Project Leadership and Society 5 (2024) 100128

Contents lists available at ScienceDirect

Project Leadership and Society

journal homepage: www.sciencedirect.com/journal/project-leadership-and-society

Empirical Research Paper

Project delivery performance: Insights from English roads major schemes

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ARTICLE INFO

Keywords:
Benefits management
Managing cost
Investment appraisal
Transport infrastructure
Cost overrun

ABSTRACT

Generally negative prevailing views of infrastructure delivery performance is sclerotic and in need of an evidence-based reappraisal. This study evaluated the project delivery performance of National Highways, the government company responsible for delivering England's road investment strategy which completed 138 road/highway major schemes over 16 years between 2001 and 2016.93% of major schemes had a benefit-cost ratio, BCR, of 1 or more which means most projects delivered more benefit than their cost. 69% have a high BCR of 2 or more, delivering benefits at least twice the cost of the project. Typical cost performance was a 2.4% overrun with 42% of projects delivered on or under budgeted cost. The overall value of cost overruns was compensated for by the value of underruns so the net cumulative balance was below zero. Cost performance improved over time, with a typical cost underrun of −6% observed in projects completed in the latter half of the studied time period. The improvement to delivery cost performance is most likely to be explained by changes in policy and practice, including: improved estimation of costs; Strengthened appraisal and approval; Developing procurement strategy; Improving programme management; Implementing lessons learned.

1. Introduction

A perception of poor project delivery performance exists within the scholarly literature with academic works exhibiting a tendency to report negative performance and also to presume poor performance (notably but not limited to: Avots, 1969; Henderson, 1977; Merrow et al., 1988; Lovallo and Kahneman, 2003; Kotter, 2007). This constant reiteration has the effect of reenforcing a belief that, "projects tend to confront, over time, a multiple "whammy" of time and cost overruns, business case failures, stakeholder disappointments, and sustainability shortfalls" (Ika and Pinto, 2022) as illustrated by contemporary views including: "projects are statistically unlikely to be successful … many projects still struggle to deliver their expected outcomes" (Bourne et al., 2023); "Every project starts with an intent to succeed, yet, its prospects of success tend to be grim" (Maylor et al., 2023) and; "In project-based organisations, projects often don't meet time and cost expectations, resulting in cost or duration overrun" (Delise et al., 2023). This presumption is well engrained and most scholars appear to subscribe to Flyvbjerg's, "iron law of megaprojects" (Flyvbjerg, 2014) summed up in the mantra, "Over Budget, Over Time, Over and Over Again" (Flyvbjerg, 2011) which neatly captures the view of project delivery as one labouring under a tiresome record of poor performance.

Behind the eye-catching headline Flyvbjerg and colleagues have sought to describe and explain this phenomena since the mid-1990s (for example Holm, 2000) in works Flyvbjerg reports via the consulting company he owns make him, "the most cited scholar in the world on megaproject management" (Oxford Global Projects, 2023). Flyvbjerg and colleagues prove inspiring role models for highlighting methodological issues and raise important questions, including over the merits of classic works (Flyvbjerg and Turner, 2018) by Hall (1980) and Pickrell (1992) that, "cover a sample of infrastructure projects too small or too uneven to allow systematic, statistical analyses" (Flyvbjerg et al., 2003), a critique reiterated verbatim in Flyvbjerg et al. (2005). Flyvbjerg critiqued Pickrell, 1992 study with its 27 rail projects as one amongst many he describes as, "small-N research" with a sample that covers, "too few projects to allow systematic, statistical analysis, and results of the studies are likely to depend on random properties of the selected samples" (Flyvbjerg, 2007).

McLeod (2023) in turn raises methodological concerns over a lack of transparency of the underlying data of studies by Flyvbjerg and colleagues, noting, "Flyvbjerg has published widely, citing databases of projects that appear to be very similar between publications, and that do not appear to be openly available." (McLeod, 2023). Similarly Merrow, another author of a 'classic', and latterly the self-styled, "world's leading industrial engineering project consultant" draws on, "a proprietary detailed database of over 1100 major projects" to advance the claim

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https://doi.org/10.1016/j.plas.2024.100128
Received 31 October 2023; Received in revised form 28 March 2024; Accepted 4 April 2024
Available online 16 April 2024

"major projects are delayed by months or years, and cost millions more than budgeted" and to offer advice on contract strategies for major projects (Merrow, 2022) Given these authors have made such an impactful scholarly contribution and their works shape the view widely held by researchers and the public of enduring poor performance in project delivery it would be beneficial if the merits of these claims were able to be independently tested. Without this ability, claims made from unverified data no matter how vigorously and frequently promoted struggle to be considered secure. One straightforward way to facilitate independent attempts to replicate these studies would be to follow the example set by authors such as Miller and Lessard (2001a), Hall (1980) and Pickrell (1992) and list the projects included in the research.

Addressing issues identified in prior studies including small N samples and opacity, findings are presented from a large N, transparent study. This research analysed the performance of a discrete population of transport infrastructure projects: 138 road/highway projects completed over 16 years between 2001 and 2016 in England. Notable methodological features of this study include.

- The data on project delivery performance included in the study is publicly available, which means:

  - Data sources are transparent.
  - Data provenance is maintained.
  - Conflicts of interest and other issues that challenge research integrity when using proprietary data are avoided.
  - This research can be independently replicated.

- Data is available on a whole population of projects, avoiding the need for sampling. This removes the issue Flyvbjerg et al. identify when studying cost overrun in transport infrastructure projects where, "In statistical analysis, data should be a sample from a larger population, and the sample should represent the population properly" acknowledging, "it is frequently impossible to meet these ideal conditions" (Flyvbjerg et al., 2003) a point reinforced when repeated near verbatim in 2018, while adding, "the sample will often not be representative of the population it is drawn from, because availability does not necessarily equate representativeness" (Flyvbjerg et al., 2018).

As to what a suitable sized sample equates to, Flyvbjerg describes his 2007 study of 44 urban rail projects, which he compares to 214 other transport infrastructure projects, as "the largest of its kind" that allows, "statistically significant conclusions regarding the economic risks involved in building urban rail projects" (Flyvbjerg, 2007), a threshold passed here.

This paper begins by setting the work in context with a brief recap of the background before focusing on the literature on capital project evaluation. Cost performance analysis of the population of transport infrastructure projects is then presented and discussed. The paper concludes with policy and methodological implications of these findings.

2. Background

"Since the dawn of civilisation, governments have been constructing roads" (Public Accounts Committee, 2007) and these transport infrastructure projects mirror characteristics found in other large engineering projects such as being the product of negotiated compromise arising from the need to address technical challenge and accommodate social expectations; facing contested externalities; being exposed to political risk, and; presenting large, irreversible commitments (Miller and Lessard, 2001a). They are important enablers of social and economic goals (Aschauer, 1989; Di Maddaloni, Favato, and Vecchiato, 2024; Infrastructure and Projects Authority, 2021) while also costing nationally significant sums of money.

Conceptions of delivery success change over time with a discontinuity existing between stakeholders (Davis, 2014) and, "Measuring success is notoriously difficult to evaluate" (Pollack et al., 2018). Viewing project success in terms of a series of criteria (Morris and Hough, 1987; Cooke-Davies, 2002; Allport, 2008) offers some guidance, where these include: doing the right project (Cooke-Davies, 2004), aligned with policy/strategic objectives and priorities; effective project management in terms of delivering to budget, on schedule and to technical specification, and; project sustainability where the resulting project performs as expected and policy success is achieved. With an eye to these wider considerations and the need to distinguish between tactical project management success and longer-term strategic project output success (Cooke-Davies, 2002; Williams in Williams et al., 2022), this paper considers project management effectiveness and also project effectiveness.

To assess project management effectiveness this work focusses on an issue of interest to transport infrastructure project funders, public sector agencies that commission them, organisations that build them and people who use them, which is the reported tendency for these projects to experience cost overruns (Cavalieri et al., 2019; Chen et al., 2023; Denicol et al., 2020; Flyvbjerg, 2014; Love et al., 2024; Merrow et al., 1988; Merrow and Yarossi, 1990; Miller and Lessard, 2001b). Cost overrun is also a topic of interest to the academic community where its nature and causes receive regular attention (Chapman and Quang, 2021; Cavalieri et al., 2019; Denicol et al., 2020; Holweg and Maylor, 2018) and is subject to lively debate/academic discourse (such as: Flyvbjerg et al., 2019; Love et al., 2019) which occasionally spills over into a battle over data and method (Kreiner, 2020) notwithstanding a general consensus that poor performance exists. Transport infrastructure projects in particular are not immune to the general malaise, and issues including cost overruns are widely reported (for example: Cavalieri et al., 2019; Di Maddaloni, Favato, and Vecchiato, 2024; Flyvbjerg et al., 2004; Love et al., 2024; Odeck, 2004).

This work also considers project effectiveness. Transport infrastructure projects are undertaken for a variety of reasons and aim to achieve a range of objectives such as travel time reduction, capacity increase, safety improvement and environmental effects so effectiveness is assessed in terms of whether a project achieved the intended benefits stated at its outset (Di Maddaloni, Favato, and Vecchiato, 2024). Encompassing both project management effectiveness and project effectiveness, the cost of a project can be considered relative to the monetized measure of benefits delivered over its useful life summarized as a Benefit Cost Ratio, BCR.

3. Ex-post evaluation of transport infrastructure projects

The standard metric for measuring project delivery performance is to compare outturn performance of a project relative to the objectives set out in the final business case, against which the final decision was made to commit investment to the project (Flyvbjerg et al., 2018; Pellegrinelli et al., 2007). This use of the estimate made at the time of decision to build as the baseline of costs has been described as, "the international standard for calculating cost development." (Flyvbjerg, 2007 pg13) that is, "followed by academics, governments, and national audit offices around the world." (Flyvbjerg et al., 2019 pg410).

Benefits are assessed after the project has been completed and the delivered capability is in use. Good practice is to undertake an assessment after a set period of time, such as one year, three years and/or five years. Reviews undertaken a longer period after completion have the advantage of the delivered capability being evaluated when it has bedded in and become 'business as usual' with adoption issues resolved and lag effects unwound. In contrast, earlier reviews have the advantage of recency so understanding of the project's purpose is more likely to be clearer and people and documentation should be more accessible, and a shorter timeframe can allow a quicker turnaround of lessons learned to invest into future projects.

3.1. Evaluation of a project population/portfolio

Evaluating a project population includes establishing the central tendency of a distribution. The choice is typically between mean and median, one illustrated by Odeck's (Odeck, 2004) study of cost overrun in 620 Norwegian road construction projects 1992–1995 which reported a mean cost overrun of 7.88% and a median of 1.96%. Were a researcher minded to tread the path of emphasizing poor project performance then the mean proves the obvious choice of descriptor however the median provides the most robust choice of measure for the central tendency given its suitability for both symmetrical and non-symmetrically distributed populations and also accommodates outliers in the data, where "The median is a nonparametric statistic, [and therefore correct for a large class of distributions] but it is also a highly robust estimate for estimating the center of a symmetric distribution as a central model." (Portnoy and He, 2000, pg1332). The median is calculated by rank ordering a data set and identifying the middle number, with half the values less than this value and half the values greater than this value.

4. Criteria for selecting a study population

Analyzing the performance of three types of transport infrastructure project (rail n = 58; fixed links n = 33; road n = 167; all projects n = 258) and whether cost performance is different for different type Flyvbjerg, Skamris Holm and Buhl conclude "Project type matters" (Flyvbjerg et al., 2003 pg80) (reiterated in Cantarelli et al., 2012) and also "project type is not important" (Flyvbjerg et al., 2004; pg8). Whichever the case may be, a mix of projects has at the very least the potential to be distracting so data was sought on projects from a discrete transport infrastructure sector. The criteria set out for choosing a data source was that it needed to demonstrate the following features.

