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Cost Escalation in Road and Rail Construction Projects- NSW Experience

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Abstract

Cost escalation is a topic of much interest for transport planners, project managers and economists who are keen to understand the drivers underlying cost increases in transport projects.

Research undertaken in Australia and overseas indicates that there are several underlying drivers including inflationary trends, market factors, scope changes and changing regulatory requirements. This paper focuses on the inflationary aspects of cost increases over the last 15 years in NSW and shows that cost of road and rail projects have increased faster than the CPI (Consumer Price Index). However, transport agencies in NSW use cost escalation factors that reflect general price trends such as the CPI for budget planning. The use of the CPI or other medium term forecasts for escalation is likely to lead to under-budgeting of project costs in terms of outturn dollars leading to potential shortfalls in cash flow budgets of transport projects.

This paper develops specific price indices for road and rail construction based on sample data from road and rail agencies in NSW and proposes escalation factors based on 15 year compound average growth rates (CAGR).

A “principal component method” was used to analyse cost trends in key road and rail transport construction projects and forecast escalation factors were developed.

The research for NSW indicates that road construction project costs have increased at a compound average growth rate (CAGR) of 3.8% compared to the overall general inflationary trend of 2.8% as measured by the CPI. The corresponding figure for rail construction projects is 4.0%.

1. Introduction

The objective of this paper is to show that cost escalation factors used to estimate road and rail construction projects in NSW in the past need to be improved to reflect actual trends in cost escalation.

There are various factors that can influence the final construction cost estimate of a project. These include scope changes, changing regulatory requirements, market conditions, climatic changes, other unknown factors and inflation. Inflationary impacts are allowed for in cost estimates using a cost escalation factor. It is used to convert Base estimates (including contingency) to cash flows in terms of outturn dollars.

In the past various cost escalation factors have been used ranging from the CPI to the Road and Bridge Construction Index from the ABS. There are also a couple of private sector firms providing cost escalation factors based on their own research.[1] The escalation factors used for transport projects range from 3.5% pa to 7% pa depending on the project and the expected rise in the cost of various inputs. There is inconsistency in the allowance for inflation both for inputs as well as for overall budgeting. The objective of this paper is to discuss the factors that determine escalation of road and rail construction costs, provide estimates of escalation for key inputs (principal components) and forecasts for the next five years.

2. Construction Cost Escalation in NSW

2.1 Background

Cost escalation as defined here captures the anticipated rise in the price of inputs (such as labour, material, equipment, etc) over time due to inflation. It is used in project construction cost estimation to convert current dollars to outturn dollars for budgeting purposes. Table 1 summarises the key factors influencing transport construction costs.

Table 1: Factors Affecting Transport Construction Cost Escalation

Factors	Inclusion or exclusion in the escalation methodology
General inflation	Included in both construction and operating costs.
Market conditions	Partially included. Construction cost could be pushed higher if large scale projects were added to the market causing a shortage of skilled workers or certain materials. It is considered such factors have been captured in historical price changes thus partially included in the framework.
Contingency	Excluded. Contingency is separately considered in cost estimation
Scope change	Excluded. The project scope can change over time due to community consultation and Government decision making. The scope change will eventually be reflected in cost change. However, scope change is project-specific thus difficult to be included in the general cost escalation methodology.
Environmental and safety regulations	Excluded. Cost can change due to conditions of environmental approval and safety regulations. These changes are project specific thus difficult to be included in the general cost escalation methodology

2.2 Current Practices and Cost Escalation

For road construction projects, there are several indices available such as the ABS Road and Bridge Construction Index (RBCI), the BITRE's Road Construction and Maintenance Index (RCMI) and the Road Cost Index (RCI) produced by the RMS which can be applied to maintenance projects. It should be noted that whilst there are several indices that track road construction costs, there are none that track rail construction costs. This paper develops a cost escalation factor for rail construction projects in NSW.

[1] Eg. BIS Shrapnel and Macro Monitor Pty Ltd provide forecasts for various road construction and maintenance costs.

The ABS Road and Bridge Construction Index, (RBCI) is a sub-index of the Producer Price index (PPI) which is available by State and Territory breakdown. It is an output based index. The ABS RBCI for NSW is based on data collected from road construction firms bidding for work in NSW. Figure 1 shows how the RBCI has tracked in NSW over the last 15 years. It shows that road and bridge construction costs have increased at a compound average growth rate (CAGR) of 3.7%.

