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Cost overruns in Australian Transport Infrastructure Projects

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Abstract

Australian governments have spent unprecedented sums on new transport infrastructure over the past decade, exceeding 1 per cent of GDP since 2009.

Accurately forecasting the ex-ante costs of prospective transport infrastructure projects is central to identifying the most important additions to already mature transport networks. However, there is little evidence regarding whether Australian transport infrastructure projects perform as expected. Substantial international evidence points to the presence of cost overruns on transport infrastructure projects, and the limited existing Australian evidence is consistent with this.

We investigate the accuracy of cost estimates for major Australian transport infrastructure projects over the period 2001 to 2015, using two separate datasets containing information on transport projects with total expected costs exceeding $20 million. We investigate the sources of cost escalation as projects progress through the investment pipeline, whether cost overruns occur early in a project's life, and whether Australia's project appraisal processes effectively reappraises projects that experienced cost overruns.

We find evidence of systematic cost overruns on Australian transport infrastructure projects. The substantial variation in the magnitude of cost overruns incurred across projects indicates that cost overruns on Australian transport infrastructure projects are distorting project selection, as well as decisions regarding how much to invest. We also find no evidence that Australia's project appraisal processes effectively reappraise projects that experience cost overruns before contracts are signed.

Examining characteristics of the appraisal process in detail, we find evidence that poor adherence to project appraisal processes is associated with a greater probability of cost overruns, and cost overruns of a greater magnitude in a number of ways. First, we observe that cost overruns are 23 per cent higher on average across projects that received a funding commitment during an election campaign, and projects contracted during or after the Global Financial Crisis are 21 per cent less likely to experience a cost overrun. Second, projects that are not approved or abandoned quickly are more prone to cost overruns. Third, projects in some Australian jurisdictions are more likely to experience cost overruns, such as New South Wales, than in either Victoria or Queensland.

These results suggest there is significant scope to improve Australia's project appraisal processes. Although a comprehensive assessment of reforms to Australian project appraisal processes is beyond the scope of this paper, we identify some priorities for further research.

1. Introduction

Australian Governments' expenditure on transport infrastructure over the last decade has been unprecedented, exceeding 1 per cent of GDP each year since 2009 (Terrill et al., 2016). In this context, the reliability of the process used to identify the most important additions to already mature transport networks is critical. However, international evidence on cost overruns on transport infrastructure projects suggests that the costs employed in project appraisal processes are systematically over optimistic (Flyvbjerg et al., 2004). The limited available evidence on Australian projects also points to cost overruns in project appraisals (Evans and Peck, 2011).

This paper makes a unique contribution to the cost overruns literature by investigating the prevalence and size of cost overruns across a large sample of Australian transport infrastructure projects over the period 2001 to 2015. The paper uses two separate datasets containing information on transport projects with total expected costs exceeding $20 million. First, we investigate the evolution of project cost estimates through the project cycle using data captured in the Deloitte-Access Investment Monitor, which includes a sample of some 542 road and rail projects that were completed over that period, and a further 294 that were not completed. We corroborate this analysis against the Grattan Transport Infrastructure dataset – a far more detailed, but much smaller, dataset of Australian transport infrastructure projects which has been constructed for this purpose.

We investigate the prevalence of cost overruns for Australian transport infrastructure projects and estimate their size. We also investigate the sources of cost escalation as projects progress through the investment pipeline, whether cost overruns occur early in a project's life, and whether Australia's project appraisal processes effectively reappraises projects that experienced cost overruns. Finally, we investigate whether indicators of poor adherence to project appraisal processes are associated with a greater probability of cost overruns, or cost overruns of greater magnitude. To the extent that this is so, we argue that there is scope to improve our project appraisal processes.

2. Literature review

The high prevalence, large magnitudes and remarkable persistence of cost overruns on transport infrastructure projects have motivated extensive research into cost overruns by academics and government bodies alike. In this section, we evaluate the evidence the average magnitude, causes and timing of cost overruns, both abroad and in Australia.

2.1. The magnitude of cost overruns internationally

Internationally, substantial research has been conducted into cost overruns, reaching as far back as Merewitz's 1973 study of cost overruns incurred in 66 American road and rail projects (Merewitz, 1973). Of this literature, the conclusions of Flyvbjerg, Holm and Bulh's 2016 paper, along with previous analysis by these authors on increasingly large subsamples of this dataset, are the most widely cited benchmark estimates of the magnitude of cost overruns on transport infrastructure projects internationally (Flyvbjerg, 2016b).

The analysis by Flyvbjerg et al is unique because their dataset, which contains 1603 road and rail projects (within a broader sample of 2062 infrastructure megaprojects) valued between US$1.5 million and US$8.5 billion that were completed between 1927 and 2013 across 20 countries, is far larger and more internationally representative than any other study. The authors find that road and rail projects finished, on average, 24 per cent and 40 per cent over budget, respectively (Flyvbjerg, 2016b).

However, these findings are not necessarily generalizable to Australia because the prevalence and magnitude of cost overruns are sensitive to institutional factors. The clearest demonstration of institutional relativism is Cantarelli et al's 2012 analysis of Dutch transport infrastructure projects. Cantarelli et al expanded upon the Dutch subset of Flybjerg et al's dataset and employed the same methodology as Flyvbjerg et al, yet arrived at a notably lower average cost overrun estimate of 16.5 per cent.

In fact, the difference between the international average rate of cost overruns estimated by Flybvjerg et al and the low rates reported in some single-country studies is substantial. Sweden and Canada appear to be the best performing countries: SIKA (2002, in (Jenpanitsub, 2011)) find cost overruns of just 5.5 per cent for Swedish road projects; and Berechman and Wu (2006) observe cost overruns of 5 per cent and 14 per cent for Canadian road and rail projects respectively ((Berechman and Wu, 2006).

These international findings have significant implications for Australian research into cost overruns. Firstly, while Flyvbjerg's findings have established an expectation that Australia is likely also experiencing high rates of cost overruns, cost overrun estimates need to be based on local data in order to be locally relevant. Secondly, the variation in the magnitude of cost overruns observed across countries suggests that cost overruns are largely preventable, as they are a consequence, in part, of institutional environments.

2.2. The magnitude of cost overruns in Australia

Evidence of cost overruns on Australian transport infrastructure projects is limited but growing. The earliest assessments of cost overruns on Australian transport infrastructure projects are those of Duffield et al's 2007 and 2008 studies Australian transport and non-transport infrastructure projects valued at over $20 million (Duffield et al., 2008, Duffield, 2007). The authors found cost overruns ranging from 24 to 52 per cent and 12 to 35 per cent, depending on the projects' procurement methodologies, but did not separately report separate cost overrun estimates for transport infrastructure projects.