A. Reliable, in that data comes from a reputable organisation known to possess subject matter expertise and experienced personnel, that operates a policy of internal review and their methods and the data are subject to external, independent audit.
B. Available, with data publicly available that allows the measurement of the (in)accuracy of estimates in line with "international convention" (Flyvbjerg et al., 2002, pg281), i.e. for each project:

1. The planned business case at the time of final decision to build, including the estimated cost of the project
2. The outturn performance, including the final cost determined at the time of project completion.

4.1. Choice of English road schemes as a study population

Applying the reliability criteria, National Highways, the UK Government owned company responsible for England's strategic road network, was identified as a suitable data source. The United Kingdom has low levels of corruption, 13th lowest internationally in 2001 and 10th lowest internationally in 2016 (Transparency International, 2022),) and high public trust in government, 15th highest internationally in 2006 and 16th highest internationally in 2016 (OECD, 2023), which sets an expectation of public sector integrity.

National Highways is the current incarnation of a public sector body that traces its roots to the Road Board set up in 1914 to build and maintain roads (National Highways, 2020) and inherited the corporate experience of its predecessor agencies: Highways Agency (1994–2015) and Highways England (2015–2021). National Highways' functions include delivery of the Road Investment Strategy (Department for Transport, 2020) set by the Secretary of State for Transport. It is subject to oversight by a range of public bodies including: the Department for Transport; is regulated by the Office of Rail and Road, and; UK Parliamentary oversight is by the House of Commons Transport Committee (House of Commons Transport Committee, 2023). Expenditure is independently audited by the National Audit Office (National Audit Office, 2007) which also reports on good practice to help government improve public services (National Audit Office, 2017), and National Highways is held to account on value for public money by the Public Accounts Committee of the UK Parliament (Public Accounts Committee, 2014). Taken together this suggests National Highways and its previous incarnations were and are subject to good governance and oversight and possess the institutional capability to undertake their remit effectively with schemes delivered by professionally competent contractors.

Applying the availability of information criteria, National Highways and its predecessor organisations undertake project evaluation studies for all Major Schemes, those improvements to the road network costing over £25 m or £10 m in the case of local major schemes, usually one or five years after opening. Schemes are appraised as per the Department of Transport's Transport Analysis Guidance (DfT, 2018) and follow a prescribed methodology (National Highways, 2022). Occasional reviews are conducted into the strengths and weaknesses in the techniques used for appraising schemes with the aim that improvements can be made in the future.

Project evaluations compare information collected before and after the opening of the scheme against predictions made during the planning process. The appraisal examines outturn performance including an appraisal of benefits and revised forecasts for benefits over the schemes' useful life and a review of forecast verses outturn capital costs. Data was collated for all 138 major schemes completed between 2001 and 2016. A list of these schemes is found in Appendix 1. English Road Schemes included in study.

4.1.1. Data limitations

Assembling data from a single organisation has the benefit of being collected on a relatively consistent basis and allows a comprehensive dataset to be compiled that is not subject to selection bias. While the specific guidance of evaluation will have been revised over time and the people involved in undertaking evaluations change there is sufficient consistency to achieve a reliable comparison between the performance of these various projects. There is lingering potential for systematic error in how data is collated, stored and processed that may have a detrimental effect on results and it may be that specific features of this setting and the approaches used, be they technical, socio-economic, political or temporal could cause the performance of these projects to be atypical and as a consequence prevent the results from being generalizable.

4.2. Evaluation of project benefits

Road project benefits typically arise from improved safety, journey time savings, journey time reliability, impact on the environment, economic development stimulation and increased accessibility. These benefits are evaluated following Department for Transport guidance (Department for Transport, 2023) and assigned a financial value. Benefits and costs over a scheme's period of usefulness are calculated in real prices, at current value and expressed as a benefits to costs ratio, BCR. To determine project delivery effectiveness, data was collated for each project on (i) the BCR forecast at final decision to build the scheme and (ii) the BCR figure calculated one or five years after the scheme was completed.

4.3. Evaluation of project delivery cost performance

For each project, two assessments of cost were made. Firstly a measure of cost overrun was calculated (Gao and Touran, 2020) using the formula:

$$\text{Cost overrun} = \frac{\text{outturn cost} - \text{forecast cost}}{\text{forecast cost}} \text{ x } 100\%$$

Here a positive number represents a cost overrun, where the outturn cost was more than the forecast cost, and a negative number indicates a cost underrun, where the outturn cost was less than the forecast cost. The second assessment was a simple calculation to determine whether there was a cost overrun or not by reviewing whether the outturn cost was greater than the forecast cost, i.e.

Is outturn cost > forecast cost? [yes / no]

The forecast cost is the cost at the time of the final investment decision to proceed with the scheme (see Table 1). To determine project delivery performance, two cost data points were collated for each project, as shown in Table 2.

5. Findings

The outturn cost profile of the population of road major schemes is shown in Table 3 below.

The cost profile shows that while the majority of projects cost in the tens of millions of British Pounds the data set includes lower cost projects in the single millions as well as some that cost hundreds of millions of pounds.

5.1. Benefits cost analysis

Ex-post evaluation of benefits is included in the evaluation undertaken one or five years after project completion with data available for 131 of 138 projects completed between 2001 and 2016. The financial value of the various benefits each scheme aims to deliver over its useful life is calculated and compared with the scheme's costs over the same period and expressed as a benefit to cost ratio, BCR. A BCR of one means that the value of the scheme's benefits is equal to its costs. A scheme with a BCR of two or more is considered as having a high BCR. A summary of the BCRs for major schemes is presented in Table 4.

This data shows that between 2001 and 2016, 93% of road projects were assessed as having a positive BCR and that 69% were assessed as having a high BCR of two or more. A more detailed view of outturn benefit cost ratio is provided in Fig. 1 where data is assembled into a cumulative distribution.

An alternative view of the same data is shown as a histogram in Fig. 2.

Taken together this data suggests that the vast majority of major schemes are economically productive, that is they deliver a value of benefits that is higher than the scheme's cost. In most cases, 69%, the value of benefits is at least double the cost and 24% of projects achieved a BCR of five or more.

5.1.1. Does outturn benefit cost ratio change over time?

Data on the outturn benefit cost ratio was available for 131 projects. Fig. 3 shows this data plotted by year of opening.

An eyeball analysis of this data suggests overall performance is fairly constant, with slight overall tendency to increase over time with the range of outcomes also increasing.

To understand the change in performance over time a little more thoroughly, the time period is bifurcated into two eight-year periods, with data on the two subset periods of time shown in Table 5 and a box and whisker diagram of the data show as Fig. 4.

This data shows that the median BCR for projects completed in both time periods was similar at 3.0 and 2.7, both above the threshold of high BCR, and both time periods have a similar lower quartile BCR of 1.8 and 1.7. Differences between the two periods are.

- The upper quartile increased in the later period to 6.2 from 4.8 previously.
- Outliers, higher and lower, increase in magnitude in the later period.
- There were five projects, 14% of the total, with a negative BCR of less than one in the later period while there were four projects, 4%, in the earlier period. This reduced the proportion of projects with a positive BCR from 96% to 86%.

Table 1
Benefits data collated for each project.

	Benefit to Costs Ratio
Forecast at final decision to build	data point 1a
Followed up after 1 or 5 years	data point 1 b

Table 2
Cost data collated for each project.

	Cost
Forecast cost at final decision to build	data point 2a
Outturn cost at project completion	data point 2 b

Table 3
Cost profile of road major schemes included in the study.

	Outturn cost (British Pounds, millions)
maximum	£489.0
3rd quartile	£65.9
median	£21.2
1st quartile	£2.5
minimum	£0.4

Table 4
Summary of outturn benefit cost ratios.

Time period	2001–2016
Sample size, *n*	131
Projects with high BCR≥2	69%
Projects with positive BCR ≥ 1	93%
Projects with negative BCR <1	7%

5.1.2. Analysis of benefit cost ratio forecasting

Fig. 5 shows a plot of forecast BCR against outturn BCR.

Examining this data, for 67% of schemes the outturn BCR was less than the forecast BCR. Table 6 provides data detailing the distribution profiles for outturn BCR and forecast BCR.

Overall, BCR forecasts tend to be higher than the outturn BCR achieved. Using a paired *t*-test, the mean for forecast BCR (M = 9.62, SD = 24.40) was higher than the mean for outturn BCR (M = 5.66, SD = 8.87). The difference in means (difference = 3.96) was statistically significant, t (130) = 2.06, p = 0.041.

5.1.3. BCR forecast accuracy over time

Figures for forecast and outturn BCR were compiled for each time period separately, the results of which are shown in Table 7 and Fig. 6.

This information shows that the median and lower quartiles for forecasted BCR and outturn BCR were similar in both time periods. The upper quartile forecasts in the latter period were notably higher in the earlier period, more than doubling from 5.9 to 14.2. The upper quartile outturn BCR also increased between the two periods, from 4.8 to 6.2. The forecasts in both periods were generally inaccurate with BCR forecasts consistently exceeding outturn BCR figures. The level of inaccuracy is difficult to accurately assess, however forecasts appear to be less accurate in the second period, indicating forecasting accuracy decreased.

5.2. Project delivery cost performance

Ex post evaluation was conducted on the road projects, specifically.

- Data point 2a: Forecast cost at final decision to build

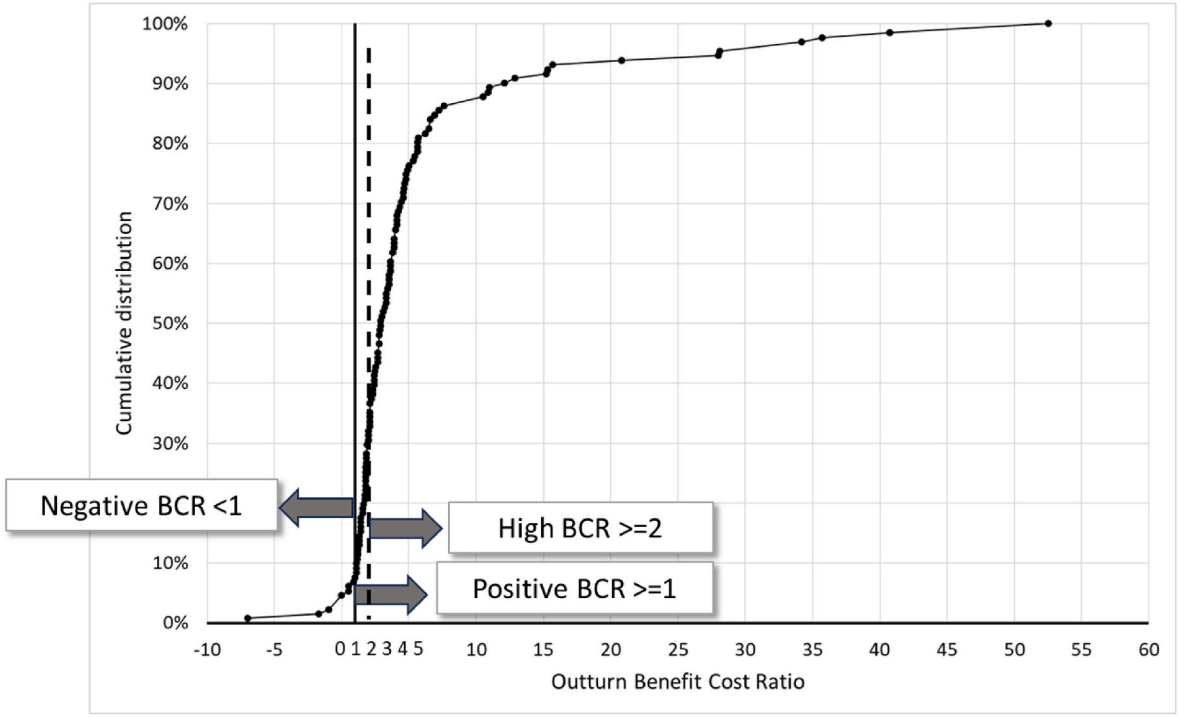

Fig. 1. Outturn benefit cost ratio cumulative distribution.

