Infometrics

The Case for Concrete Roads

for Concrete New Zealand

Prepared by Infometrics Ltd
December 2018

Table of Contents

In 2013 Infometrics produced a report for the then Cement and Concrete Association of New Zealand (CCANZ) entitled *Concrete Roads: Not Competitive?*

The report addressed issues such as the historical changes in the prices of petroleum products (which include bitumen) and non-metallic mineral products (covering cement and concrete), the choice of discount rates and time horizons for roading projects, and the outlook for future changes in prices.

A set of scenarios clearly demonstrated the case for concrete roads, reinforced by the expected trends in relative prices and greater certainty around cement prices than bitumen prices.

In this December 2018 report, Infometrics has updated the price data – historical and forward looking. Infometrics' previous conclusions stand.

Dr Adolf Stroombergen
December 2018

Email: adolfs@infometrics.co.nz

Infometrics

Executive Summary

This report investigated the high-level case for building concrete roads. It found in a baseline scenario comparing the economics of asphalt and concrete roads, that concrete is 25.1% cheaper than its asphalt counterpart.

The calculation took into account international prices, price volatility, the cost of carbon emissions and travel time disruption.

The price volatility of oil compared with cement is a material factor. The future trend of oil and cement prices look to further enhance the case for concrete roads. Petroleum products prices have risen 123% since 1994 and look likely to continue to increase annually at 4%. This is compared to a rise of just 55% in cement prices over the same period, with a projected annual increase of 1.8%.

Construction and maintenance costs constitute the largest components of roading investment, but increasing disruptions to travel time, caused by road maintenance, is a growing factor. The report found that an asphalt road has greater disruption to traffic over the road's lifetime, than its concrete counterpart.

Overall the difference in CO_2 emissions associated with concrete and asphalt roads is not significant. However, concrete roads have a range of environmental benefits, such as less tyre-rolling resistance and therefore lower fuel consumption, particularly for heavy vehicles, that further strengthen the case for concrete roads.

The report also found that some roading contracts include an escalation clause for the price of bitumen or oil. This transfers risk from the supplier to NZTA and can have the effect at the tendering stage of making asphalt pavement look cheaper than it really is. The escalation clause is in effect an implicit subsidy for one type of construction material in preference to any other.

Objective

In this report we look at the high level case for building roads with concrete pavement rather than asphalt pavement. We do not focus on fine detail – we are interested in whether there is a case for concrete pavement that is strong enough to be robust to minor changes in road construction detail.

Our base data comes from URS (2009).[1]

Discount rates

We start with four fundamental properties of discount rates:

1. *When a project delivers returns that can be reinvested at the same rate and risk profile as the project itself, the cost of capital is an appropriate discount rate. This discount rate should incorporate a market based risk premium.*
2. *However the capital cost of the project must truly represent the opportunity cost of that capital used for other investment.*
3. *If the project delivers intangible consumption benefits, the cost of capital will usually be an inappropriate discount rate. A social discount rate will be more appropriate.*
4. *Infrastructure investments which are designed to lift the productive capacity of the economy should attract a lower discount rate to reduce the likelihood of locking the economy into a low growth path with a low capital-labour ratio.(This argument should not be pushed too far – it applies only to projects that deliver long lasting benefits and that would not be undertaken by the private sector).*

We look at how each of the above affects the asphalt versus concrete debate.

Cost of capital

The standard Capital Asset Pricing Model (CAPM) is formulated in Treasury (2008)[2] as:

$$r_i=[r_f\,(1-t_c)+\beta_i . r_m]\,/\,(1-t_e)$$

r_i as the cost of capital for project **i**

r_f is the risk free rate
(e.g. on long term government stock)

r_m is the equity market risk premium

t_c is the corporate tax rate

t_e is the effective tax rate

β_i is the cov(r_i, r_m)/var(r_m) for assets of type **i**. A project with a high has a return that is highly correlated with the market return.