In an attempt to address the lack of Australian data, a number of survey-based studies have been undertaken. Most notably, Wood observed an average cost overrun across 46 transport infrastructure projects of between 5 and 10.5 per cent (Wood, 2010). Love observed an average cost overrun of 12 per cent for 58 road and rail projects (Love, 2012).

The policy challenge highlighted by these and like early results has motivated a number of government audit bodies to undertake empirical studies of cost overruns in recent years. For example, the Victorian Auditor General observed a 5 per cent cost overrun for 7 road and rail projects valued at over $30 million and the New South Wales Auditor General reported a 6.7 per cent cost overrun across 50 transport and non-transport infrastructure projects valued above $50 million (Wood, 2010, Victorian Auditor General, 2010, Victorian Auditor General, 2011, NSW Auditor General, 2015))[1]. However, the sample sizes of empirical studies into Australian transport infrastructure projects remain limited.

2.3. The causes of cost overruns

Broadly speaking, there are three potential causes of systematic cost overruns for transport infrastructure projects: overly optimistic ex-ante cost estimates; poor project management and contracting practices that cause projects to be more expensive than they should be; and scope changes.

The academic literature on cost overruns has focused primarily on the psychological biases and strategic intentions that may motivate project proponents to advance overly optimistic initial cost estimates (van Wee, 2007) . Auditor-led studies have commonly emphasised the real costs of poor planning and risk management on observed outcomes (Seimiatycki, 2009, Love, 2011). Some studies outside the cost overruns literature dismiss cost overruns as less problematic than the literature suggests, under the assumption that most cost overruns are driven by scope changes and that such changes are not undesirable. These differences in

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[1] Reported averages from the Victorian Auditor General's reports are the arithmetic mean of the reported cost overruns in each study.

the hypothesised causes of cost overruns are important, as the implications and appropriate policy responses associated with cost overruns of each type are markedly different.

Cost overruns that are a result of overly optimistic ex-ante cost estimates are problematic because they distort policymakers' transport infrastructure investment decisions. Optimistic cost estimates affect choices over the appropriate amount to invest in transport infrastructure overall, and obstruct efforts to identify which projects promise the greatest benefits to citizens. Policymakers have sought to mitigate the impact of such optimism bias in project appraisals by requiring project proponents to inflate expected project costs by an appropriate margin during the project appraisal process (Infrastructure Australia, 2016). In an effort to make such adjustments commonplace, extensive research has been undertaken in recent years into reference class forecasting for transport infrastructure proposals (Flyvbjerg and COWI;, 2004).

Cost overruns that are a consequence of unnecessarily high actual costs are arguably even more problematic because they pose large avoidable costs, as well as distorting the planning process. To the extent that cost overruns are attributable to poor value-for-money final costs, we can do better than resigning ourselves to expectations large cost overruns. Avoidable cost overruns could be reduced by increasing the rigor of the project planning processes, increasing the competitiveness of the tender process used to award construction contracts, and ensuring that contracts are watertight and well managed.

The true costs posed by cost overruns which result from scope changes is unclear. Cost overruns that arise as a consequence of qualitative scope changes are comparable to overly optimistic ex-ante cost estimates, as the need for such quality in order to deliver the planned benefits should have been foreseen.

Cost overruns that arise as a consequence of substantive scope changes may not distort the project selection process to the same degree, as these changes may also increase the benefits a project delivers substantially. However, previous analysis of the same Grattan dataset employed in this study indicates that such substantive scope changes are a minor contributor to cost overruns on Australian infrastructure projects, appearing to explain only 11 per cent of cost overruns (Terrill and Danks, 2016).

2.4. The timing of cost overruns

The timing of when cost overruns occur also matters, for two reasons. Firstly, the hypothesised causes of cost overruns and the appropriate policy responses relate to specific stages of the investment pipeline. For example, specific hypotheses like poor management of construction risks correspond to a specific project stage. Secondly, the consequences of cost overruns depend on the timing of the cost overrun. Early cost overruns, for instance, can compound over time and affect the probability of later cost overruns, but occur at a time where investment decisions can still, in theory, be revised.

Despite its importance, the timing of cost overruns has received little attention in the cost overruns literature. The cost overruns literature has investigated the relationship between cost overruns and time in a historical sense, where it has largely concluded that the average magnitude of cost overruns over time not changed significantly (Flyvbjerg et al., 2004, Adams et al., 2014, Shrestha et al., 2013). There have also been a number of studies which have analysed the relationship between cost overruns and the length of the project planning process (Morris, 1990, Flyvbjerg et al., 2004, Odeck, 2004, Sambasivan and Soon, 2007), which have found that sluggish projects perform worse. However, the relationships between cost overruns over successive periods or between characteristics of the planning process and overruns at each stage are yet to have been interrogated.

One explanation for lack of attention on the timing of cost overruns is that data on the evolution of costs over the life a project is rarely available. Duffield et al's 2008 paper, which categorises cost overruns as being between: "original announcement", "budget approval", "contractual commitment" and the "actual final cost", is one of very few studies which has been able to disaggregate cost overruns by project stage to any degree. However, this study focused on the impact of contract types on cost outcomes rather than the dynamics of cost overruns. Given the paucity of such research, our investigation of how cost overruns evolve over projects' lives is a distinguishing characteristic of our analysis.

2.5. Our contribution

In this paper, we estimate the magnitude of cost overruns on Australian transport infrastructure projects, and interpret their implications with reference to the stage in a project's development when cost overruns occur. We complement these estimates with analysis of the effectiveness of the appraisal processes employed to assess Australian transport infrastructure projects, where we consider both the evidence that the process is successful and the evidence that it has further scope to improve.

To the best of our knowledge, our investigations into the timing of cost overruns and the effectiveness of Australia's project appraisal processes are unique. Furthermore, our estimates of the magnitude of cost overruns in Australia are also more robust that has previously been possible, as the primary dataset we consider is nine times larger than those employed in previous Australian studies. Both of these contributions are facilitated by uniquely rich data sources.

3. Data sources

This paper employs two unique datasets on Australian transport infrastructure projects. The majority of our findings are based upon a near-comprehensive record of Australia's planned and actual transport infrastructure investment that Grattan Institute has constructed from the archived releases of the Deloitte Access Economics Investment Monitor (the Investment Monitor). We complement the analysis of this large, routinely collected dataset with analysis of the Grattan Transport Infrastructure Investment dataset (the Grattan dataset): a smaller dataset which has been manually collected with the express purpose of understanding the dynamics of cost overruns on transport infrastructure projects and the characteristics of affected projects.

Since 2001, Deloitte Access Economics has been screening government budgets, announcements by private companies, the media and other publicly available sources for updates on public and private investment plans (Deloitte Access Economics, various years). From this information, quarterly project-level summaries of the value and degree of certainty of planned public and private investment in Australia have been compiled to form the Investment Monitor. Grattan Institute has linked the quarterly releases of the Investment Monitor over 2001 – 2015 to form a panel dataset that tracks the value and degree of commitment to all publicly announced investment projects from first announcement through to completion. Project costs have been inflated from nominal outturn costs to $2016 using the Australian Bureau of Statistics construction price index from the midpoint of each project's period under construction.