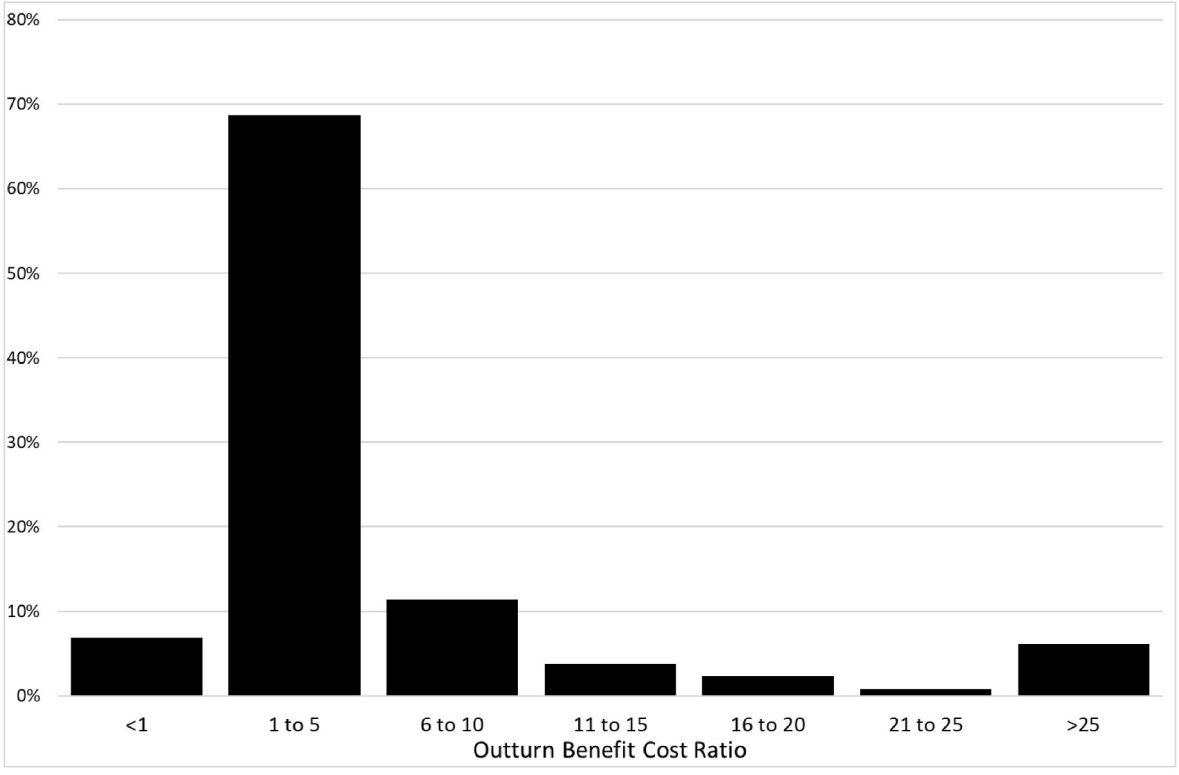

Fig. 2. Outturn benefit cost ratio distribution histogram.

- Data point 2 b: Outturn cost at project completion

Data on cost was available for 134 out of 138 completed road major schemes.

Comparing outturn cost against forecast cost for individual projects and compiling this data allowed project delivery cost performance to be determined for the population, and in particular: (i) median cost overrun, (ii) proportion of projects delivered within budget, (iii) proportion of projects delivered within +10% of their budget. The summary findings are presented in Table 8.

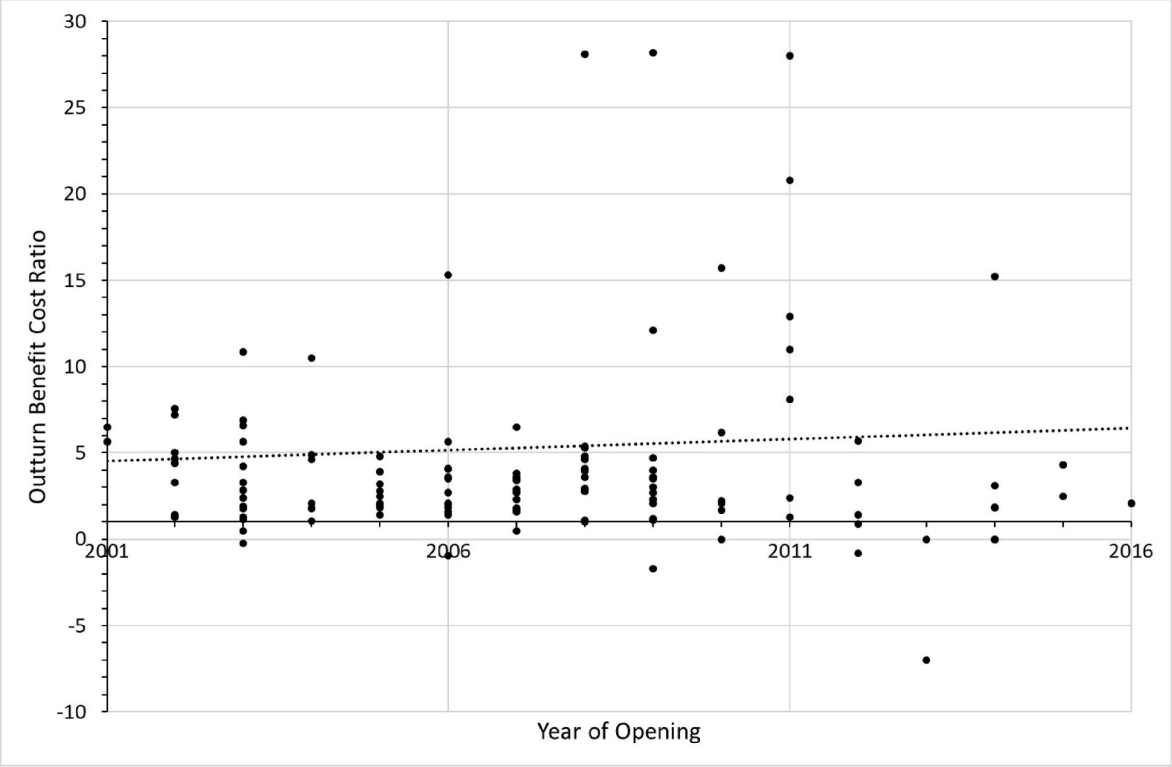

Fig. 3. Outturn benefit cost ratio over time.

Table 5
Summary of outturn BCR for projects completed in periods 2001 to 2008 and 2009 to 2016.

Project completion period:	2001 to 2008	2009 to 2016
Sample size:	94	37
Maximum BCR:	45	53
75th percentile:	4.8	6.2
Median BCR:	3.0	2.7
25th percentile:	1.8	1.7
Minimum BCR:	−1.0	−7.0
Projects with positive BCR:	96%	86%
Projects with negative BCR:	4%	14%

5.2.1. *Road project delivery cost performance*

Fig. 7 shows the distribution of cost overrun for the 134 road projects delivered in England between 2001 and 2016.

Broadly speaking this profile shows a distribution approximating to a normal distribution centered just above zero, with a typical (median) cost overrun of 2.4% and an average (mean) cost overrun of 10.4% (see Table 9). This difference between median and mean is symptomatic of positive, right-hand skew to the distribution as can be observed in Fig. 7. Other descriptive statistics that support this interpretation are the measures of skewness, 2.49, and kurtosis, 10.29. Kline (2016) interprets measures of skewness less than 3 as being skewed but not severely so and measures of kurtosis above 10 but less than 20 as suggesting a problem but not a severe one. 42% of these projects were delivered on or under the budget assigned at the time of decision to proceed with construction. Taking a common industry perspective, 60% of projects were delivered on or within +10% of their budgets.

5.3. *Analysis of cost performance*

The size and duration of the data set allows cost performance temporal and scale characteristics and trends to be examined, specifically.

- *Is cost overrun changing over time?*
- *Do higher cost projects risk greater cost overrun?*

5.3.1. *Is cost overrun changing over time?*

Data for road project cost overrun over time is shown in Fig. 8.

Considering cost performance over time shows that while there is variability in the level of cost overrun on individual projects a trend of reducing cost overrun can be observed. The implications of this trend can be discerned by segmenting the time series into two halves to analyze those projects completed in 2001–2008 separately from those completed 2009 to 2016.

While the samples sizes differ, the two time period data sets possess sample sizes sufficient to support meaningful analysis. The contrast between typical cost performance in the two time periods is stark with the median value changing from a cost overrun of 11% in 2001–2008 to a cost underrun of −6% in 2009–2016. The change in delivery performance is also shown when observing the P75 value which reduces from 34% to 3% in the later period. The difference between the two time periods is also observed in the number of projects delivered on or under their forecasted budget which shifts from 33%, one third, to 61%, close to two thirds. Taking the more relaxed but common industry perspective, 88% of projects completed in 2009–2016 were delivered for a cost on or less than their budget plus ten percent in contrast to 47% of projects completed in 2001–2008. This evidence provides a strong indication that cost overrun in road major schemes reduced over time over the period 2001 to 2016.

5.3.2. *Do higher cost projects risk greater cost overrun?*

Data for road project cost overrun against forecast cost is shown in Fig. 9.

This data suggests cost overrun reduces with forecast cost, a point illustrated by noting that 10 of the 11 projects with a forecast cost of £150 million and higher were delivered for less than their forecast cost.

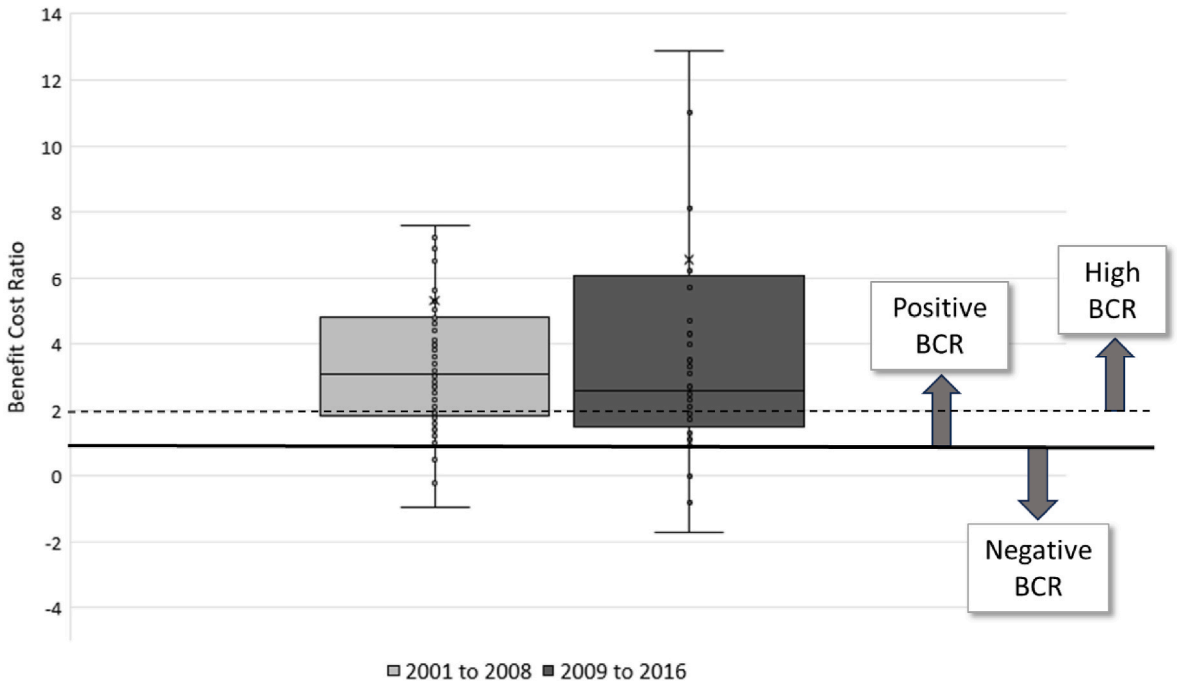

Fig. 4. Outturn BCR for projects completed in periods 2001 to 2008 and 2009 to 2016.