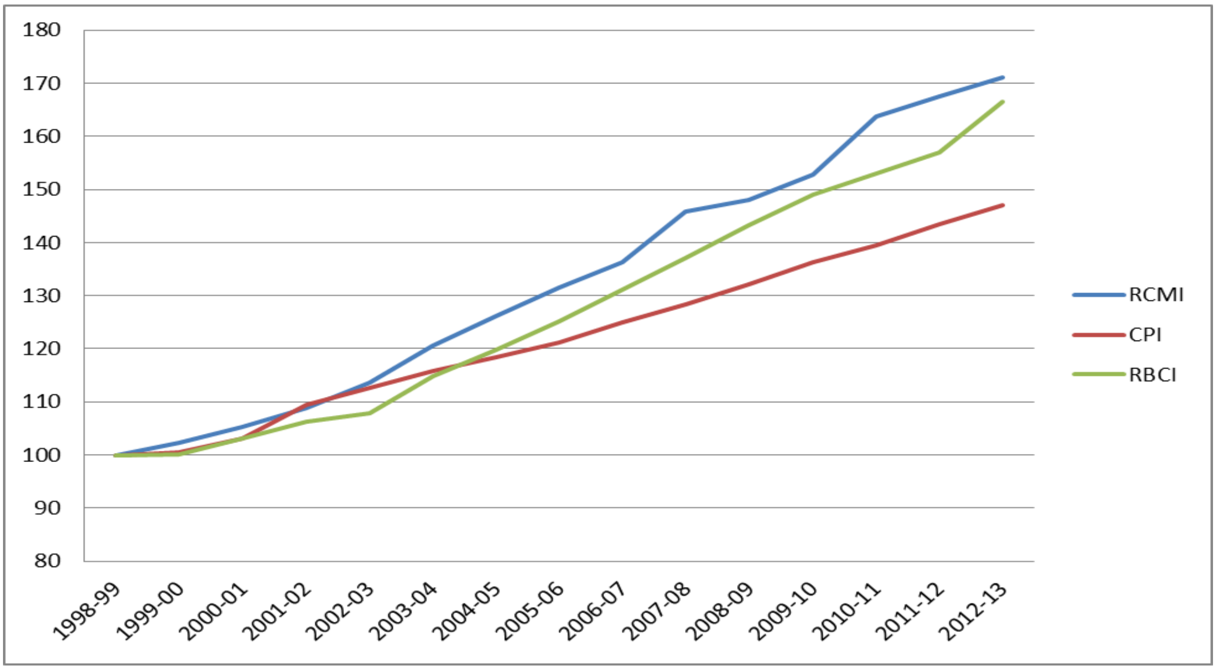
The RCMI on the other hand is an input price index compiled by the Bureau of Infrastructure, Transport and Regional Economics (BITRE) annually from changes in prices of inputs into road construction. The index does not include sub-contractor margins so it is not reflective of output prices. The RCMI has also increased at an average annual rate of 3.7% pa over the last 15 years (see Figure 1).

The Consumer Price Index (CPI) is sometimes used to escalate various cost components. Over the last 15 years it has grown at a Compound Average Growth Rate (CAGR) of 2.8% pa. (see Figure 1).

2.3 Comparison of indices

A comparison of the RCMI, CPI and RBCI indices over a 15 year period (1998/99-2012/13) shows some interesting trends. The ABS, RBCI has increased at an annual rate of 3.7%; the CPI has increased at 2.8% pa and the BITRE's RCMI has increased at an annual average rate of 3.7%. Refer to Figure 1 below. Both road based cost indices have increased faster than the CPI indicating that CPI is probably not the best indicator to forecast cost escalation for road and rail projects. Prior to 2004-05 the CPI was tracking closely to the RBCI and RCMI, however, since then the CPI has been consistently overtaken by the two indices.

Figure 1: Comparison of Various Cost Indices (1998/99=100.0)



Source: TfNSW (2015) and ABS (2013a and b) various tables.

2.4 Framework for Road and Rail Cost Indices

The framework for developing road and rail construction indices is shown in Figure 2. It uses a “principal component analysis” method to analyse road and rail project expenditure for a sample of projects (see next section) and derives expenditure weights for principal components which are then applied to relevant ABS data to derive a new set of construction cost indices customized for NSW. The indices are estimated for the last 15 years. Forecasts escalation factors are then derived based on the Compound Average Growth Rate (CAGR) over the last 15 years.