The Investment Monitor is a unique data source because it monitors the population of planned investments in Australia in real time, rather than collecting data retrospectively on a sample of the investments that took place. In this paper, we restrict our attention to the 836 publicly funded road and rail infrastructure projects that were valued above $20 million, and conduct the majority of our analysis on the 542 of these which were completed (**Table 1**). In addition to the statistical advantages of this large and representative dataset, Deloitte Access Economics' systematic review of the population of transport infrastructure projects allows conclusions to be drawn regarding the overall magnitude of cost overruns on Australian transport infrastructure projects over this period.

Table 1: Investment Monitor sample sizes by road/rail and completed/ deleted

	Completed projects	Deleted projects
Rail	121	110
Road	421	184
Total	542	294

Source: Deloitte-Access Investment Monitor; Grattan analysis.

The Investment Monitor panel dataset is also particularly well suited to investigating the timing and dynamics of cost overruns. For each quarter that a project appears in the dataset, we observe the planned value of each investment and whether the investment proposal in that quarter is classified as: 'Possible'; 'Under consideration'; "Committed'; or 'Under construction' (**Table 2**). The variation in the statuses of projects when announced and when abandoned is an important dimension of the Investment Monitor panel dataset because it allows us to observe the impact of initial cost estimates' maturity on project outcomes, and the probability that a project is abandoned at each stage.

Table 2: Number of projects that enter and exit the dataset at each stage

	Possible	Under consideration	Committed	Under construction	Completed
Entry	120	279	205	232	NA
Exit	48	100	50	96	542

Notes: Investment Monitor uses four definitions of project status: 'Possible', where no early decision whether to proceed with the project is likely; 'Under Consideration', where a decision whether to proceed with a project is expected in the reasonably near future; 'Committed', where a project has received the necessary regulatory and financial approval and generally has a definite start date (though may still be undergoing tendering for contracts); and 'Under Construction', where the project is currently underway. The general minimum threshold used within the database is that major earthworks at the construction site have commenced.
Source: Deloitte-Access Investment Monitor; Grattan analysis.

This information on the certainty of each planned investment also allows us to analyse the dynamics of cost overruns as projects progress through the investment pipeline, and the impact of a number of factors that relate to the timing of each project's assessment and execution. **Table 3** presents descriptive statistics on the project characteristics observed in the Investment Monitor panel dataset.

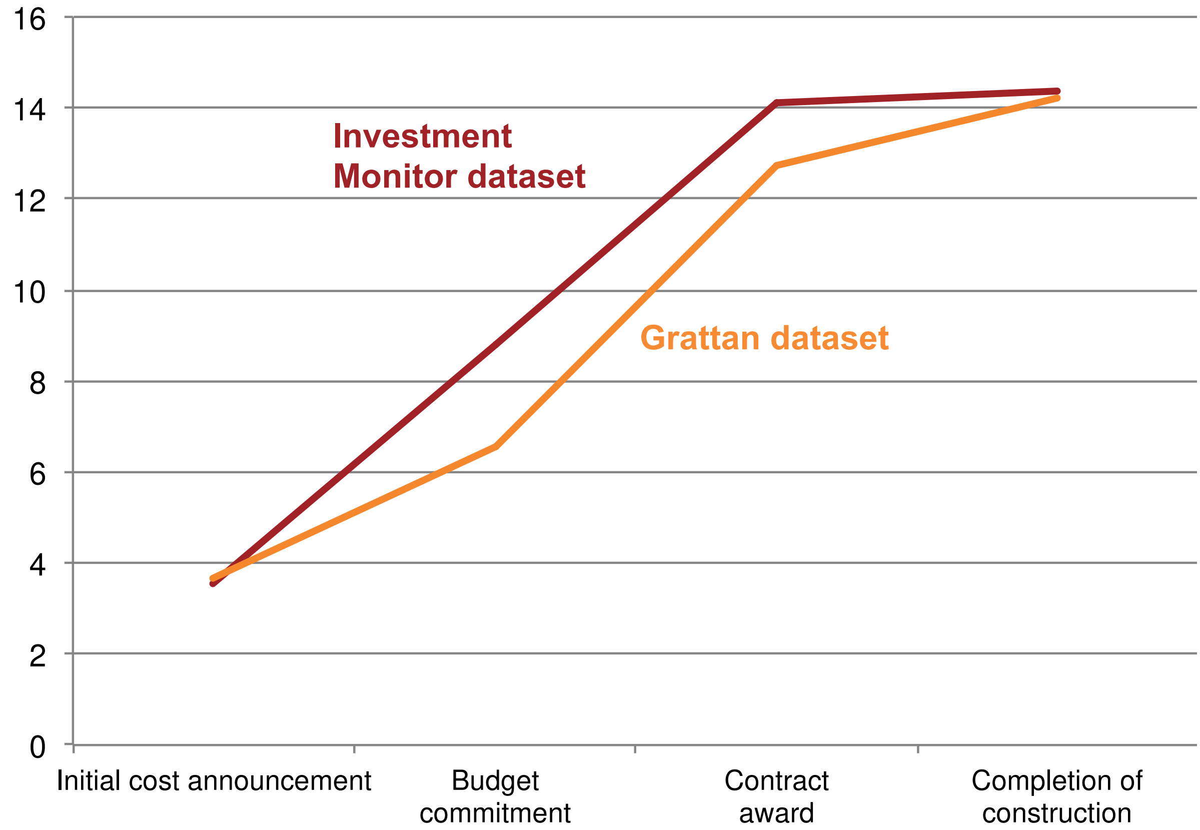
Table 3 Descriptive statistics, dependent variables

	Number of observations	Mean	Variance
Mode (0 if rail, 1 if road)	421	77.67%	0.17
Contracted after the GFC	170	31.36%	0.21
Election within 180 days	37	6.83%	0.06
Queensland	134	24.72%	0.19
New South Wales	153	28.23%	0.20
Victoria	96	17.71%	0.15
Western Australia	84	15.50%	0.13
Smaller states	75	13.83%	0.12
log(Total cost when contracted)	N/A	4.58	1.26
Log(Total days pre-construction)	N/A	3.27	9.23

Source: Deloitte-Access Investment Monitor; Grattan analysis.

To verify the accuracy of the Investment Monitor panel dataset, Grattan Institute has manually collected data on 51 transport infrastructure projects included in the Investment Monitor panel dataset that were completed between 2008 and 2013, and valued above $100 million (real, 2016). The Grattan dataset tracks expected project costs at five points in the investment pipeline: the initial funding commitment; the final funding commitment; the overall cost when the largest project contract was awarded; the overall cost after the largest contract's final revision during construction; and the final cost of the project. It also contains detailed information on the project's mode (road/rail), type (bridge/tunnel/surface), contract type, ownership and scope changes.