1. URS (2009): *Final Report: Addendum to SH20 Alternative Pavement Report: 2009 Evaluation*. Report to CCANZ.
2. Treasury (2008): Public Sector Discount Rates for Cost Benefit Analysis

Converting to a real rate: $R_i = [(1+r_i)/(1+\Delta p)]-1$

We assume that the returns from a road do not vary with the type of pavement – at least to within a first order effect. Nevertheless it is important that the cost of capital be at least approximately correct as for two projects with different time profiles of costs their relative present values are not independent of the discount rate.

Adjusting the parameter values given in Treasury (2008) for the lower corporate tax rate generates a cost of capital for infrastructure of about 7%. Treasury assume ß=0.65 for infrastructure, which seems to be based on the experience of just one company in the transport business. Thus this is likely to be an overestimate of the for roading infrastructure projects, so cost of capital should actually be lower than 7%.

Opportunity Cost

The cost of capital is also known as the social opportunity cost of investment; the implicit assumption being that government investment displaces other investment that would have earned a rate of return.

However, in the case of government investment in roading, this is unlikely to be the case. Funding to NZTA is 'dedicated' funding; secured from road user charges, fuel excise duty, and motor vehicles licensing and registration fees. The opportunity cost of this funding is likely to be lower private consumption, not lower (private) investment, albeit that road user charges in particular could have a small negative effect on private sector investment.

Thus the cost of capital is not the appropriate discount rate to use for NZTA projects, or at least it should be substantially reduced towards something like the Social Rate of Time Preference (SRTP), which is the appropriate rate for discounting when the opportunity cost of the project is in the form of less consumption.

The SRTP is usually expressed as:

$$r = d + \varepsilon . g$$

r is the social rate of time preference

d is the rate at which future consumption is discounted over current consumption

g is the annual growth of consumption per capita

Ɛ is the elasticity of the marginal utility of consumption

The variable d is frequently further disaggregated into two components:

$$d = \rho + C$$

ρ is the pure rate of time preference

C is the risk of a catastrophe which severely disrupts life on earth. See for example Stern et al (2006)[3] in connection with climate change.

There is much debate on the values of these variables, but this is beyond the ambit of this paper. The interested reader is referred to Parker (2009)[4] for example. Parker suggests that a reasonable value of the SRTP for New Zealand is around 3.0% – 4.0%.

Intangible Consumption benefits

Construction and maintenance costs constitute the largest components of roading investment and, as discussed above, they should be discounted at a conceptually appropriate rate for the cost of capital – not all countries have hypothecated taxation for investment in roading infrastructure.

Another cost component is the increase in leisure travel time that is caused by road maintenance. Leisure travel time is an example of an intangible consumption benefit. Savings in congestion costs associated with leisure travel cannot be cannot be reinvested for the benefit of future generations. Hence the discount rate for travel interruptions must therefore reflect inter-generational welfare comparisons. As above, there is no correct answer to what this discount rate – the social rate of time preference – is, but it is almost certainly less than the cost of capital.

As an asphalt road has greater disruptions to traffic over the road's lifetime, a lower discount rate applied to the cost of such disruptions will generate a more accurate estimate of their true value.

Long Term Infrastructure Investments

Grimes (2010)[5] argues that New Zealand likes to compare its standard of living with that in Australia. If Australia has a lower discount rate for infrastructure projects than New Zealand it will become a more capital intensive society, with a higher capital-labour ratio and hence higher wages and a higher standard of living.

The important point is that even if the discount rate adopted in New Zealand is theoretically correct, if it is higher than that adopted in Australia for similar projects relative living standards will eventually diverge. Migration of New Zealanders to Australia can be expected.

As with the discussion on the theoretically appropriate cost of capital, concrete and asphalt roads have different time profiles of costs so their relative present values are not independent of the discount rate.