A “principal component analysis” method was used to analyse road and rail cost data. This involved identifying the major (or principal) cost components from an expenditure point of view for a sample of road and rail projects, identifying key elements that form inputs into the principal cost components and then forecasting their price movements using ABS data from the Producer Price Index and Wages Price Index[2]. The steps used in estimating the road and rail construction indices are as follows:

Step 1: Collect road and rail project expenditure data for sample of projects.

Data items include:

- Labour,
- plant,
- materials,
- subcontractors,
- project development & design cost,
- property acquisition and
- project management cost
- Other costs such as handover and insurance.

Step 2: Re-classify expenditure into the following principal component categories and determine weights:

- Direct labour
- Technical labour
- Internal labour cost
- Materials
- Plant, Equipment and property

Step 3: Identify appropriate ABS data series to match principal component categories.

Step 4: Estimate the Road and Rail TCI for last 15 years based on weights in Table 2 and corresponding ABS data in Table 3.

Step 5: Forecast Road and Rail TCI for next 5 years.

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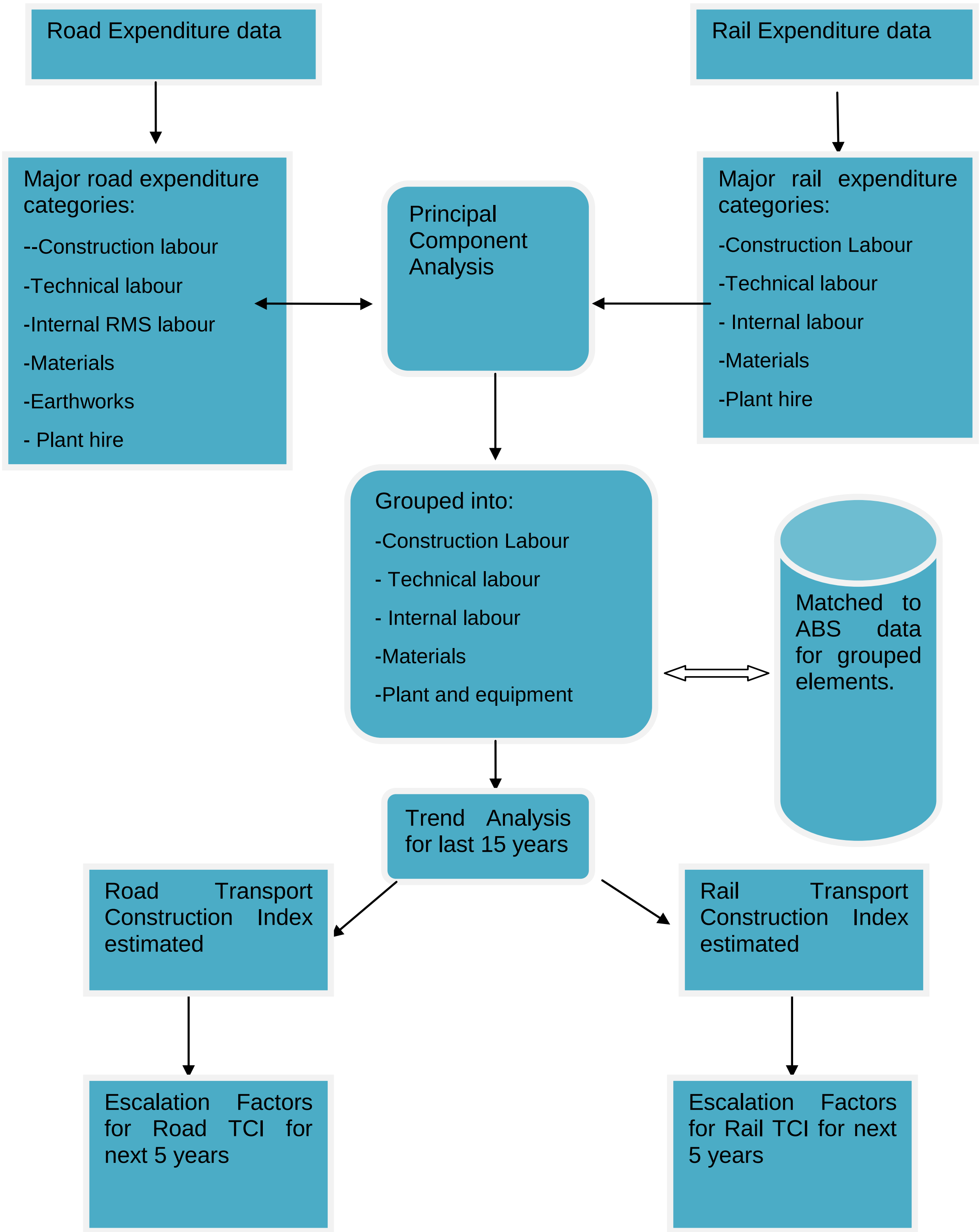
[4] ABS, Wages Price Index, Catalogue no. 6345 and Producer Price Index, Catalogue no. 6427, Canberra