Figure 1: Cost estimates contained within the Investment Monitor data appear reliable overall
Total value of the portfolio of projects contained within the Grattan dataset by project stage, $billion



Source: Deloitte-Access Investment Monitor; Grattan dataset; Grattan analysis.

Figure 1 compares the Investment Monitor and Grattan datasets' estimates of the total value of the projects included in the Grattan dataset. Although the Grattan dataset only covers a limited number of projects, the high level of similarity between the value of the Investment Monitor and Grattan datasets' portfolios at each project stage provides assurance that the Investment monitor dataset is unbiased. The comparability of the Grattan and Deloitte datasets also holds at the individual project level, as there is no statistically significant difference between the average cost change on individual projects observed across the Grattan and Investment Monitor datasets[2].

Despite this similarity, we expect the average magnitude of cost overruns observed in the Investment Monitor will be substantially lower than observed in the Grattan dataset. This is because the Investment Monitor considers all projects valued over $20 million, the Grattan dataset only considers projects valued above $100 million and project size has been found in the literature to be a consistent predictor of the size of cost overruns (Flyvbjerg et al., 2004, Koushki et al., 2005, Anastasopoulos et al., 2012).

[2] The t-distribution critical statistic of the difference between the two means is 0.35, far lower than the threshold of 1.68 required for statistical significance at the 90 per cent level of confidence with a sample of this size.

Finally, while the Investment Monitor dataset appears to be reliable at the aggregate level, the routine approach to data collection that underpins the dataset means that the reliability of individual observations cannot be guaranteed. For this reason, we take a conservative approach to outliers, and exclude all Investment Monitor projects recorded as experiencing cost overruns greater than the maximum overrun observed across the Grattan dataset of 520 per cent. Although the largest cost underrun observed in the Grattan dataset is 34 per cent, only cost underruns of more than 50 per cent of projects' value are excluded on the grounds of implausibility.

4. The overall size of cost overruns in Australia

We commence our investigation by examining the prevalence and magnitude of cost overruns observed across the Investment Monitor and Grattan transport infrastructure datasets. First, we estimate the average magnitude of cost overruns in Australia, and draw comparisons to estimates of the cost overruns observed overseas. We then discuss the extremity of the cost overruns observed, canvas the common explanations for this characteristic of cost overruns and discuss the implications for project selection.

4.1. The average magnitude of cost overruns in Australia

The limited existing evidence on cost overruns in Australia has established an expectation that Australian transport infrastructure projects are afflicted by cost overruns, but at a lower rate than the international averages of (25 per cent) and (42 per cent) for road and rail projects established in Flyvbjerg's seminal study. Flyvbjerg's cost overrun estimates, and indeed almost all other estimates in the literature, refer to cost growth after the projects' principle contracts have been awarded. Our estimates of average cost overruns of 9 and 20 per cent after principal contracts have been awarded in the Investment Monitor and Grattan datasets respectively suggest this expectation is well founded in general, but not for larger projects (**Table 4**).

In other countries where average cost overrun estimates are also far lower than the international average, it has been hypothesised that this is partially because the institutional context encourages cost overruns to be incurred earlier in the investment pipeline (Cantarelli, 2012). Our analysis supports this hypothesis in the Australian context: in the Investment Monitor panel dataset, an additional 15 per cent cost overrun is observed on average prior to the principal contract being awarded. The higher average pre-contract cost overrun observed in the Grattan Transport Infrastructure dataset is consistent with the fact that the Investment Monitor dataset only captures pre-contract costs for 57 per cent of projects.

Table 4: Overall cost overrun estimates

	Investment Monitor	Grattan dataset
Proportion of projects with cost overruns	34%***	65%***
Average size of overruns before contract	15%***	32%***
Average size of overruns after contract	9%***	20%***
Average size of cost overruns overall	24%***	52%***

*Note: *** indicates significance at the 1 per cent level, ** indicates significance at the 5 per cent level and * indicates significance at the 10 per cent level. Cost overruns are defined as the percentage change over the period of interest as a proportion of the project's initial cost estimate.*
Source: Deloitte-Access Investment Monitor; Grattan analysis.