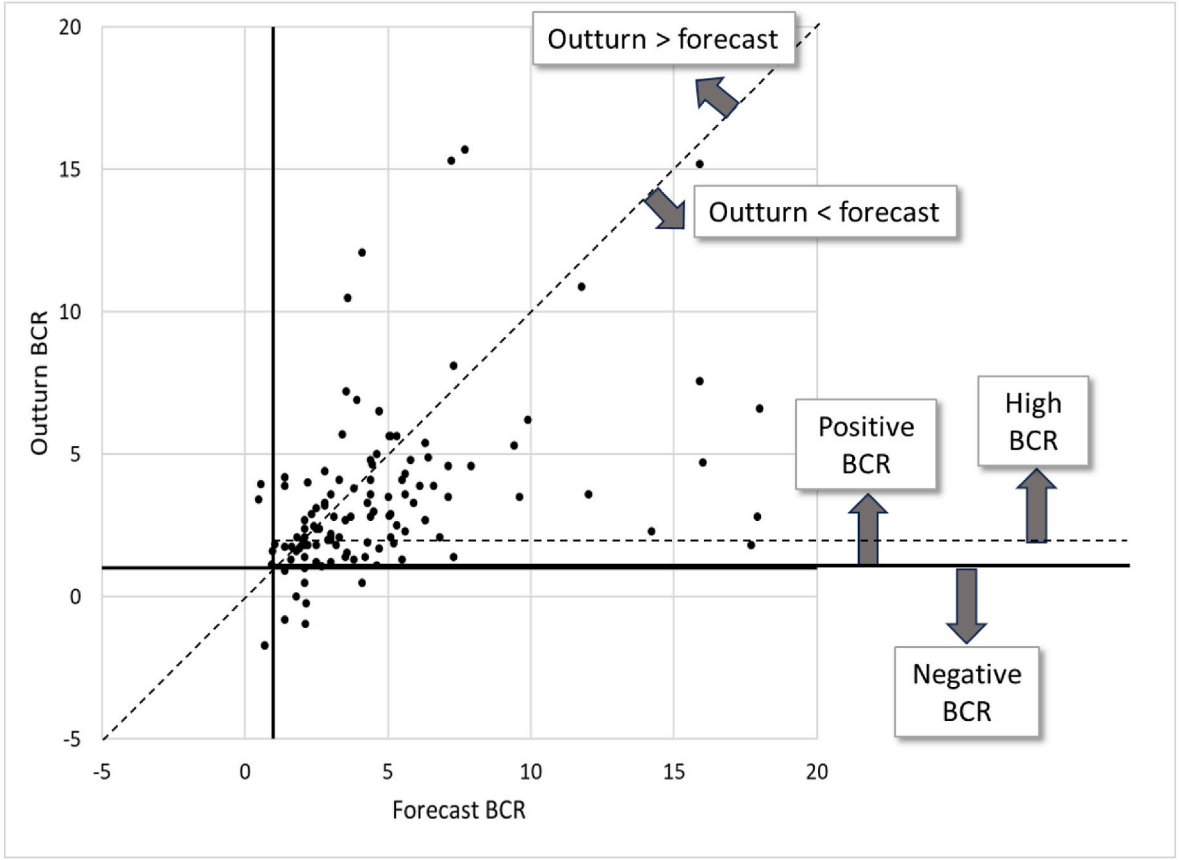

Fig. 5. Forecast BCR and outturn BCR.

6. Analysis

The data on the project delivery performance of English roads major schemes is assembled and summarized in Table 10.

Assembling and summarizing the data on project delivery performance provides evidence that runs contrary to the popular narrative that in general projects fail to achieve their intended benefits and are delivered over budget. Instead, the data on performance of English road

Table 6
Distribution profiles for forecast BCR and outturn BCR.

	Forecast BCR	Outturn BCR
Maximum:	248	53
3rd quartile:	6.9	4.9
Median:	4.3	2.9
1st quartile:	2.5	1.8
Minimum:	0.5	−7.0

Table 7
Forecast and outturn BCR data.

	2001 to 2008		2009 to 2016	
	Forecast BCR	Outturn BCR	Forecast BCR	Outturn BCR
Maximum:	80	45	248	53
75th percentile:	5.9	4.8	14.2	6.2
Median:	4.2	3.0	4.6	2.7
25th percentile:	2.6	1.8	2.1	1.7
Minimum:	0.5	−1.0	0.7	−7.0
Sample size:	94	94	37	37
High BCR (=>2)	87%	70%	8%	68%
Positive BCR (=>1)	96%	96%	97%	86%
Negative BCR	4%	4%	3%	14%

projects shows the vast majority achieve a positive benefit to cost ratio and individually are typically delivered close to budget while collectively the additional cost of projects that are over budget is compensated for by the lower cost of those delivered under budget.

Dividing the 16-year time period over which information is available into two halves provided the opportunity to understand whether delivery performance changed over time. Performance data for projects completed in the two time periods of 2001–2008 and 2009 to 2016 is separated out in Table 10. The performance of projects completed in these two time periods can be seen to have improved and the proportion of projects delivered for a cost on or under their budget increased. The Benefit Cost Ratio is seen to have marginally reduced.

6.1. Project delivery performance against multiple criteria

Individual measures provide a limited view of performance so combining multiple criteria offers the potential for a more rounded view.

Compiling data from the evaluations of English road major schemes allows the achievement of benefits and delivery against forecast budget

Table 8
Ex-post cost evaluation of English road major schemes.

	Population		Median cost overrun	Projects delivered	
	No of projects	Time period		within budget	within budget +10%
Road major schemes	134	2001–2016	2.4%	42%	60%

Table 9
English road project cost performance of projects completed in 2001–2008 and 2009–2016.

		Project completion date	
		2001 to 2008	2009 to 2016
Cost overrun	sample size:	93	41
	Maximum:	228%	31%
	75th percentile:	34%	3%
	Median:	11%	−6%
	25th percentile:	−6%	−19%
	Minimum:	−51%	−43%
projects delivered on or under budget		33%	61%
projects delivered on or under budget +10%		47%	88%

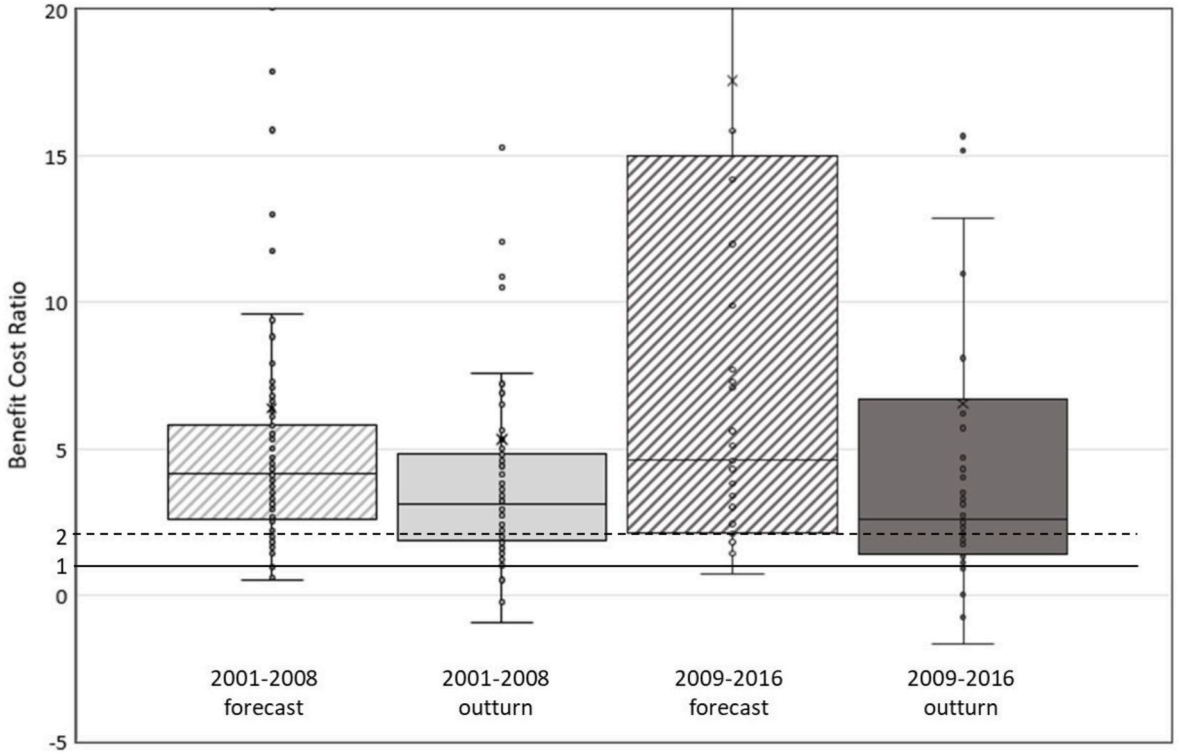

Fig. 6. Box and whisker charts of forecast and outturn BCR for 2001 to 2008, and 2009 to 2016.