Figure 2: Framework for Road and Rail Construction Cost Escalation Indices



2.5 Analysis of Road Construction Data

The above steps were applied to analyse and construct a Road Transport Construction Index (RTCI) for NSW. Data from a sample of 18 road projects in NSW were used to identify weights for road construction projects. These road projects were a mix of urban and rural road projects ranging in cost from $20m to $600m. They involved duplication of existing roads as well as new sections on the Pacific Highway. As shown in Table 2 below the principal components at the RMS (NSW) WBS (Work Breakdown Structure) level 2 for road construction projects were disaggregated to allow easy tracking of prices from ABS data. Weights for the principal components were derived and applied to the ABS data.

Table 2 below shows how expenditure categories in Step 1 were re-classified in Step 2 to determine weights.

Table 2: Road Cost Expenditure Categories and Weights

Expenditure Category	Expenditure (% of total in sample)	Principal Component Category	Expenditure weight (%)
Labour	4%	Direct labour	10%
Plant	11%	Plant, Equipment and Property	23%
Materials	19%	Materials	30%
Subcontractors during construction	25%	Re-allocated to above 3 categories pro-rata as it comprises mix of direct labour, plant and materials. [3% allocated to Direct labour, 8% to Plant, Equipment and property and 14% to Materials.]	-
Subcontractors during project development	25%	Technical labour	25%
Project Development and design	6%	Technical labour	6%
Property acquisition	3%	Plant, Equipment and Property	-
Project management	5%	Internal labour	6%
Other cost	2%	Re-allocated to internal labour and direct labour. [1% to Internal labour and 1% to direct labour.]	-
	100%		100%

In step 3 appropriate ABS data series were identified to match the principal component categories (see Table 3 below).

Table 3: Principal Component Categories matched to ABS Data

Principal component Category	ABS Data Source
Direct labour	ABS Wage Price index, Quarterly index for all workers in the private and public construction sector, Australia. (Catalogue no. 6345, Series ID A2603589K).
Technical labour	ABS Producer Price index, Quarterly Index of engineering design / engineering consulting services and technical labour, Australia. (Catalogue no. 6427.0, Series ID A2314202T).
Internal labour	ABS, Total Hourly Rates of Pay, Quarterly index for all NSW public sector employees excluding bonuses. (Catalogue no. 6340.0Series ID A2599999R).
Materials	ABS Producer Price Index, (Catalogue no. 6427.0 Tables 18 and 19 Series ID A2314821C; A2390858A and A2390945X respectively) for estimation of price changes for materials such as bitumen, concrete and steel, Sydney.
Plant, equipment and property	ABS Producer Price Index, (Catalogue no. 6427.0) Table 23 Series ID A2314181T) for escalation of transport plant and equipment costs, Australia. Property costs monitored using NSW Land and Property Information database.

2.6 Analysis of Rail Construction Data

Steps 1, 2 and 3 above were repeated for analysis and derivation of the Rail Transport Construction Indices. Data from a sample of 20 rail capital projects were used to analyse rail construction costs and to develop a suitable index for rail projects.

Data was provided by Sydney Trains at both program and project levels for two years 2011/12 and 2012/13. Expenditure categories were aggregated into five categories as shown in Table 4 below. These categories were chosen so that appropriate indices could be used to track price movements from ABS data.

Table 4: Principal Cost Components for Rail Construction Projects

Principal Cost Category	Element Cost Category	Weight %
Labour	Construction labour (Direct)	47
	Technical labour	25
	Internal labour	16
Plant	Plant hire	4
Major Materials	New power supply, wayside detection system, re-signalling, anti-throw screens.	8
	Total	**100.0**

Source: Sydney Trains, 2011-12 and 2012/13 data.