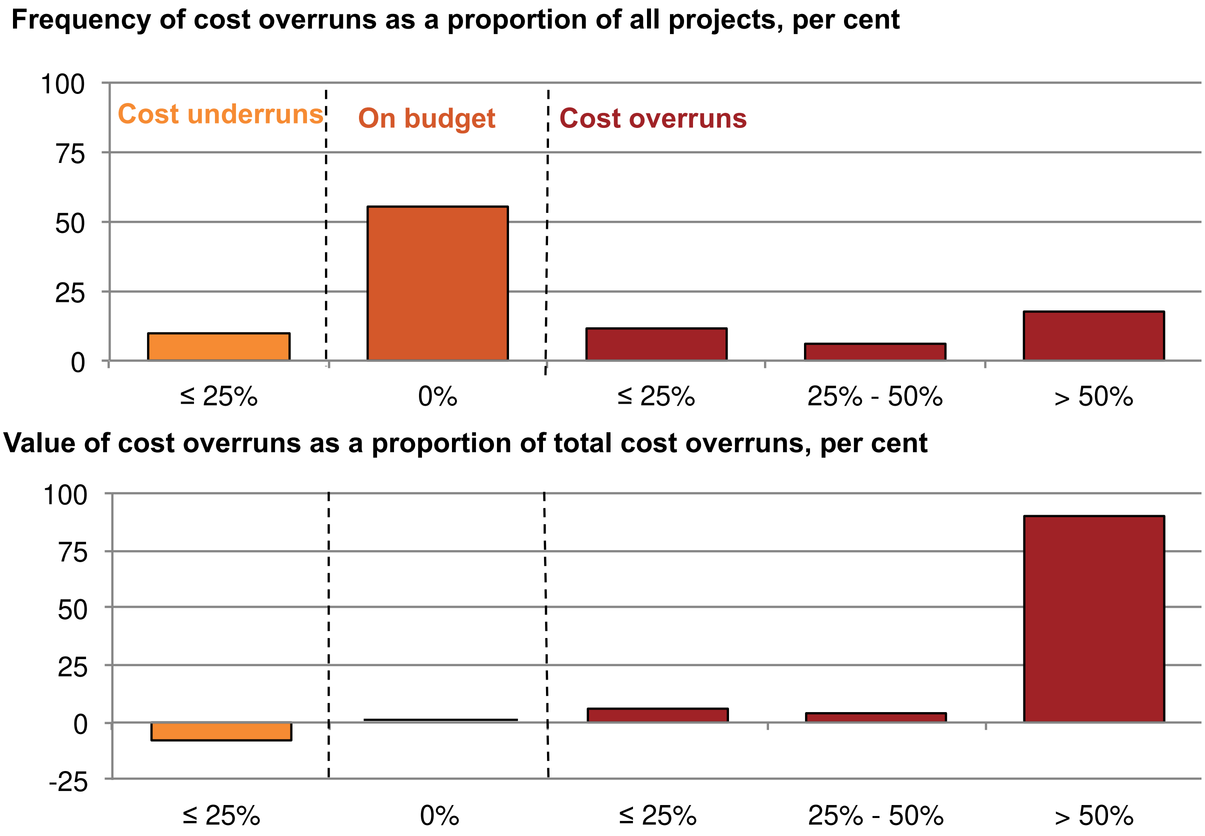
4.2. The extremity of cost overruns

A distinctive characteristic of both datasets is that the magnitude of cost overruns observed across projects varies widely, and is positively skewed. This characteristic is illustrated by Figure 2, which shows that the 18 per cent of cost overruns greater than 50 per cent of initial project costs account for 90 per cent of the total value of cost overruns. A similar phenomenon is observed in the Grattan dataset, where the 18 per cent of cost overruns greater than 20 per cent of initial project costs account for 70 per cent the total value of the cost overruns.

The heavy-tailed nature of our data is a well-documented and well explained characteristic of cost overruns. From a statistical perspective, cost overruns are anticipated to have kurtosis at least as large as a log normal distribution because errors in cost overruns compound multiplicatively over time (Jahren and Ashe, 1990). In addition to this, Flyvbjerg hypothesises that project risks are often correlated, complexity increases disproportionally with project size and the indivisible nature of infrastructure projects means that the costs of a project not going according to plan can't be abated by simply truncating the size of the project (Flyvbjerg, 2016a).

These hypotheses are supported by the findings of Love and colleagues, who observes the cost overruns of 115 Australian road projects, 58 Australian road projects and 228 Australian water infrastructure projects to be best described by a generalised logistic distribution, log-logistic distribution and generalised logistic distribution, respectively (Love, 2012, Love et al., 2015, Baccarini and Love, 2014). Both of these empirical distributions feature the skewed, heavy tail that characterises the Investment Monitor and Grattan transport investment datasets.

Figure 2: A fifth of projects are responsible for 90 per cent of cost overruns by value



Note: Cost overruns are defined as the percentage change over the period of interest as a proportion of the project's initial cost estimate.
Source: Deloitte-Access Investment Monitor; Grattan analysis.

4.3. Summary

The large variation in the magnitude of cost overruns has important implications for the project appraisal process. Cost overruns distort decisions about how much money to invest in transport infrastructure, and if they occur unevenly, also distort decisions regarding which projects to invest in.

Psychologists argue that optimism bias – the psychological tendency to underestimate potential downside risks and overestimate potential upsides – is one of the factors that explain the higher prevalence of cost overruns than underruns (Kahneman and Tversky, 1979). If this were the only cause of cost overruns, decisions about which projects to invest in would not be distorted, as all cost estimates would be affected by similar margins of error.

However, our analysis indicates that a large proportion of projects do not experience cost overruns and that the magnitude of cost overruns varies substantially across projects indicate that projects are affected by cost overruns to varying degrees. This suggests that cost overruns have had a distortionary effect on Australia's project selection decisions.

5. The dynamics of cost overruns in Australia

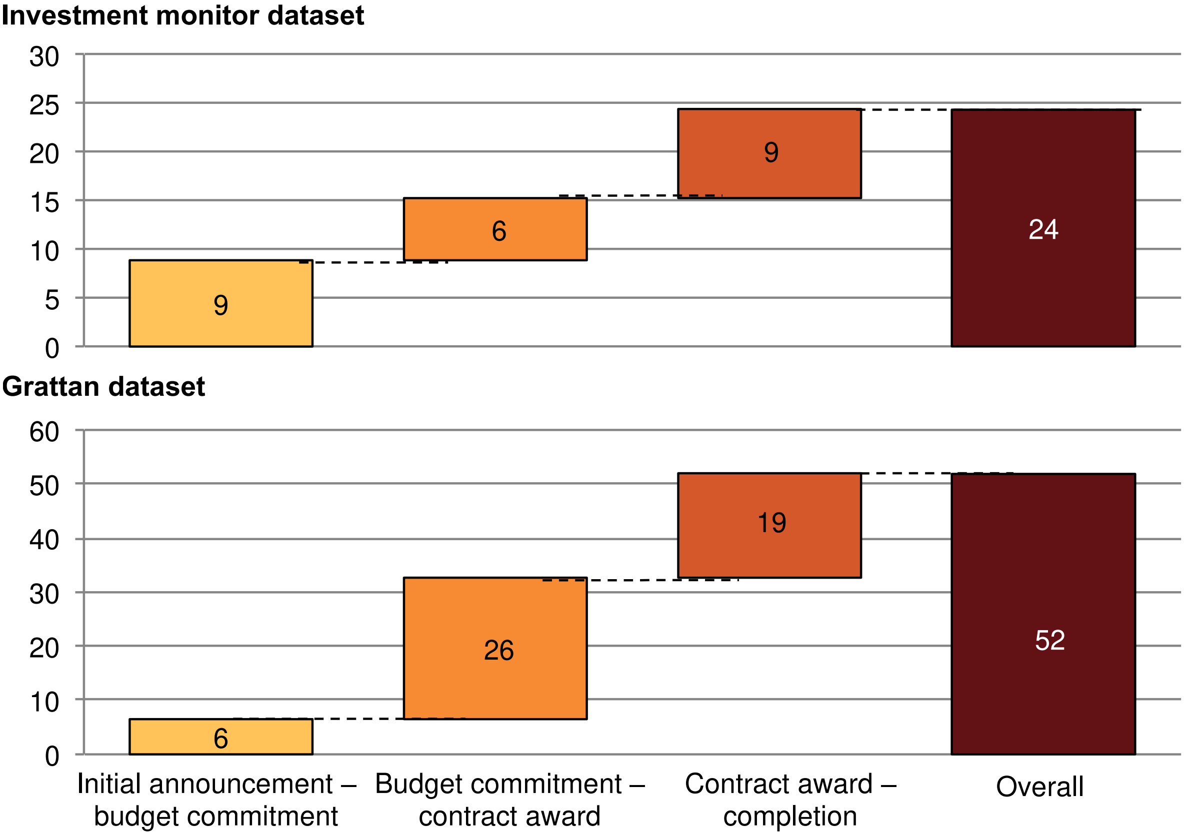
The timing of when overruns occur in a project's life matters. To the extent that cost overruns are occurring prior to contracts being awarded, there is scope of policymakers to adjust. A project appraisal process that actively reappraises projects as cost estimates mature would nullify the impact of cost overruns that occur prior to contracts being awarded, and reference class forecasting could be employed to align expectations with projects' likely final costs.

