	Switches and Crossings (S&C) Density (number of S&C/track-km)		X	X
	Criticality 1 & 2 density (criticality 1 & 2 km/track-km)	X	X	
	Proportion of track category 1A, 1 & 2 (category 1A, 1 & 2 km/track-km)			X
Usage	Total (passenger + freight) train-km			X
	Passenger train-km		X	
	Freight train-km		X	
	Passenger traffic density (train km/track km)	X		
	Freight traffic density (train km/track km)	X		
Output	Average length of Possession (Days)	X	X	
	Lagged Enhancement Expenditure (£ million)	X		
	Lagged Maintenance expenditure (£ million)	X		
	Number of track-km renewed using conventional methods (km)			X
	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)	X	X	

Exogenous Factors	Average rainfall (mm per year)	X	X	X
	Year-specific dummy variable (applies to 2020-21)	X	X	X
	Year	X	X	X

Estimation approach

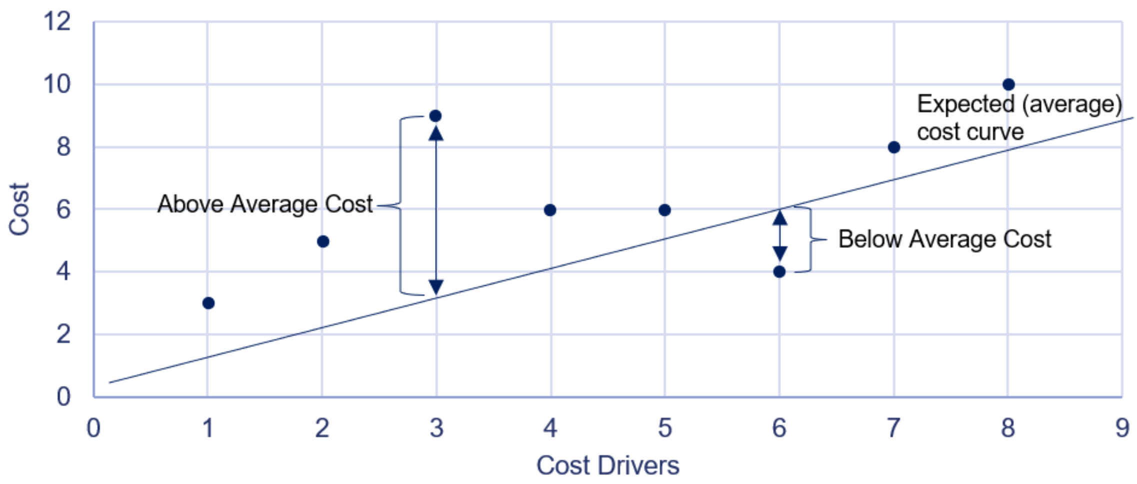
12. We have adopted the same functional form as in last year's report, namely the Cobb Douglas log-log formulation (i.e. where the dependent variable and most explanatory variables are entered in natural logarithms). With this functional formulation, most coefficients can be interpreted as constant elasticities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

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.

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.

15. This is illustrated in Figure 22 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 22: Illustrative OLS regression line and cost performance



16. For more details about the conceptual framework 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	Conventional track renewals unit cost Coefficient
Track-km	0.50***	0.37***	-
Conventional track-km	-	-	-1.10***
Refurbished track-km	-	-	-
High output track-km	-	-	-
Passenger traffic density	0.33**	-	-
Freight traffic density	0.01	-	
Train-km	-	-	0.06***
Passenger train-km	-	0.33***	-
Freight train-km	-	0.12***	-
Average number of tracks	-	-0.10*	
Switches and crossings density	-	0.23***	0.02***
Average rainfall	-0.02	0.15***	-0.18
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***	0.17***
Proportion of track criticality 1 & 2	0.49**	-0.06	-
Proportion of track category 1A, 1 & 2	-	-	0.13***
Lagged maintenance expenditure	0.40***	-	-

Variable	Maintenance Coefficient	MDU Coefficient	Conventional track renewals unit cost Coefficient
Lagged enhancement expenditure	0.07***		-
Year (average annual unexplained growth rate in expenditure)	0.04***	0.03***	0.03***
Dummy for 2020-21 (deviation from the annual growth rate due to COVID-19)	0.11***	0.11***	-0.02
Dummy for 2022-23	-	-	-
Constant	-8.55***	-9.84***	6.49***
Number of observations	60	315	50
R^2	0.98	0.64	0.87

*** 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

1. This Annex presents renewals average unit costs per asset type. It compares the renewals average unit costs for CP5, the first four years of CP6 and the year 5 of CP6 (2023-24).

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[6]. 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.

3. Table 3 below presents the renewals average unit costs by asset class and by region for CP5, the first four years of CP6 and the year 5 of CP6 (2023-24). It also presents the average percentage change in renewals unit costs from the first four years of CP6 average to year 5 of CP6.

[6] This is common with signalling renewals.

Table 3: Region average unit costs per asset class (2023-24 prices)

Asset class	Region	Average unit cost for CP5	Average unit cost for CP6 Y1 to Y4	Average unit cost for CP6 Y5	% change from CP6 Y1 to Y4 to CP6 Y5
Track (£k per km)	Scotland	503	693	700	1%
	Eastern	612	680	994	46%
	NW&C	545	1379	1600	16%
	Southern	671	821	1046	27%
	W&W	546	989	1,046	12%
	GB	**578**	**869**	**1,108**	**27%**
S&C (£k per km)	Scotland	287	422	183	-56%
	Eastern	308	286	375	31%
	NW&C	236	741	637	-14%
	Southern	285	336	423	26%
	W&W	300	571	494	-13%
	GB	**285**	**394**	**400**	**2%**
Signalling (£k per SEU)	Scotland	334	1,041	176	-83%
	Eastern	599	378	273	-28%
	NW&C	1,064	1,250	498	-60%
	Southern	692	681	607	-11%
	W&W	347	844	145	-83%
	GB	**533**	**726**	**297**	**-59%**
Level Crossings (£k per unit)	Scotland	1,795	2,887	1000	-65%
	Eastern	2,524	713	290	-59%
	NW&C	621	2,356	3,706	57%
	Southern	2,015	2,703	1,133	-58%
	W&W	2401	971	1,312	35%
	GB	**1867**	**1309**	**1085**	**-17%**
Structures (£k per m2)	Scotland	2.5	2.4	2.3	-2%
	Eastern	2.8	1.1	1.1	-1%
	NW&C	3.1	5.8	6.0	3%
	Southern	5.2	3.6	4.6	27%
	W&W	3.9	3.1	6.0	95%
	GB	**3.3**	**3.0**	**3.2**	**27%**
Earthworks (£k per 5-chain)	Scotland	41	46	66	44%
	Eastern	31	29	34	18%
	NW&C	59	84	61	-28%
	Southern	98	186	131	-29%
	W&W	112	48	56	16%
	GB	**48**	**67**	**63**	**-5%**
	Scotland	1.6	1.0	4.1	320%
	Eastern	0.7	0.9	1.4	61%

Asset class	Region	Average unit cost for CP5	Average unit cost for CP6 Y1 to Y4	Average unit cost for CP6 Y5	% change from CP6 Y1 to Y4 to CP6 Y5
Buildings (£k per m2)	NW&C	1.8	9.0	5.0	-44%
	Southern	2.1	1.1	3.5	-224%
	W&W	2.0	5.7	1.9	-67%
	GB	**1.5**	**2.0**	**3.1**	**63%**