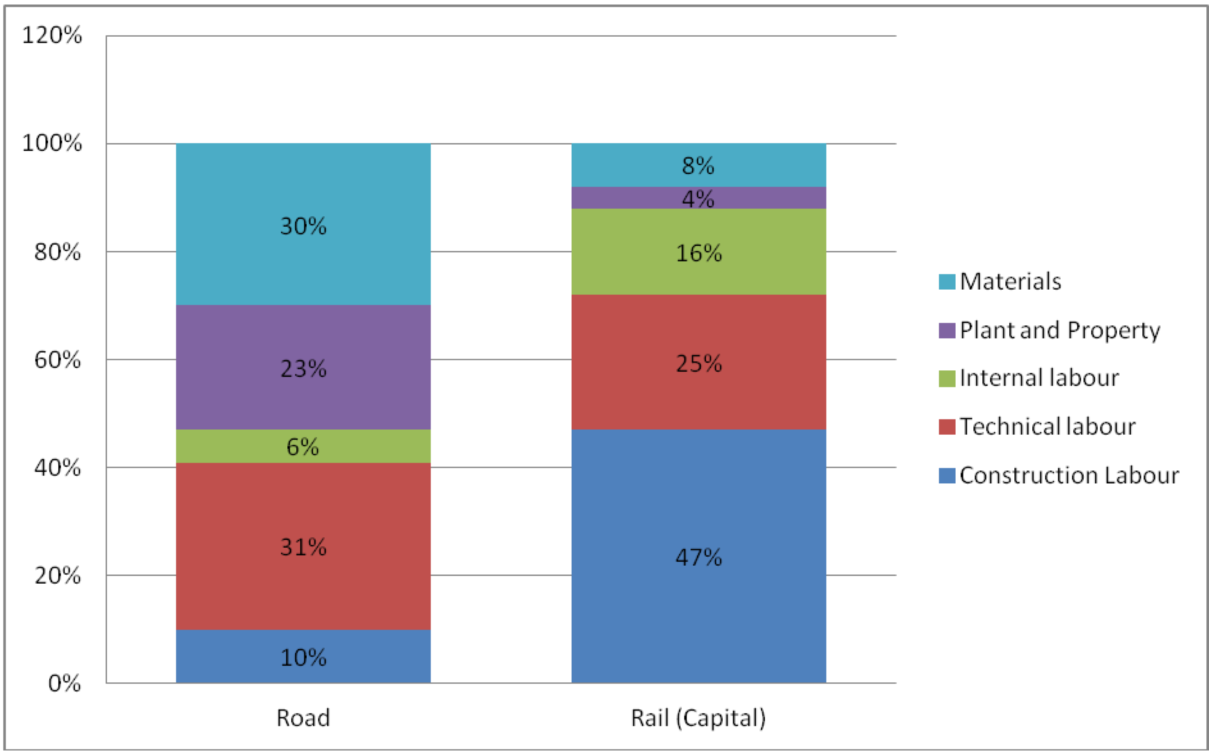
This grouping of key cost categories was selected to align with those used for road projects (i.e. construction labour, technical labour, internal labour, plant & property and materials). The construction labour includes sub-contractors as well as day labour and is assumed to be mainly unskilled labour. Internal labour cost is internal staff assigned to projects in RMS.

A summary of the road and rail construction element weights are shown in Figure 3 to illustrate the difference in expenditure on the key Principal Cost Components.

The high component of construction labour (47%) in rail capital works is due to the high use of sub-contractor and direct labour in rail projects and programs such as overhead wiring, re-signalling, track reconstruction and control system upgrades. This compares with a lower component of construction labour for road construction projects (10%) but higher levels of technical labour (31%).

Other components such as property acquisition costs and overheads vary between projects. For the sample of road projects property costs were about 3% and there were nil for the sample of rail projects. Property costs were grouped with the plant and equipment category.

Figure 3: Road and Rail TCI Principal Component Weights



Source: RMS and Sydney Trains. Rail data is for Sydney Trains capital works only and excludes major tunnelling projects such as Sydney Rapid Transit projects.

3. Estimated Road and Rail Construction Cost Indices

3.1 Methodology

Step 4 involved estimating the road and rail transport cost indices over the last 15 years.

The road, rail and other transport indexes were calculated using the principal component weights and the relevant ABS indexes based on the following equations:

Equation 1

Road TCI = 31% x Tech Labour +10% x Direct Labour + 6% x Internal Labour

+23% x Property Plant & Equipment + 30% x Materials

Equation 2

Rail TCI = 25% x Tech Labour +47% x Direct Labour + 16% x Internal Labour

+ 4% x Plant & Equipment + 8% x Materials

Using the data in Appendix A and the equations above a new set of road and rail indices can be estimated.

Table 5 below presents these calculated indexes over the period 1998/99 to 2013/14 and the compound annual growth rates (CAGR) during the 15 year period.