In this chapter, we decompose cost overruns by project stage, using both the Investment Monitor and Grattan datasets, and assess the dependence between cost overruns at different stages over time. We use this analysis to ascertain whether early overruns increase the risk of later overruns, and the extent to which there is scope for the distortions to investment decisions caused by early cost overruns to be mitigated through active reappraisal of projects' investment merits.

5.1. The magnitude of cost overruns by project stage

Figure 3 presents the cost overruns observed in the Investment Monitor and Grattan datasets decomposed by project stage. While the definitions of project stages vary slightly across the two datasets, both figures indicate that sizable cost overruns are occurring at all stages in the investment pipeline. This observation provides credence to the wide array of causes of cost overruns that have been proposed in the literature: it appears that cost overruns occur at the hands of both politicians and public servants, and are a consequence of unrealistic initial cost estimates as well as the realisation of greater construction risks than contingencies allowed for.

Figure 3: Cost overrun by project stage in Investment Monitor and Grattan datasets



Notes: Cost overruns are defined as the percentage change over the period of interest as a proportion of the project's initial cost estimate.
Source: Deloitte-Access Investment Monitor; Grattan dataset; Grattan analysis.

5.2. The correlation between cost overruns at each stage

We also assess the evidence of dependence between cost overruns at each subsequent stage. Among the 51 large projects contained within the Grattan dataset, we observe no statistically significant correlations between the magnitudes of cost overruns in adjacent periods. The projects that incurred overruns early in their lives incurred later cost overruns of the same average size as other projects. This means that cost overruns compound over projects lives.

A similar relationship between overruns over time was observed across the 542 completed projects tracked in the Investment Monitor. There was no significant correlation between the size of cost overruns incurred prior to a funding commitment, and those incurred later on. 27 per cent of the value of cost overruns incurred between a formal funding commitment and the commencement of construction was offset through lower cost overruns than average during the construction period, which means that only 73 per cent of the value of cost overruns incurred during this stage contributed to higher overall overruns.

The high degree of independence between cost overruns over time means that early cost overruns have a disproportionate impact on the total overrun incurred across the project's total life. This is because projects that experience early overruns are equally likely to experience later overruns, but these later overruns will come at a greater absolute cost than they otherwise would have because each subsequent overrun compounds upon those incurred earlier.

The compounding behaviour that we observe for cost overruns over time suggests that the early nature of the cost overruns observed on Australian transport infrastructure projects is not necessarily preferable to the later nature of the cost overruns that have been observed overseas. However, it does indicate a real opportunity for an effective project appraisal process to identify early cost overruns and account for these cost changes when evaluating the investment merits of each project.

5.3. Summary

Both the Investment Monitor and Grattan datasets indicate that cost overruns are prevalent at all stages of the investment pipeline, and compound over time. These findings suggest that, as many have hypothesised (Cantarelli et al., 2010), it is likely that there are a number of factors which cause cost overruns in Australia. However, the more important implication of these results is that cost overruns that occur at any stage of the investment pipeline are problematic.

It is often argued that cost overruns that occur prior to construction are less problematic because the decision to invest in the asset is yet to be finalised. In this chapter, we demonstrated that early cost overruns cause greater overall cost overruns than an equivalent late cost overrun. This is because projects which experience early cost overruns are just as likely to experience later cost overruns, but these later cost overruns will compound against a higher base cost.

In the following chapter, we investigate whether the Australian project appraisal process is effective. This allows us to assess whether the most recent project cost estimates are in fact actively accounted for in the later stages of the project appraisal process, and whether there is scope to reduce cost overruns observed in Australian transport infrastructure projects by increasing the rigor of the project appraisal process.

6. Is the project appraisal process working?

Selecting the right projects and in the optimal combination is the most important aspect of achieving good outcomes for the community from public infrastructure (Terrill et al., 2016). Cost overruns are problematic in this regard, as investment decisions made on overly optimistic cost estimates distort transport infrastructure investment decisions. When misleading information causes policymakers to invest in projects where the benefits do not outweigh the actual costs of the project, and do so at the expense of projects that would have offered net benefits to the community, the public ends up worse off.

A rigorous project appraisal process is a powerful tool for mitigating cost overruns' distortionary impacts on project selection. This is because project appraisal processes that actively reappraise the business cases for infrastructure projects in light of increases in expected project costs can prevent investment in projects where the benefits do not outweigh the costs. Further to this, by requiring detailed analysis of projects' cost estimates and business cases, rigorous project appraisal processes can reduce cost overruns via improving the quality of initial cost estimates.

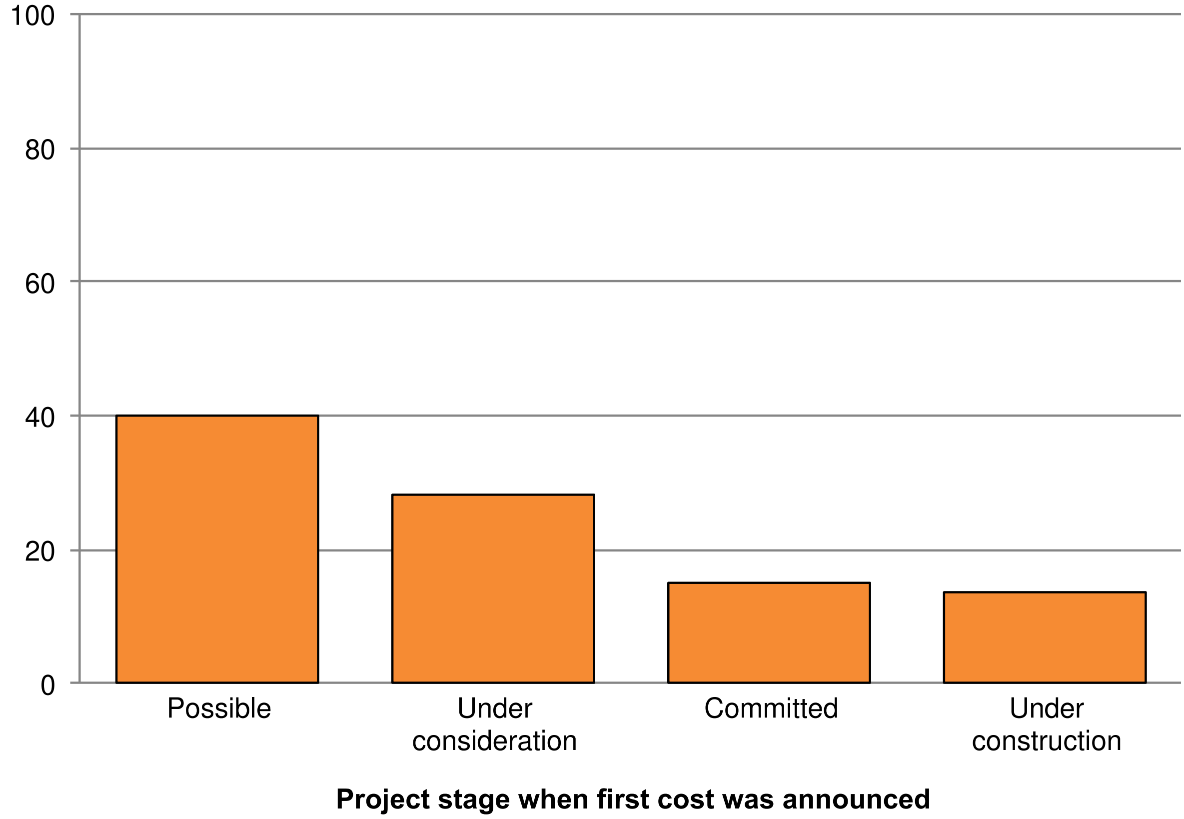
In this chapter, we assess the evidence that cost overruns on Australian transport infrastructure projects could be reduced by a more effective project appraisal process. We investigate this hypothesis in two ways. Firstly, we investigate whether there is evidence that the project appraisal process for Australian transport infrastructure projects is currently discriminating: that is, actively preventing the projects with poor business cases from progressing through each stage by refusing to approve these projects. Following this, we investigate whether indicators of poor adherence to project appraisal processes are associated with a greater probability of cost overruns, or cost overruns of greater magnitude. If so, this would point to scope to improve our project appraisal processes.