3. Stern, N. et al (2006): *The Economic of Climate Change. HM Treasury.*

4. Parker (2009): "The implications of discount rate reductions on transport investments and sustainable transport futures." *NZTA research report 392.*

5. Grimes (2010): "The Economics of Infrastructure Investment: Beyond Simple Cost Benefit Analysis." *Motu Working Paper 10-05.*

Historical Price Trends

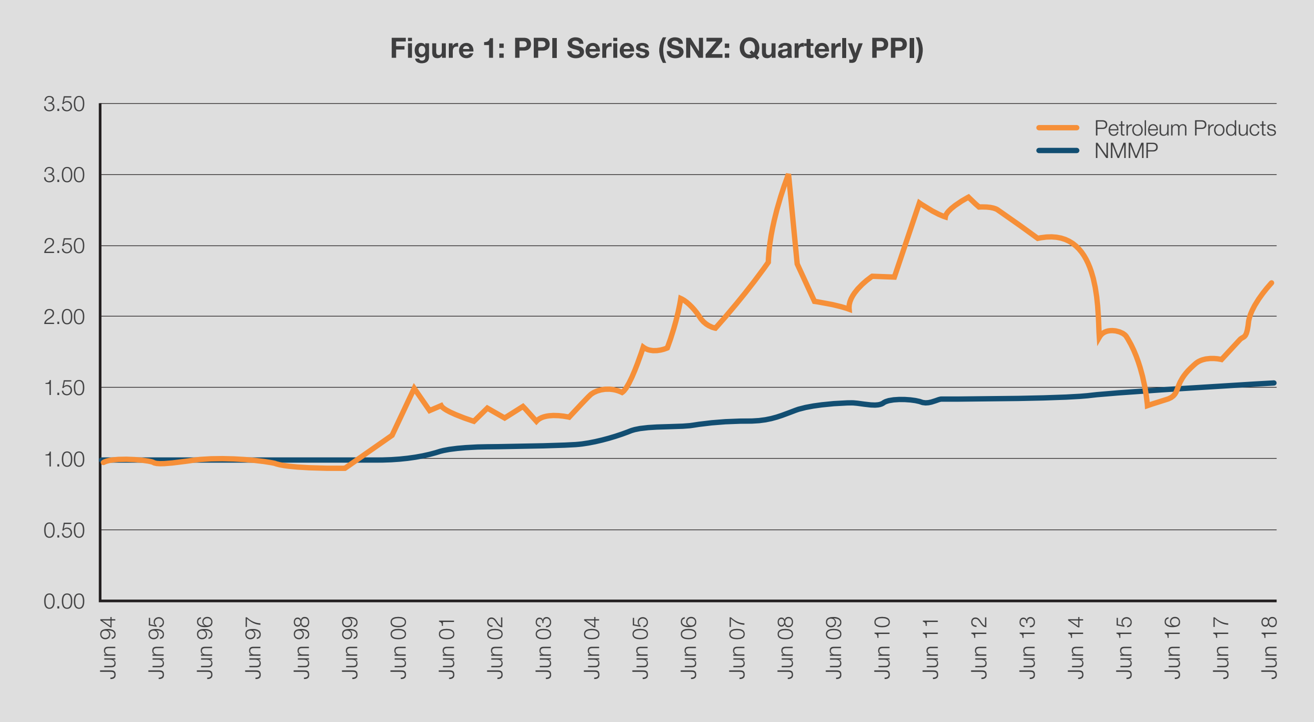


Figure 1 shows the Producers Price Indices (PPI) output series for two industries, Petroleum Products and Non Metallic Mineral Products (NMMP).

Producers Price Indices

The cost of asphalt typically represents 52-68% of the costs for asphalt pavement, and the cost of concrete is around 58% of the cost of continuously reinforced concrete pavement. As these proportions are similar we infer that the cost of asphalt pavement is as sensitive to the price of oil as the cost of concrete pavement is to the price of cement.