Analysis of the above indices shows that the growth in the cost of rail projects has been similar over the last 15 years compared to road projects (4.0% pa for rail cf.3.8% pa for road in terms of CAGR). Both of these indices are similar when compared to the ABS, RBCI (3.7% pa) but higher than the CPI (2.8% pa). On average the Road and Rail TCI are about 1.0% above the CPI rate. The Road TCI is about the same as the RBCI (see Figure 4 below).

Table 5 Road and Rail Transport Construction Indexes (TCI)

Year	Road TCI	Rail TCI
1998/99	100.0	100.0
1999/00	101.5	100.8
2000/01	102.7	103.3
2001/02	103.9	106.3
2002/03	105.8	109.6
2003/04	112.5	115.2
2004/05	118.8	120.9
2005/06	125.0	127.0
2006/07	131.9	134.5
2007/08	138.4	142.1
2008/09	147.4	150.9
2009/10	163.7	161.6
2010/11	162.6	164.4
2011/12	165.3	169.1
2012/13	173.5	176.6
2013/14	176.1	180.9

CAGR (FY1999-2014)	**3.8%**	**4.0%**

Figure 4 shows the estimated Road and Rail TCIs and compares it to the CPI and the RBCI.

A more detailed breakdown of the principal cost components of road and rail projects such as direct labour costs, technical labour, materials and plant were analysed based on ABS data. The trends are shown in Figure 5 below. Details of the estimated series of indices for the principal components are shown in Appendix A.

Figure 5 shows that the cost of technical labour (sub-contractors) has grown faster compared to direct labour costs over the last 15 years (i.e. compound average annual rate of 4.9% compared with 3.8%). Internal labour costs for RMS and Sydney Trains increased at a similar rate of 3.8% and follow the increases granted under the various Public Service awards. Internal labour costs are forecast to rise on average by 2.5% p.a. On the other hand, prices for plant hire and equipment have remained relatively stable recording an average annual increase of 1.3%. Prices for materials such as bitumen and concrete and steel have also increased substantially at a compound average annual rate of 4.2% (see Figure 5.)