6.1. Are project appraisals discriminating?

As it is expensive to ascertain detailed information about the likely costs and benefits of projects, appraisal processes typically have multiple stages: projects have to satisfy one set of criteria before further analysis is warranted, and then the project should only go ahead if the results of the further analysis undertaken are favourable. For this reason, the first requirement of an effective project appraisal process is that not all projects progress through each subsequent stage.

To investigate whether Australia's project appraisal process has been discriminating, we consider the Investment Monitor's broader sample of 836 projects that were proposed for construction, and analyse the cancellation rate relative to projects' maturity when their cost estimates were first made public. Figure 4 indicates that the promised made by politicians' prior to official budget commitments stick: these projects are more likely to continue through to completion than be cancelled.

Figure 4: Few projects are cancelled once announced
Percentage of projects cancelled at each project stage, per cent



Sources: Deloitte Investment Monitor; Grattan analysis

Moreover, the cancellation rate of 35 per cent observed across the Investment Monitor dataset overall appears to be insufficient. This is because, when the average magnitude of cost overruns is considered, this cancellation rate is less than the amount of projects which would be expected to have costs that are greater than their benefits[3].

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[3] This conclusion relies upon the assumption that the cancelled projects contained within the Investment Monitor dataset had an average benefit cost ratio that was at least 2 per cent lower than the average benefit cost ratio observed across the 39 business case summaries of transport infrastructure projects published on Infrastructure Australia's website.

We next consider the correlation between cost overruns and project survival using a univariate logit regression. **Table 5** presents the magnitude and statistical significance of the marginal effects of the cumulative cost overrun variables included in our models of the probability of project survival at each project stage. The absence of a statistically significant marginal effect at any project stage indicates that there is insufficient evidence to conclude that cost overruns increase the probability of projects being abandoned.

Table 5: Marginal effects of cumulative cost overruns on the probability of surviving each stage

Stage	Magnitude	P-value
Possible	-0.03	0.28
Under consideration	-0.04	0.39
Committed	-0.03	0.28
Under construction	0.04	0.80

Note: *** indicates significance at the 1 per cent level, ** indicates significance at the 5 per cent level and * indicates significance at the 10 per cent level.
Source: Deloitte-Access Investment Monitor; Grattan analysis.

This finding does not provide evidence that Australia's project appraisal process is successfully preventing projects with poor returns on investment from being built. However, we caution the reader from assuming that the inverse conclusion is implied: the absence of a negative correlation between cost overruns and the probability of project survival does not necessarily imply that the project appraisal process is not discriminating between projects which are and are not worthwhile.

This is because there are circumstances, such as where a project's scope increases, where cost overruns do not correspond to a deterioration of a project's return on investment. There are also circumstances where the impacts of cost overruns on projects' appraisals are unobserved, because the cost overruns that lead to project cancellation may be foreseen rather than realised. For these reasons, we emphasise that a negative correlation between cost overruns and project survival would be sufficient evidence that the appraisal process discriminates effectively between good and bad projects. However, such a relationship is not a necessary characteristic of effective appraisal processes.

Overall, we conclude that there is poor evidence that Australia's project appraisal process is discriminating. We do not appear to be cancelling enough projects, and there is no evidence that the right projects are being cancelled. In this environment, early cost overruns matter.

In the following section, we complement this analysis of the successes of Australia's project appraisal process with analysis of where shortcomings of the project appraisal process have led to greater than average cost overruns.

However, this assumption is extremely defensible. The benefit cost ratios of cancelled projects are likely to be worse than the 39 projects that had undergone an advanced level of planning and voluntarily submitted their business cases for publishing. It is also reasonable to suspect that benefit cost ratios are overestimated by more than 2 per cent on average, as numerous studies have found that estimates of project benefits are routinely optimistic (FLYVBJERG, B. 2016b. The fallacy of beneficial ignorance: A test of hirschman's hiding hand. *World Development,* 84**,** 176-189.). Finally, the business case for completing projects with benefit cost ratios that are only very marginally above one is contentious.

6.2. Evidence of scope for improvement

In Australia, flagrant abuses of the proper project appraisal processes are known to be commonplace. For example, after reviewing the circumstances underlying the cost overruns observed across 50 NSW infrastructure projects, NSW Auditor General Grant Hehir described the degree of non-compliance with the government's external assurance mechanisms as significant (Winestock, 2015). In this section, we consider the evidence that indicators of poor adherence to project appraisal processes are associated with a greater probability of cost overruns, or cost overruns of a greater magnitude.

Tables 6 presents the marginal effects of each covariate on the probability that a project finishes on budget and, if not, the marginal effect of the covariate on the average magnitude of the overrun as a percentage of initial project costs. We observe that a 1 per cent increase in project size, as measured by the project's estimated cost when first under construction, is associated with a 6 per cent higher probability of a cost overrun. This relationship between project size and cost overruns is a consistent finding of studies into cost overruns (Rowland, 1981, Jahren and Ashe, 1990, Flyvbjerg et al., 2004, Shrestha et al., 2013).

We also observe that, although road projects are no more likely than rail projects to finish over budget, when they do finish over budget, they have an average overrun that is 19 per cent higher than that of rail projects. This finding is contrary to what has been identified in international studies (Merewitz, 1973, Flyvbjerg et al., 2002, Lee, 2008). However, it supports the established understanding that the magnitude of cost overruns, and the factors which are associated with them, are specific to each country's institutional context ((van Wee, 2007)).