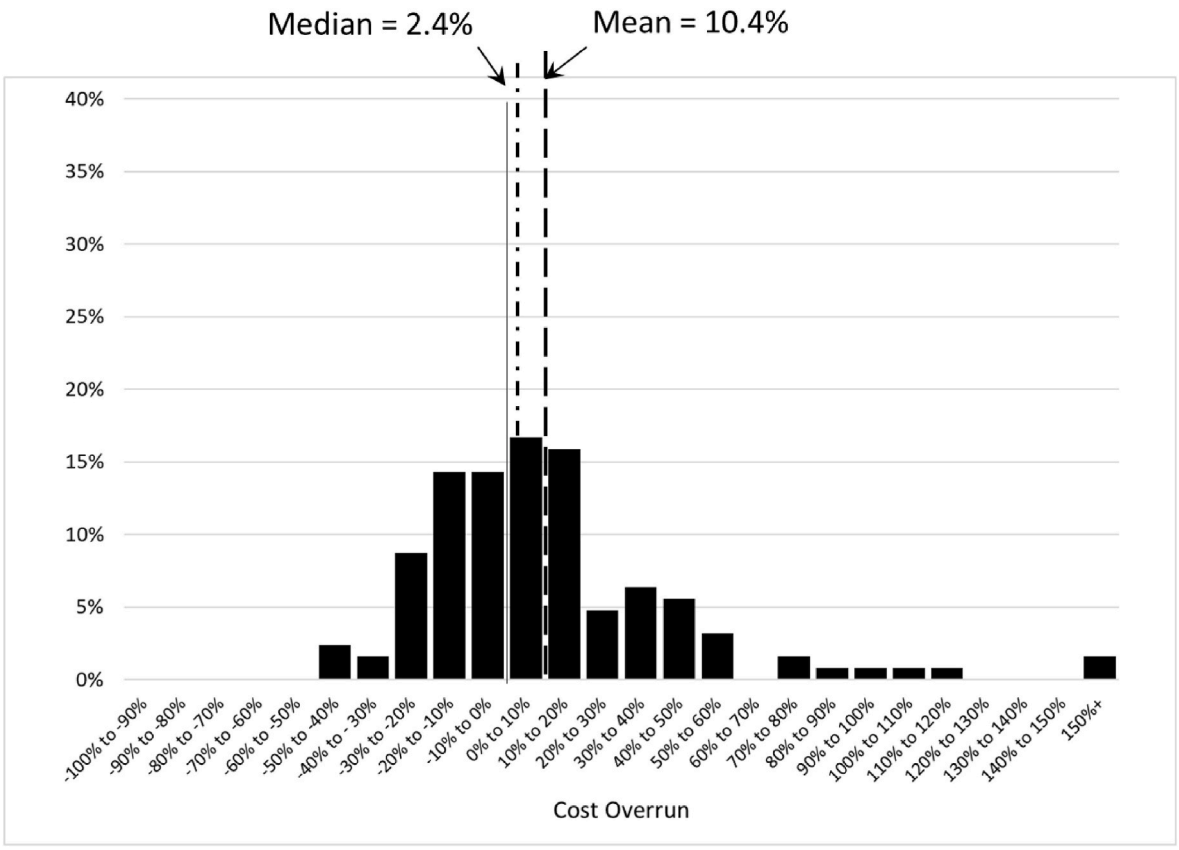

Fig. 7. Distribution of English road major schemes cost overrun 2001–2016 (n = 134).

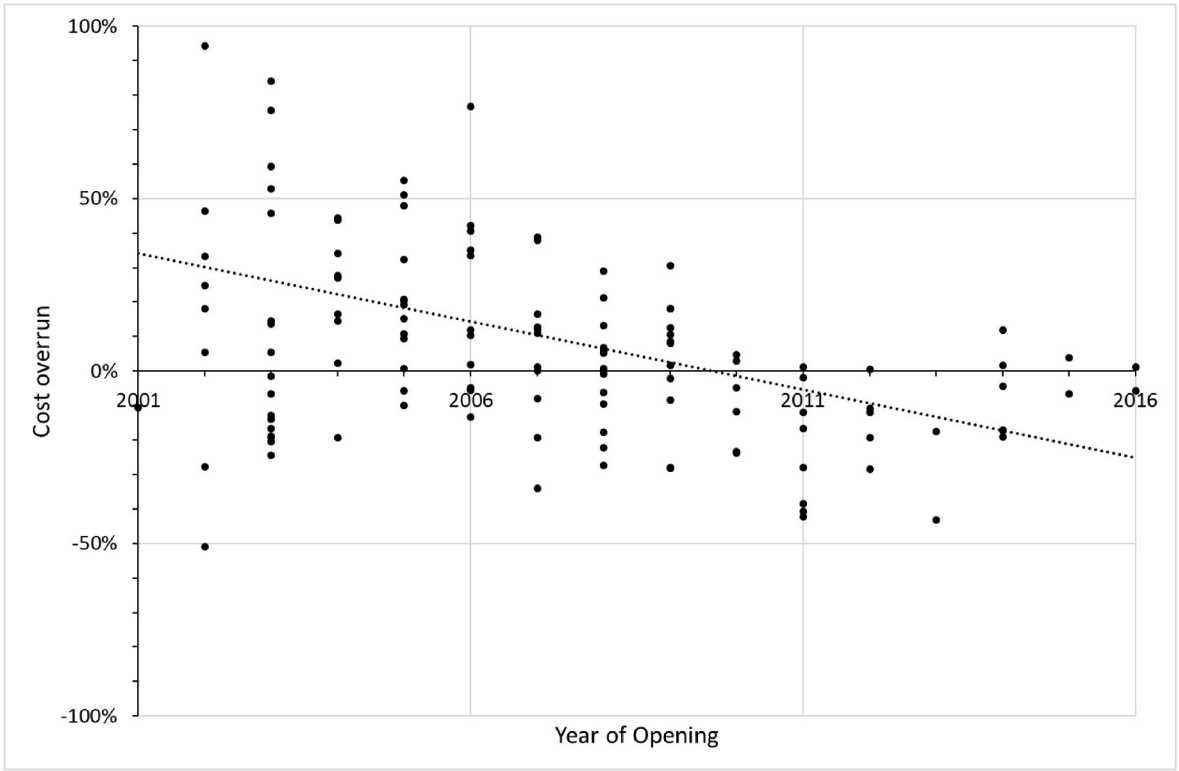

Fig. 8. English road project cost overrun 2001–2016, by year of scheme opening.

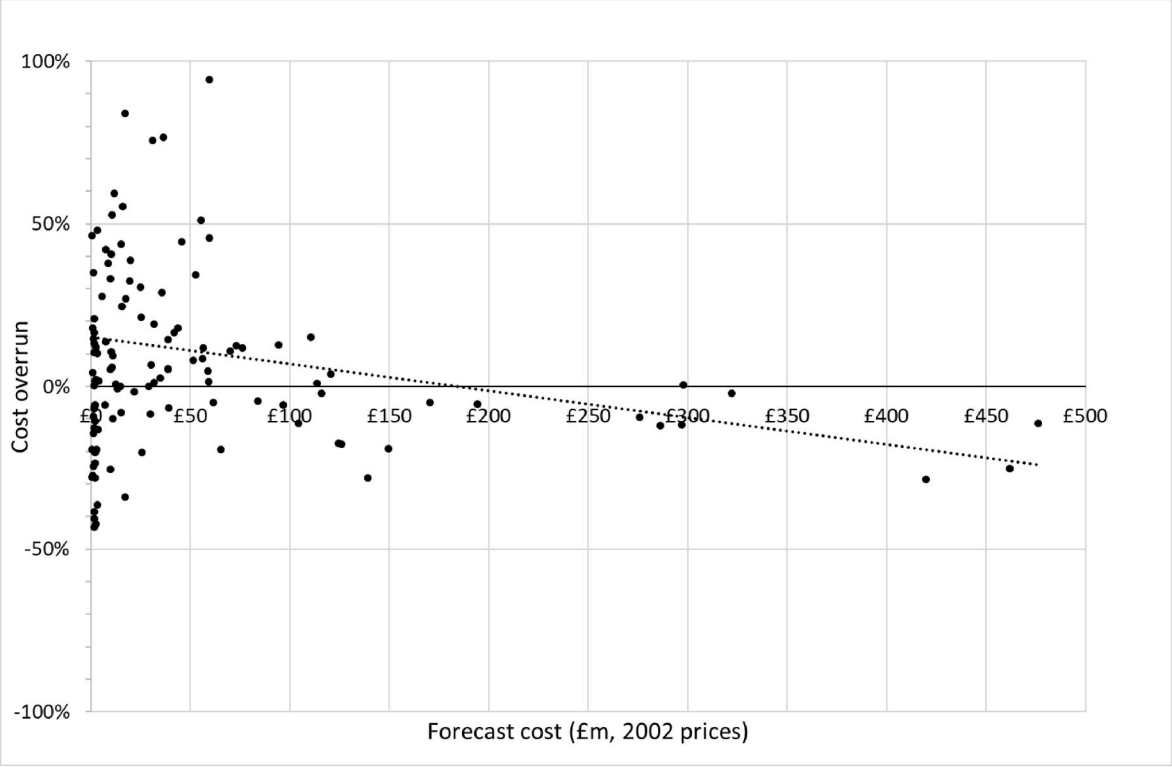

Fig. 9. English road projects cost overrun by forecast cost.

Table 10
English roads major scheme delivery performance.

Major schemes	Benefit Cost Ratio		Typical cost overrun	Projects delivered	
	Positive BCR (≥1)	High BCR (≥2)		on budget	on budget +10%
2001 to 2016	93%	70%	2.4%	42%	60%
2001 to 2008	96%	69%	11%	33%	47%
2009 to 2016	88%	68%	−6%	61%	88%

Table 11
Data on benefit cost ratio AND cost relative to budget.

		Benefit Cost Ratio		
		High (≥2)	Positive (1–2)	Negative (<1)
Cost	on or under budget	31%	6%	5%
	over budget	40%	16%	2%

Table 12
Data on benefit cost ratio AND cost relative to budget +10%.

		Benefit Cost Ratio		
		High (≥2)	Positive (1–2)	Negative (<1)
Cost	on or under budget +10%	43%	12%	5%
	over budget +10%	27%	11%	2%

to be jointly considered. Table 11 presents the results of this analysis (see Table 12).

It is a matter of perspective on the extent to which this combining of criteria informs conclusions on project success and project failure. Combining BCR and cost data shows that 37% of road projects are delivered on or under budget and achieve a positive BCR, which seems a safe bet to consider as being a project delivery success, which rises to 55% when assessed against their budget +10%. Some projects are delivered at a cost that exceeded their budget while still achieving a positive BCR and in a sizable proportion of cases the BCR was high. Adding economically productive projects with a BCR of one or more raises the proportion of projects viewed as successful to 93%.

The alternative perspective on employing this combination of project performance measures is that 63% - nearly two thirds - of the projects fail to achieve intended performance against at least one of these important criteria. Looking into this low level of performance, failure to deliver within budget is the main contributor. As noted previously, project cost overruns balance out against and are offset by cost underruns so at the population level delivery cost performance is not of undue concern so in this situation where it has been established that at a portfolio level there is not an issue of delivery against budget then including cost in the assessment of overall performance seems to miss the point and creates an issue that does not really exist.

7. Discussion

The findings show that project delivery performance of major road schemes in England is better than results generally reported in the literature and as widely understood. 93% of projects, the vast majority, were found to be economically profitable and were delivering benefits with a value greater than the cost of the project. It was also found that 70% were delivering high benefits, twice or more than the project cost, and that 25% of these major schemes were delivering benefits five times or more than the project cost. Typical cost overrun on these road projects is 2.4% with 42% of projects delivered on or below their cost budget. Analysis of the overall cost performance for the population overall identified the cost reductions of those projects delivered for less than their forecast budget exceeded the additional costs of those projects

delivered over budget. Analysis of delivery performance over time found that cost overrun reduced. An illustration of the extent of this reduction in cost overrun was that for the second half of the time series, the eight years from 2009 to 2016, there was a typical cost underrun of −6%.

When considering what causes project delivery performance Siemiatycki reports, "Even more difficult than obtaining reliable data on project costs has been obtaining much of the information that would be necessary to prove the causes of cost overruns on infrastructure projects" (Siemiatycki, 2009). Noting but undeterred by this sobering advice an attempt was made to diagnose the cause of improved performance. Inclement weather increases cost overrun of road infrastructure projects (Bordat et al., 2004) however UK annual precipitation relative to average (data source: World Bank) was broadly comparable in the two time periods so this explanation was discounted. Consideration was however given to whether there were discernible effects resulting from.