Figure 4: Road and Rail TCI vs CPI and RBCI

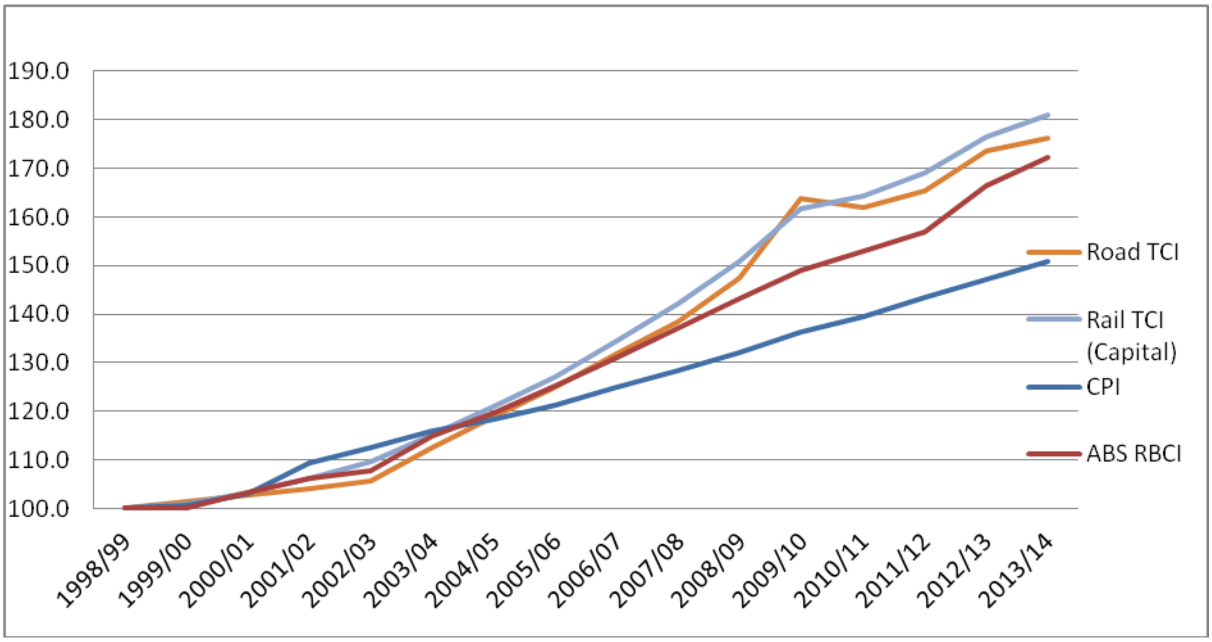
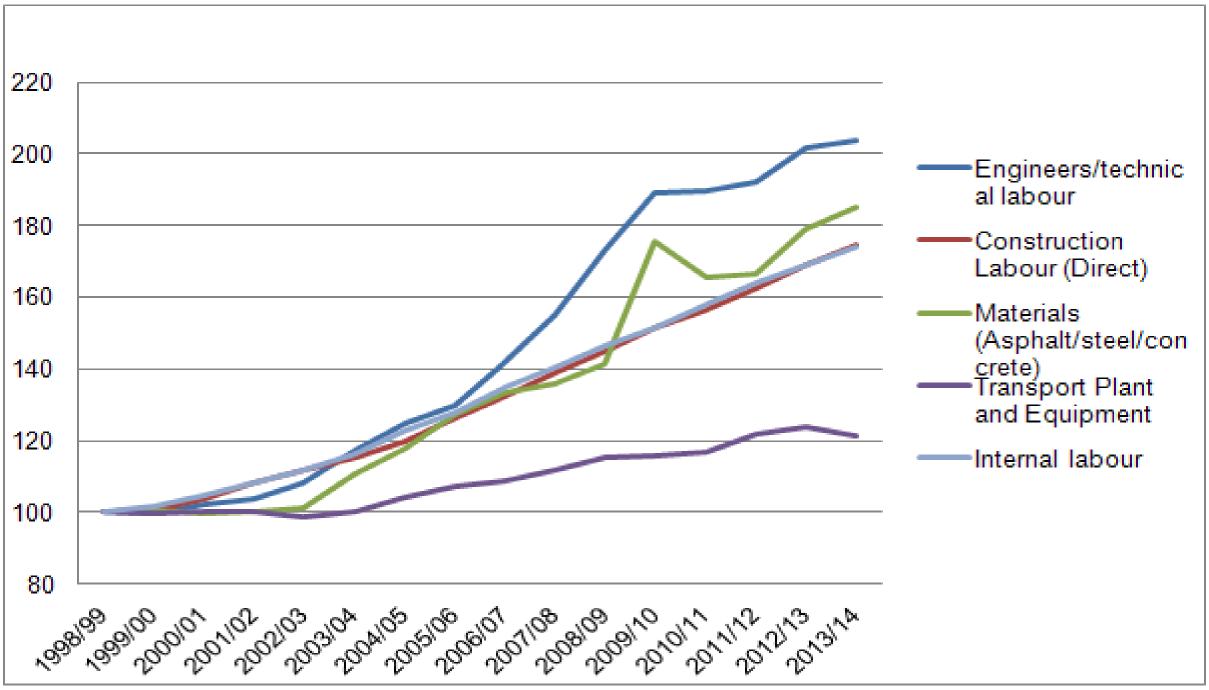


Figure 5: Comparison of Key Transport Construction Elements



3.2 Variation Analysis

In order to test the robustness of the weights used for compiling the Road TCI and Rail TCI variation analysis was performed by changing the composition of the largest cost component. This was done by assuming that construction labour comprises a larger percentage of overall costs than technical labour and internal labour charges are excluded. Table 6 shows the results of applying a new set of weights. Often the different types of labour costs are mixed in project costs and difficult to dis-aggregate. This test shows the impact of vastly different weights applied to various types of labour on the overall Road and Rail cost indices.

The Road TCI increased slightly from 3.8% to 4.0% whereas the Rail TCI increased slightly from 4.0% to 4.1%. This shows that the weights of the four key components (construction labour, technical labour, plant and equipment and materials) are relatively robust and can be used for estimating the Road and Rail TCIs and for forecasting.

Table 6: Variation Analysis

Expenditure Component	**Original Weight (%)**	**Test Weight (%)**
Road Construction		
Construction labour (Direct)	12	29
Technical labour	31	11
Internal labour	7	-
Plant, equipment and property	20	22
Materials	30	38
Road TCI	**3.8%**	**4.0%**

Rail Construction	Original Weight (%)	Test Weight (%)
Construction labour (Direct)	47	22
Technical labour	25	16
Internal labour	16	-
Plant and equipment	4	15
Materials	8	47
Rail TCI	**4.0%**	**4.1%**

3.3. Forecasting over the Next 5 Years

3.3.1. Methodology

There are various forecasting methods that can be used to forecast escalation factors for road and rail construction projects. One option is to consider broad economic trends in terms of fuel costs, material costs, import prices of plant and equipment, currency fluctuations and property prices. In this paper, the trends in principal component prices over the last 15 years is used in forecasting to 2019/20, except when forecasts can be made on the basis of more accurate information. For example, the public sector award increase for internal labour has been agreed with the public sector union at 2.5% pa for the next year and is assumed to continue until 2019/20, ceteris paribus. The Compound Average Growth Rate (CAGR) is used to estimate the cost escalation factors.