Controlling for these project characteristics, we assess the marginal effects of the characteristics of the project appraisal process. Our first hypothesis is that the rigor politicians apply to their decisions of what to fund, and that public servants apply when awarding construction contracts, may vary in relation to characteristics of the time that the decision was made. Indeed, we observe that cost overruns are 23 per cent higher on average for projects that received a funding commitment during a state or commonwealth election campaign.

In the 2016 Australian federal election, less than 15 per cent of the funding promised to transport infrastructure projects valued above $100 million was allocated to projects with business cases that have been favourably reviewed by Infrastructure Australia as is required, despite there being numerous projects without support that satisfy this criterion (Terrill et al., 2016). The routine disregard for the maturity of election promises' cost estimates is a probable cause for this group of projects' below average cost performance.

We also identify that projects contracted during or after the Global Financial Crisis are 21 per cent less likely to experience a cost overrun. This finding is in line with our hypothesis that perceived budget constraints affect the emphasis placed within government departments on ensuring a project proposal is adopted relative to ensuring projects finish on budget. Prior to the Global Financial Crisis, Australia may have been simply too rich to care whether contracts were watertight and proposed extensions to projects' initial scope delivered a satisfactory return on investment.

Our second hypothesis is that projects which are not approved or abandoned quickly will be more prone to cost overruns. This is because a longer planning process must either reflect a slower progression through the appraisal process, perhaps due to a lack of enthusiasm for the project, or that the amount of work involved in the appraisal process is greater than average, which may be the case if the initial cost estimates were not based on a proper business case.

This hypothesis is supported by the estimated coefficients of Model A, which indicate that a 1 per cent increase in the length of time between project announcement and construction is associated with a 4 per cent lower probability of a project finishing on budget. This finding is in line with what has been observed previously in the cost overruns literature (Morris, 1990, Flyvbjerg et al., 2004, Odeck, 2004, Sambasivan and Soon, 2007).

Our final hypothesis regarding the impact of project appraisal process characteristics on cost overruns is that, if there is scope for cost overruns to be reduced by increasing the rigor of the project appraisal process, we would expect to observe variation in the prevalence and magnitude of cost overruns across jurisdictions. This hypothesis is supported by the 12 and 19 per cent higher probability of a project finishing on budget if it is built in Queensland or Victoria, respectively, relative to New South Wales. When cost overruns occur, they are larger on average in Western Australia. This may be associated with the heightened cost uncertainty associated changing levels of competition in the construction industry over the course of the state's resources boom.

Table 6: Regression coefficients

	Model A *Probability*	**Model B** *Magnitude*
(Intercept)		0.07
Project characteristics		
Log(First cost when under construction real)	0.06***	0.03
Mode (0 = rail, 1 = road)	0.05	0.19***
Premature initial cost announcement	0.13*	0.14*
Characteristics of the project appraisal process		
QLD	-0.12**	0.04
Smaller states	-0.005	0.09
VIC	-0.19***	-0.05
WA	-0.06	0.23***
Log(Total days pre-construction)	0.04***	0.002
Constructed after the collapse of Lehman Brothers	-0.21***	-0.02
Committed to within 180 days of an election	-0.02	0.23**

Notes: Model A is a logit model of the probability that a project will be completed on budget; Model B is a log-normal model of the magnitude of cost overruns observed across projects which did not finish on budget. Initial cost announcements are classified as premature if they occurred prior to an official budget commitment.
NSW is the control state, which means the marginal effects of the state variables should be interpreted as the difference between the average outcome observed in the state the variable refers to and the average outcome observed across NSW.
Projects are categorised as being announced within 180 days of an election if a commonwealth election or a state election in a project's home state was held within that 180 days.
**** indicates significance at the 1 per cent level, ** indicates significance at the 5 per cent level and * indicates significance at the 10 per cent level.*
Source: Deloitte-Access Investment Monitor; Grattan analysis.

6.3. Summary

These findings regarding the time-specific incentives facing politicians and public servants, the nature of projects' planning processes and jurisdictional differences suggest that there are significant opportunities to improve the rigor of the project appraisal process in Australia. Together with the lack of evidence that the project appraisal process is effective at rejecting projects when their investment merits are lost, these results suggest that there is further scope to reduce the cost overruns by increasing the rigor of the project appraisal process.

7. Conclusion

In this paper, we have employed two unique datasets to explore the prevalence, magnitude, and dynamics of cost overruns in Australian transport infrastructure projects from 2001 to 2015. Through this analysis, we have identified that overall cost overruns are substantially larger than the existing estimates of cost overruns during a projects' construction have suggested. The substantial variation in the magnitude of cost overruns incurred across projects indicates that cost overruns on Australian transport infrastructure projects are distorting project selection, as well as decisions regarding how much to invest.

Moreover, early cost overruns are particularly important for two reasons. First, projects with early cost overruns are just as likely to experience later cost overruns, but these will occur on a higher base. By increasing the absolute value of later cost overruns, early cost overruns pose further costs even if the project is actively reappraised. Second, we found no evidence that Australia's project appraisal processes effectively reappraises projects that experienced cost overruns.

Further, we find evidence that poor adherence to project appraisal processes are associated with a greater probability of cost overruns, and cost overruns of a greater magnitude. First, we observe that cost overruns are 23 per cent higher on average for projects that received a funding commitment during a state election campaign, and projects that were contracted during or after the Global Financial Crisis are 21 per cent less likely to experience a cost overrun. Second, projects that are not approved or abandoned quickly are more prone to cost overruns. Third, projects in some Australian jurisdictions are more likely to experience cost overruns, such as New South Wales, than either Victoria or Queensland.

These results suggest there is significant scope to improve Australia's project appraisal processes. Foremost, rigorous, independent evaluation of business cases prior to governments making commitments to fund transport infrastructure projects would improve the quality of the information that investment decisions are made on. Terrill and Danks argue that Infrastructure Australia, the Productivity Commission and, for particularly large projects, standalone legislation all have a role to play in improving the transparency of the investment pipeline (Terrill and Danks, 2016). Clear and consistent guidance regarding how project risks should be measured and managed would improve the quality of information available during this process.

Secondly, post-completion reporting of projects' costs and realised benefits have an important role to play in incentivising active reappraisal of business cases throughout the investment pipeline. This could readily be achieved by requiring projects' expected and actual cost outcomes to be published by the Commonwealth Department of Infrastructure on data.gov.au, and by requiring Infrastructure Australia to report projects' realised benefits, costs and investment merits to the Parliamentary Standing Committee on Public Works. Moreover, transport infrastructure projects should be included in the Productivity Commission's annual Report on Government Services alongside other government expenditures of similar magnitudes (Terrill and Danks, 2016).

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