- Systematic error/bias in planning
- Changes to policy and practice

7.1. Evidence of systematic error/bias in planning

Evaluating the Benefit Cost Ratio of these major schemes shows the vast majority are economically effective, i.e. the value of benefits exceeds the cost of the project. In many cases the value of benefits far exceeded the cost of the project. This observation together with a typical cost overrun of 2.4% across the 16 years of the time series, with cost overrun reducing over time and the difference in the value of overruns and underruns netting out evenly, there is no evidence of systematic error or bias in the planning of English roads major schemes so this explanation was discounted.

7.2. Changes to policy and practice

Cantarelli, Molin, van Wee and Flyvbjerg, (Cantarelli et al., 2012) in a study of 78 Dutch large-scale transport infrastructure projects reject technical explanations, i.e. "imperfect forecasting techniques, inadequate data, honest mistakes, etc." as the main reason for forecasting errors on the basis that, "If imperfect techniques were main explanations of the underestimations, an improvement in forecasting accuracy over time would be expected, since errors and their sources would be recognised and addressed through the refinement of data collection, forecasting methods, etc, but accuracy has not improved over time." This later point echoing Flyvbjerg, Skamris Holm and Buhl's (Flyvbjerg et al., 2003) point from a decade earlier, "that cost performance has not improved over time. Cost escalation today is in the same order of magnitude as it was 10, 30 or 70 years ago".

In a contemporaneous work, Cantarelli and Flyvbjerg together with Buhl (Cantarelli et al., 2012) report findings from a study of project cost performance on possibly the same 78 Dutch transport infrastructure projects where, "The study showed with statistical significance … that geographical location matters for project performance" noting that geographical location relates to characteristics like, "the decision-making style, the system of governance, and the culture". Odeck (2004) reports that effort exerted in, "proper management" of projects in the Norwegian roads sector resulted in lowering cost overrun and Welde and Odeck (2017) in their further investigation of cost overrun in Norwegian road projects identify front-end management and the role of project ownership as important influences on cost overruns of road projects. They also advocate for increased use of benefit–cost analysis to prioritize projects for investment and implementation and as an incentive for avoiding cost escalation, and also for increased use of ex-post evaluation studies to shed light on issues needing further attention. Such studies require accurate assessment of project performance data where, "little progress can be expected in the state of our knowledge of projects without systematic and very detailed data collection … Otherwise the results are not meaningful." (Merrow and Yarossi, 1990 pgH.6.2). The systematic and detailed data collection Merrow and Yarossi advocate requires financial data to be expressed in real terms (Johnson, 2015, pg28) where the choice of inflation index used to adjust nominal values is known to have a, "substantive effect on the outcome of ex-post cost evaluation" of transport infrastructure projects and is a key factor in cost estimation accuracy and managing cost escalation risk (Chapman, 2021).

Drawing together these perspectives, taking Cantarelli, Molin, van Wee and Flyvbjerg's (2012) point that, "If imperfect techniques were main explanations of the underestimations, an improvement in forecasting accuracy over time would be expected" the improvement observable over time in outturn cost performance of English road major schemes lends credence to viewing this as resulting from improvement through changes to policy and practice such as: decision-making style, the system of governance, and the culture noted by Cantarelli et al. (2012); to "proper management" (Odeck, 2004); practices including front-end management, a fuller role of project ownership, increased use of benefit–cost analysis, and ex-post evaluation studies to shed light on issues needing further attention (Welde and Odeck, 2017). Winch and Leiringer (2016) propose a further feature of project owners, one presumably key to improvement over time, which is increasing maturity through acquiring capability. In summary, aspects of policy and practice identified as affecting project delivery performance include.

- Improved cost estimation and manage cost escalation risk through better choice of inflation index (Chapman, 2021)
- Decision-making style, the system of governance, and the culture (Cantarelli et al., 2012)
- Front-end management and the role of project ownership (Welde and Odeck, 2017)
- Project owners increasing maturity through acquiring capability (Winch and Leiringer, 2016).
- Use of ex-post evaluation studies to shed light on issues needing further attention (Welde and Odeck, 2017)

7.2.1. Economic and political turbulence (and lack of)

Any 16 year period, not just 2001–2016, will inevitably feature social, economic and political changes that have the potential to affect project outcomes. For example, in 2001–2002 the UK experienced an outbreak of Foot and Mouth Disease and control measures were imposed to restrict access to rural areas. In 2007–2009 the global financial crisis led to an economic crisis and a prolonged recession that affected most economies worldwide and had a particularly sharp negative effect on residential construction. The UK government responded with a package of financial stimulus, including accelerating £400 m of investment into major road schemes to bring forward planned spending for 2010–11 to 2008–9 and 2009–10 as well as quantitative easing, which increased liquidity in the economy and lowered interest rates. Over this period the UK held four general elections: 2001 (Labour); 2005 (Labour); 2010 (Conservative/Liberal Democrat coalition); 2015 (Conservative). While turbulence proves newsworthy and memorable, stability is rather ignored and goes largely unreported, as are its effects. For example UK inflation (CPIH) Q1 2001 - Q1 2008 ranged between 1.3% and 2.8% which is remarkably flat for an extended period. The 2010–2015 coalition government in the UK is notable for its stable administration with what turned out to be unprecedentedly low turnover in Ministers. These events, and lack of, will have presented various headwinds and tailwinds to the highways sector in general and to delivery plans of the Highways Agency (as was). Whether their effects on delivery performance proved material is difficult to assess.

7.2.2. Changes to policy and practice in the English highways sector

Looking to England's highways ecosystem, delivery of schemes is undertaken by corporate contractors operating in a competitive private

sector marketplace. There is an active professional community where professional bodies include the Chartered Institute of Highways and Transportation, the Institution of Civil Engineers and the Association for Project Management, the Chartered body for the project profession. Though unlikely to be detrimental, it is difficult to identify specific changes that directly led to improvements observed in the performance of England's road projects.

7.2.3. Changes to policy and practice in UK government

During the period considered in this study the UK public sector sought to develop project delivery policy, practice and capability, for example establishing the Office of Government Commerce in 2000, the activities of which were bolstered with a mandate from the Prime Minister and transferred to the Major Projects Authority in 2011 and subsequently further reinforced and developed to form the Infrastructure and Projects Authority in 2013. Across these incarnations there was consistency in pursuing the broad mission of developing a center of excellence and seeking to improve performance by acquiring capability through professionalizing project delivery within the public sector with career paths and promoting professional development as well as developing and implementing technical and professional standards and guidance. Efforts to develop public sector capability were undertaken more broadly, including at HM Treasury, the UK government's economic and finance ministry which maintains control over public spending. The Treasury's 'Green Book' sets out guidance on how project proposals should be appraised before significant public funds are committed. The 2003 update of The Green Book placed, "a stronger emphasis on the identification, management and realisation of benefits" (HM Treasury, 2003) and together with the 2004 revision of The Orange Book, Management of Risk guidance sought to improve corporate governance and ability to deliver (HM Treasury, 2004). Similar to inferred changes in the highways sector, these changes to policy and practice in the UK Government are unlikely to have a negative effect on road scheme performance but the case for them being directly responsible for the improvement observed in English road project cost performance seems weak.

7.2.4. Changes to policy and practice at Highways Agency/National Highways

Evidence of the state of policy and practice directly relating to investment in roads exists in the contemporaneous 2007 enquiry of the Public Accounts Committee, PAC, on 'Estimating and monitoring the costs of building roads in England' (Public Accounts Committee, 2007) and accompanying investigation by the National Audit Office, NAO (National Audit Office, 2007) and also a 'Review of Highways Agency's Major Roads Programme' (Nichols, 2007) commissioned by the Transport Secretary. Each report address the issue of scheme costs exceeding estimates with the PAC attributing 45% of variation in cost to inflation in the cost of construction work along with poor oversight in the Department of Transport and the Highways Agency of the delivery of major road schemes, lack of data on performance and failure to aggregate data to identify the main trends or reasons for cost overruns and the lack of project management expertise and inhouse capability to be an intelligent customer. Nichols also attributed about half of cost increases to inflation, and identified issues with risk management practices, methods of procurement and delivery capability. In doing so these findings on the deficiencies found in the Department of Transport and the Highways Agency offer considerable overlap with those characteristics that are identified in the literature, discussed above. The NAO report documents work undertaken in 2005–7 to address these issues by the Department of Transport and the Highways Agency with the aim to improve monitoring and control of costs. This work is summarized in Table 13 where it is classified against the issues identified in the PAC enquiry and Nichols Report, and the policies and practices that affect project delivery performance identified in the literature.

The work undertaken by the Department for Transport and the Highways Agency that aimed to improve its policies and practices appear to align with and address those issues identified by the Public Accounts Committee and by Nichols as being the principal cause of road scheme cost overrun, and are consistent with policies and practices identified in the literature as affecting transport infrastructure project delivery performance. Progress on implementing changes to policy and practice is reported in the Highways Agency Annual Reports and Accounts. While they are statutory documents these reports are examples of 'second line of defence' assurance at best and lack the authority of a 'third line of defence' assessment of practice and performance by independent experts (Davies and Zhivitskaya, 2018; Hone et al., 2011). In 2008 the Highways Agency's Chief Executive stated, "The speed of implementing the recommendations of Nichols and the National Audit Office on control of our major projects through the introduction of our

Table 13
Summary of policies and practices, issues identified and areas of work undertaken that relate to road scheme cost performance.

Policies and practices that effect project delivery cost performance Source: Literature	Issues identified that cause road scheme cost overruns Sources: Public Accounts Committee, 2007; Nichols (2007)	Areas of work implemented to improve monitoring and control of costs Source: National Audit Office, 2007
• Effect of inflation on transport scheme cost (Chapman, 2021)	• Inflation in construction costs (PAC) • Inflation (Nichols)	• Improved estimation of road scheme costs: Introduced revised inflation assumptions; Issued guidance on need to use an inflation rate appropriate to the scheme.
• Front-end management and the role of project ownership (Welde and Odeck, 2017) • Decision-making style, the system of governance, and the culture (Cantarelli et al., 2012)	• Poor oversight of the delivery of major road schemes (PAC)	• Strengthened appraisal and approval of schemes: Revised approval process; More comprehensive business case development; Larger schemes require independent review; Appraisal includes assessment of quality of project management capability; Requests to approve cost increase require reappraisal of scheme and reassessment of value for money.
• Project owners increasing maturity through acquiring capability. (Winch and Leiringer, 2016)	• Lack of in-house capability to be an intelligent customer (PAC) • Methods of procurement (Nichols)	• Developing procurement strategy: Move away from traditional contracting methods; Introduced early contractor involvement; Improved contracting arrangements.
• Project owners increasing maturity through acquiring capability. (Winch and Leiringer, 2016)	• Lack of project management expertise (PAC) • Delivery capability (Nichols) • Risk management practices (Nichols)	• Improving programme management: Set up and resourced a Center of Excellence for Programme and Project Management; Peer review; Sharing good practice.
• Use of ex-post evaluation studies to shed light on issues needing further attention (Welde and Odeck, 2017)	• Lack of data on performance and failure to aggregate data to identify the main trends or reasons for cost overruns (PAC)	• Evaluation of lessons learned from road schemes: New procedures to identify lessons on project management; Each common issue assigned an owner to tackle problem.

Projects Control Framework has been exemplary, and we look forward to making progress with our capital build programme" (Highways Agency, 2008, pg4). The 2011–12 annual report describes implementation of further changes to policy and practice to improve efficiency and reduce scheme costs and to prioritize the allocation of resources to schemes based on their intended benefits (Highways Agency, 2012, pg16). The 2013–14 annual report describes efforts to build capability in areas including contract performance and project and programme performance (Highways Agency, 2014, pg35).