3.3.2. Forecast Escalation of Principal Components

Preliminary escalation factors for the 5 key components of technical labour, construction labour, internal labour, materials and plant are provided in Table 7. They are based on trend analysis of data from 1998/1999 to 2013-14 and are principally based on ABS data as detailed in Table 3. They may be used for comparing with actual cost of these inputs for road and rail projects.

Table 7: Forecast Escalation Factors for Key Components (% p.a.)

	Tech labour	Direct labour	Internal labour	Materials	Property Plant & Equipment
2014/15 – 2019/20	4.9%	3.8%	2.5%	4.2%	1.7%

Technical labour costs are forecast to increase at a rate of 4.9% pa based on previous trend in professional labour costs from the ABS data. Direct labour costs are forecast to increase by 3.8% pa. These are based on previous trend in wage rises from ABS data. Internal labour costs are assumed to grow at the award wage increase negotiated with the Government (i.e. 2.5% pa). Material costs are forecast to increase at an annual rate of 4.2% based on previous trend estimates over the last 15 years. These include price movements for concrete, bitumen and steel. Prices for property, plant and equipment are forecast to grow at

1.7% p.a. based plant and equipment historical growth of 1.3% and % changes in land property values of 6% pa[3].

3.3.3. Forecast Escalation Factors for Road and Rail Construction

Based on the above analysis, the cost escalation factors based on inflationary impacts for road and rail construction have been estimated. These are shown in Table 8 below. Road and rail TCI calculations resulted in escalation growth of 3.8% for road and 4.0% for rail.

Table 8: Forecast Annual Escalation Factors for Road and Rail Construction projects

	Road TCI	Rail TCI
2014/15-2019/20	3.8%	4.0%

These escalation factors are purely default values and apply to overall construction/capital works. They are more useful at a strategic phase of projects when costs need to be estimated over the next 3 to 5 years for budgeting purposes.

These forecast escalation factors need to be updated annually with new data when available.

4. Conclusions

Based on the above research it can be concluded that more appropriate cost escalation factors need to be used to estimate road and rail construction costs. The CPI is not an appropriate index and is likely to lead to an underestimation of project costs. The alternative indices of Road and Rail TCI may be used instead.

Acknowledgement
The views expressed in this paper are those of the author and not necessarily supported by Transport for NSW.

[3] Historical increases in land values of representative properties in Sydney Metropolitan Area, Newcastle Central Coast and Wollongong and country NSW, Land & Property Information (LPI)

Appendix A

Estimated Indices for Principal Components for Road and Rail Projects

Date	**Engineers/ technical labour**	**Construction workers**	**Internal Labour**	**Asphalt/ steel/concrete)**	**Transport Plant and Equipment**
1998/99	100.0	100.0	100.0	100.0	100.0
1999/00	99.5	100.8	101.8	100.6	99.7
2000/01	102.4	103.7	104.7	99.5	100.2
2001/02	103.9	108.0	108.1	100.1	100.1
2002/03	108.3	111.6	111.5	101.0	98.6
2003/04	117.3	115.3	116.1	110.8	99.9
2004/05	124.9	119.6	122.8	117.5	104.4
2005/06	129.9	126.1	128.1	127.4	107.4
2006/07	141.9	132.3	134.8	133.5	108.7
2007/08	155.2	138.7	140.6	135.8	111.7
2008/09	173.0	144.8	146.2	141.4	115.4
2009/10	189.1	151.5	151.3	175.7	115.5
2010/11	189.5	156.4	158.1	165.4	116.9
2011/12	192.0	162.6	164.0	166.4	122.0
2012/13	201.6	169.2	169.0	179.3	123.6
2013/14	203.8	174.8	174.2	184.9	121.1
CAGR 1998/99-2013/14	**4.9%**	**3.8%**	**3.8%**	**4.2%**	**1.7%**

Source: ABS (2013) Producer Price Index, Catalogue No. 6427.0, various tables and ABS Wage Price index, Quarterly index for estimation of construction labour costs of all workers in the private and public construction sector. (Catalog no. 6345, Series ID A2603589K).

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