7.2.5. Effect of changes to policy and practice on cost performance

Reviewing cost performance shown in Fig. 8, cost overrun is common up to and including 2009 then in 2010 and subsequent years more projects are completed under cost than over cost. If there is a causal relationship between the policies and practices reported as being implemented during 2006–7 and possibly subsequently sustained, then the effect appears to take three to five years to be observable in outturn performance. This is not an insignificant time lag so raises a question over whether it is the effect of these actions that resulted in the change in outturn performance. To consider this point, a review was made of the time taken to progress major schemes through the project control framework phases of options, development and construction (Highways England, 2018), especially the latter two phases which is where the policies and practices being introduced are implemented. Project evaluations provide some indication of the history of schemes however time taken to progress through phases is not systematically nor comprehensively documented. Indicatively, the options phase takes two years or so to identify the preferred solution for a scheme and the development phase can last one to three years to take the solution through statutory process up to the point of a decision to commit to investment. 110 schemes had useable data on the construction start and scheme opening dates, allowing the construction phase duration to be measured. The median duration of construction was 22 months, approximately two years, with a range between two months and six and a half years. This suggests that the effect of actions taken to change policy and practices are likely to take two to ten years to be observable in the performance of completed projects, which is consistent with findings on changes to cost performance.

To narrow the potential lag between performance outcomes resulting from changes to policy and practice data on cost overrun was recast against date of construction start, rather than against opening date. Start of construction dates were available for 116 projects, 87% of the population, and this analysis is shown in Fig. 10.

Separating the projects into those started in 2007 and earlier from those started in 2008 and later allows the effect on cost performance of changes to policy and practice to be examined, as shown in Table 14.

An eyeball assessment of Fig. 10 suggests cost overrun differs between projects with construction starting in 2007 and earlier from those projects where construction started in 2008 and later (see Table 15). The data shown in Table 14 provides a more illuminating account of this difference where typical cost performance changes from an overrun of 11.5% to an underrun of −6.0%. One of the more vivid changes is in the proportion of projects that are delivered on or under budget which changes from 28% to 74%. This difference in performance before and after changes were made to policy and practice is revealed when plotting

Table 14
English road project cost performance of projects where construction started in 2007 and earlier and in 2008 and later.

		Project construction start date	
		2007 and earlier	2008 and later
Cost overrun	sample size:	78	38
	Maximum:	178%	12%
	75th percentile:	32%	0%
	Median:	11.5%	−6.0%
	25th percentile:	0%	−19%
	Minimum:	−51%	−43%
projects delivered on or under budget		28%	74%
projects delivered on or under budget +10%		46%	95%

Fig. 10. English road project cost overrun of projects opening during 2001–2016, by year of construction start.

Table 15
Difference cost overrun between projects with construction start in 2007 or earlier, and 2008 or later.

	2007 or earlier		2008 or later					
	M	SD	M	SD	df	t	P	Cohen's d
Cost overrun	0.182	0.334	−0.107	0.153	114	6.38	<0.001	0.997

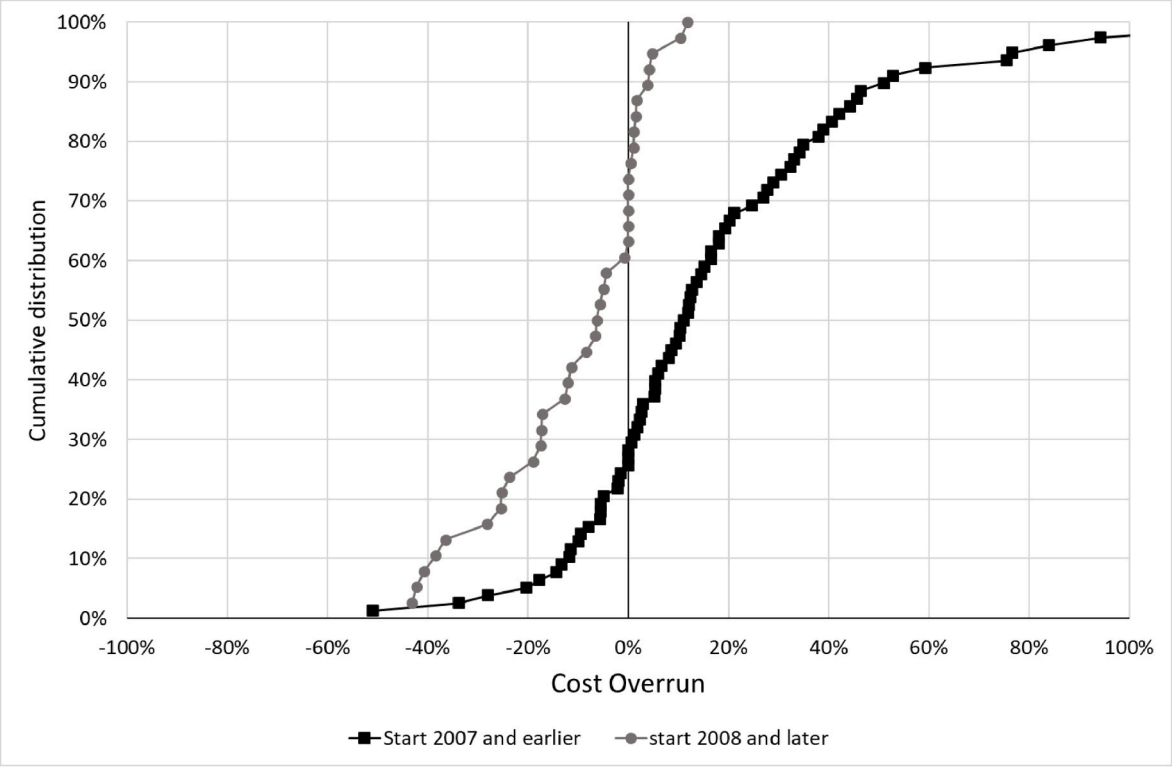

Fig. 11. Cost overrun of projects started in (i) 2007 and earlier and (ii) 2008 and later.

the cumulative distribution of cost overrun for the two time periods, as shown in Fig. 11.

A final analysis of delivery cost performance of projects started in the two time periods is to test whether there is a statistically significant difference using an independent *t*-test. The null hypothesis is that the means of the two populations are the same. Output data from undertaking an independent *t*-test in SPSS is reported. Levene's test for equality of variances returns a significance of 0.01, which is less than the alpha level of 0.05 so equal variances are not assumed.

The result of the independent *t*-test were significant, t (113) = 6.36, $p < 0.001$, d = 0.997, indicating there is a statistically significant difference between mean overrun of projects started in or before 2007 (M = 0.182, SD = 0.334, n = 78) and the mean overrun of projects started in 2008 and later (M = −0.107, SD = 0.153, n = 38). The effect size, Cohen's d, was 0.997 which represents a large effect. The null hypothesis that the means of the two populations are the same was rejected.

The conclusions drawn from this analysis of delivery cost performance of English road schemes are.

- Delivery cost performance of projects where construction started in 2007 or earlier is statistically different to the cost delivery performance of projects where construction started in 2008 or later.
- Cost overrun reduced over time and projects that started construction after 2007 typically experienced cost underruns.
- Improvement to cost performance appears to result from changes to project delivery policy and practice.

7.2.6. Effect of changes to policy and practice on benefits performance

The median BCR of the 131 projects completed in 2001–2016 with benefits data was 2.9. High BCR figures of two and above were achieved by 69% of projects and 93% of projects achieved a positive BCR of 1 or more. To examine the effect of the 2007 changes to policy and practice on BCR outcomes available data was recast to separate projects where construction was started in 2007 and earlier from projects where construction was started in 2008 and later. This data was available for 107 projects, 82% of the total, and an analysis of BCR data for the two time periods is shown in Table 16.

The cumulative distribution of the outcome BCR for projects where construction started in these two time periods is shown in Fig. 12.

The data shows that median BCR increased in the later time period,

Table 16
Outcome BCR data for projects with a construction start date of (i) 2007 or earlier and (ii) 2008 and later.

		Project construction start date	
		2007 and earlier	2008 and later
Benefit Cost Ratio	sample size:	79	28
	Maximum:	44.6	52.5
	75th percentile:	4.1	8.8
	Median:	2.8	3.6
	25th percentile:	1.8	1.9
	Minimum:	−1.0	−7.0
Projects with positive BCR≥1		95%	82%
Projects with high BCR≥2		67%	71%

Table 17
Difference in BCR between projects with construction start in 2007 or earlier, and 2008 or later.

	2007 or earlier		2008 or later					
	M	SD	M	SD	df	t	P	Cohen's d
BCR	4.3	6.8	7.4	11.4	34	−1.32	0.197	−0.366

and that the distribution range of outcomes increased with a higher proportion of projects having a negative BCR, 18% against the previous 5%, and also a higher proportion of projects having a high BCR, 71% against the previous 67%.

The result of the independent *t*-test was not significant, t (34) = −1.32, p = 0.197, d = −0.366, indicating there is not a statistically significant difference between the mean BCR of projects started in or before 2007 (M = 4.3, SD = 6.8, n = 79) and the mean BCR of projects started in 2008 and later (M = 7.3, SD = 11.4, n = 28). The effect size, Cohen's d, was −0.366 which represents a small effect. The null hypothesis that the means of the two populations are the same was not rejected.

The conclusions drawn from this analysis of benefit cost ratio performance of English road schemes are.

- Outturn BCR performance of projects that started construction either (i) 2007 or earlier, or (ii) 2008 or later were different however this difference is not statistically significant.
- Changes to policy and practice implemented around 2007 did not have a significant effect on BCR outcomes.

7.3. Implications for researchers

A common premise that serves as a foundation for many studies into project delivery is that delivery performance is poor, and this poor performance is prevalent and persistent. The findings reported in this study do not support that narrative. It may be that the setting for this research is atypical, perhaps as a result of the criteria employed in its selection, where the capability of the organisation and availability of public information are factors that coincide with those factors that foster better deliver outcomes. An independent study is warranted to check the validity of the data and analysis undertaken in this study, and to further investigate and assess the merits of alternative explanations for the delivery performance observed.

There would also appear to be merit in employing the approach used here to investigate performance of road projects delivered in other setting and also the delivery of other types of transport infrastructure or indeed to entirely different types of project to establish whether the findings from this study exist elsewhere, perhaps even being widespread, or if the delivery performance of road schemes in England is an anomaly. A curiosity that may motivate such studies is that finding one setting with projects typically delivered to budget and achieving productive outcomes exposes a thread that appears worth pulling to see what unravels. Evidence from such studies will be useful in testing the merits of general explanations of project performance such as those anchored in behavioural decision making and agency dynamics such as optimism bias and strategic misrepresentation, as well as those explanations that take a more technical view of the causes of project delivery success and failure.

7.4. Implications for practitioners

The project delivery performance identified at National Highways serves as an example that may give heart to practitioners that organisations can buck the apparent trend of projects being persistently poorly delivered. With policy and practices shown to affect outcomes practitioners are advised to access and review the readily available resources that set out the practices used by National Highways to plan and deliver projects. Organisations that shape and operate the system of governance in the UK public sector including the Infrastructure and Projects Authority and HM Treasury also publish guidance on their policies and practices and openly discuss the role and culture of the project delivery

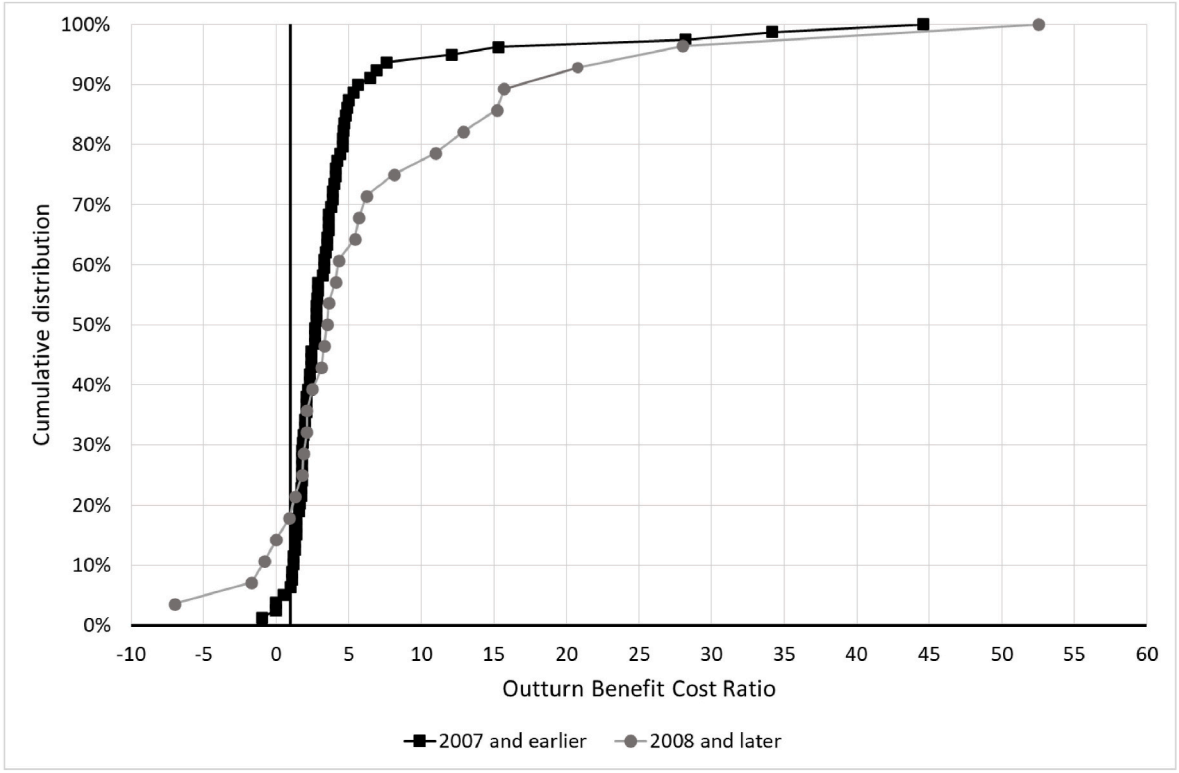

Fig. 12. Cumulative distributions of outcome BCR for projects where construction started in (i) 2007 or earlier and (ii) 2008 and later.

profession in a number of fora.

While project delivery performance was found to be positive overall, this study also documented that some projects go over budget, for example 25% of projects experienced a cost overrun of 20% or higher. Some projects were also found to destroy value, where the value of the benefits was less than the cost of the project. This means that practitioners should recognize that success is not guaranteed and there remains a need to mitigate risks through mechanisms such as engaging project professionals and employing professional practices.

Media, watchdogs of public spending and academics have legitimate reasons for drawing attention to these failures and to ask hard questions of those responsible. The debate would be better informed if outcomes of specific projects were set in context by considering them relative to overall performance and trends, and it may be this work can contribute in that regard. The temptation needs to be avoided to extrapolate from specific, high-profile examples to make general claims along the lines of, "that project failed, which means they all do". As this research demonstrates, some projects perform badly but most do not.

8. Conclusion

This study assembled publicly available information published by National Highways, the public sector company responsible for England's strategic road network, on the delivery of the 138 road/highway major schemes completed over 16 years between 2001 and 2016. This information was sourced from evaluations of these schemes conducted one or five years after their completion, which contained data on outturn results against ex-ante estimates on benefits and capital costs.

Most projects were found to be economically productive with 93% of projects achieving a positive BCR of one or more and 69% of projects achieved a high BCR of two or more. Projects were typically delivered in line with their budget, and at a population level cost underruns balanced out cost overruns. Over this time there was a statistically significant reduction in cost overrun to the extent that for the second half of the time series projects were typically delivered with a −6% cost underrun.

These findings do not support the common view that most projects 'fail'. In doing so these results challenge the theories that projects are afflicted by malignant agency dynamics and inherent bias in decision making that result in unachievable business cases and subsequently to project delivery failure through cost overrun and unachieved benefits. In contrast, the findings from this study show that projects can be successfully delivered in line with their budgets and achieve economically productive benefits. The most likely explanation for this outcome and for improved performance over time is that this resulted from the adoption of more effective policies and practices.

This work provides a 'use case' of an approach to assembling project delivery performance data in a transparent manner that lends confidence to the findings. This approach can be adapted and followed to study other project populations with publicly available data to investigate project delivery performance in a similar manner. Doing so opens the potential to benchmark practices and performance of organisations against those observed at National Highways, and for action researchers and practitioners to assess the effect that changes to policies and practices have on outcomes.

Funding

This research received grant funding from the Saïd Business School, University of Oxford 'Faculty Research Fund'. The funding source had no involvement in the conduct of this research or preparation of this article. No further funding was received.

CRediT authorship contribution statement

Paul Chapman: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix 1. English Road Schemes included in this study

A1 Coal House to Metro Center improvements.
A1 Denton Interchange.
A1 Dishforth to Leeming
A1 Durham climbing lanes.
A1 Peterborough – Blyth Grade Separated Junctions.
A1 Rainton Crossroads.
A1 Stannington Grade Separated Junction.
A1 Willowburn to Denwick Improvements.
A1(M) Bramham to Wetherby.
A1(M) Ferrybridge to Hook Moor Improvement.
A1(M) Wetherby – Walshford
A1(M)/M18 Wadworth Interchange.
A2 Bean – Cobham (Phase 1).
A2 Bean – Cobham (Phase 2).
A2 Kingston Bridleway Bridge.
A2/A282 Dartford Improvement.
A3 Hindhead
A5 Bayleys Roundabout.
A5 Dunstable Queue Relocation Scheme.
A5 Nesscliffe Bypass.
A5 Weeford - Fazeley Improvements.
A6 Alvaston
A6 Clapham Bypass.
A6 Great Glen Bypass.
A6 Rothwell-Desborough Bypass.
A6 Rushden – Higham Ferrers Bypass.
A10 Wadesmill, High Cross and Colliers End Bypass.
A11 Attleborough Bypass Improvements.
A11 Fiveways to Thetford.
A11 Roudham Heath to Attleborough Improvements.
A12 Hatfield Peverel POPE of LNMS.
A12 Stanway to Spring Lane Interchange.
A14 Brampton Hut Interchange – New Traffic Signals.
A14 Girton to Fen Ditton Safety Cameras.
A14 Haughley New Street to Stowmarket Improvement.
A14 Huntingdon to Cambridge Safety Cameras.
A14 Jane Coston Bridge.
A14 Junctions 7–9 Kettering Bypass Improvement.
A14 Rookery Crossroads.
A14 Spittals Interchange – Provision of Traffic Signals.
A19 Black Swan Bridge.
A21 Johns Cross Junction Improvement.
A21 Lamberhurst Bypass.
A23 Handcross to Warninglid
A27 Polegate Bypass.
A27 Southerham – Beddingham Improvement.
A30 Bodmin to Indian Queens Improvement.
A30 Chiverton Cross Roundabout Improvement.
A30 Whiddon Down Junction Improvement (formerly Merrymeet roundabout).
A34/M4 J13 Improvement.

A35 Stinsford Roundabout.
A35 Weymouth Road Roundabout.
A38 Dobwalls Bypass.
A41 Aston Clinton Bypass.
A43 Improvements (Silverstone).
A45 Ryton-on Dunsmore Junction Improvement.
A45/A509 Wilby Way Junction Segregated Left Turn Lane.
A46 Newark – Lincoln.
A46 Newark to Widmerpool Improvement.
A46/A607 Junction Improvement Scheme.
A47 Honingham Roundabout.
A47 Thorney Bypass.
A47/A10 Hardwick Roundabout.
A55/A483 Junction Improvement Scheme-Segregated Left Turn from A483(N) to A55.
A63 Garrison Road Roundabout.
A63 Melton Grade Separated Junction.
A63 Selby Bypass.
A64 Colton Lane Grade Separated Junction.
A64 Hopgrove Roundabouts.
A64 Top Lane Copmanthorpe
A66 Carkin Moor to Scotch Corner Improvement.
A66 Greta Bridge to Stephen Bank Improvement.
A66 Long Newton Grade Separated Junction.
A66 Sadberge Grade Separated Junction.
A66 Stainburn and Great Clifton Bypass.
A66 Temple Sowerby Bypass & Improvements at Winderwath
A69 Haydon Bridge Bypass.
A120 Stansted to Braintree.
A249 Iwade to Queenborough Improvement.
A419 Blunsdon Bypass.
A419 Calcutt Access Roads.
A419 Commonhead Junction.
A421 Bedford to M1 junction 13.
A421 Great Barford Bypass.
A428 Caxton Common to Hardwick.
A453 Widening M1 J24 to A52.
A500 Basford, Hough, Shavington Bypass.
A500 City Rd & Stoke Rd Junction improvements.
A523 Leek to Hazel Grove Traffic Safety Measures.
A590 High and Low Newton Bypass.
A595 Parton to Lillyhall Improvement.
A596 Calva Brow.
A596 Northside.
A650 Bingley Relief Road.
A1033 Hedon Road Improvement.
A5117/A550 Deeside Park Junctions Improvement.
M1 J6a to 10 Widening.
M1 J10 to 13 smart motorway and junction improvements.
M1 J25 Safety Improvements.
M1 J25 to 28 Widening.
M1 J28 Capacity Improvement Scheme.
M1 J31-32.
M1 J34 North.
M1 J39 to 42 smart motorway.
M4 J18 Eastbound Diverge.
M4 J19 to 20 & M5 J15 to 17 smart motorway.
M4/M5 Almondsbury Interchange Phase 2 A M5 Southbound & Northbound to M4 Eastbound.
M5 Climbing Lanes Five Years After Study - HALLEN HILL.
M5 Climbing Lanes Five Years After Study - Naish Hill.
M5 Climbing Lanes Five Years After Study - Twickenham Hill.
M5 J12 Improvements.
M5 J31 – Main Line Lane Drop at Parallel Diverge (Capacity Improvement).
M6 J5 to 8 smart motorway.
M6 J8 to 10a smart motorway.
M6 J10a to 13 smart motorway.
M6 J32 Southbound Widening.
M6 J40 Modification.
M6 Carlisle to Guards Mill Improvement.
M11 J4 Northbound Slip Road Merge.
M20/M26 Street Lighting.
M25 J1b – 3 (& controlled motorway).
M25 J5 to 7 smart motorway.
M25 J12 - J15 Widening.
M25 J16-12 Widening.
M25 J16-17 Climbing Lane.
M25 J18-19 Climbing Lane.
M25 J23-27 Smart Motorway All Lane Running.
M25 J27-28 Climbing Lane Study (Site 4).
M25 J27-30 Widening (Section 4 - M11 to A13).
M25 J28 (A12 Brook Street) Improvements.
M27 J3-4 Widening.
M27 J11-12 Climbing Lanes.
M40 J4/A404 Handy Cross Junction Improvements.
M40 J15 (Longbridge) Bypass.
M60 J5-8.
M62 J6 Improvement.
M62 J25-30 Smart Motorway.
M62 J27 Westbound Entry.

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