Accordingly these two PPI series are likely to be reasonable proxies for the price trends in bitumen and concrete.

Since 1994, NMMP prices have risen by an average 1.8% pa while Petroleum Product prices have rises by 4.0%. The cumulative increases are 55% and 123% respectively.

Price Volatility

Price volatility is a separate issue from price trends. Some cost-benefit analysts adopt a higher discount rate to allow for volatility in input prices, but this shows a poor understanding of the concept of discount rates and can generate very perverse results. In particular if the discount rate for asphalt pavement is lifted above that for concrete pavement because its cost is more uncertain, the effect would be to lower the discounted cost of asphalt, thereby encouraging its use!

Figure 1 clearly shows that the Petroleum Products price is more volatile than the NMMP price. The summary statistics in Table 1 confirm that this is indeed the case, with the standard deviation of the de-trended NMMP price index being only about one tenth of that for the de-trended Petroleum Products price index.

Table 1:
De-trended Series Summary Statistics

	Petroleum	NMMP
Mean	-0.003	-0.001
Standard deviation	0.039	0.420

Covariance

The volatility in commodity prices raises the question as to whether their volatility is correlated to the volatility in real GDP. Such as, feedback effect could be important when forecasting future prices.

The relationship between commodity prices and economic growth is not straight-forward. Fast economic growth can put upward pressure on prices, but rising prices can lead to lower growth. Thus, correlation could be positive or negative and may depend on an appropriate treatment of lags. However, our interest is not in the covariance between trends, but in the covariance between the de-trended series.

Table 2 shows some simple correlation coefficients between real GDP (de-trended and de-seasonalised) and commodity prices (just de-trended as they are not seasonal). Although the coefficients are not particularly strong; two observations are made:

1. The commodity price movements tend to lead changes in GDP with a negative effect.
2. Changes in the Petroleum Products price have a slightly stronger effect than changes in the NMMP price.

The implication is that future changes in GDP are unlikely to have a major effect on the cost of concrete or asphalt, but the prices of those commodities (notably oil) can impact GDP growth and therefore construction activity.

Table 2: Correlation Coefficients

Commodity price lead or lag	NMMP	Petroleum Products
Lag 4 quarters	0.070	-0.067
Lag 3	-0.020	-0.125
Lag 2	-0.117	-0.204
Lag 1	-0.199	-0.282
Contemporaneous	-0.262	-0.342
Lead 1	-0.337	-0.405
Lead 2	-0.403	-0.468
Lead 3	-0.437	-0.517
Lead 4	-0.479	-0.533

Future Price Trends

What are the likely future paths of prices for concrete and bitumen, as proxied by NMMP prices and oil prices respectively?

Concrete Prices

Figure 2 reproduces the NMMP producer price index from Figure 1 and adds the All Industries producer price index, as a measure of general price inflation. The trend rate of increase in NMMP prices since 1994 has been 1.8% per annum, below the rate of 2.3% pa for All Industries.

A naive assumption of a continued slow escalation in NMMP prices below the general rate of inflation, would seem a reasonable forecast. We are not aware of any forecasts of the All Industries PPI, but as a guide, since 1994 the CPI has averaged 2.1% pa, so just below the All Industries PPI. As long as monetary policy does not change significantly we can expect the CPI to change by around 2% pa. Hence NMMP price changes are likely to be of a similar amount, perhaps slightly less.

It is also worth reiterating the assumption that changes in the price of output from the NMMP industry are a reasonable proxy for the changes in the price of concrete.

Bitumen Prices

Bitumen price forecasts present a rather greater challenge, as there are two significant underlying prices involved: the oil price in US dollars and the US$/NZ$ exchange rate.

Figure 3 depicts oil prices in both US$ and NZ$. It demonstrates that the NZ price closely follows the US price despite the movements in the NZ dollar.

In NZ$ terms the oil price has risen by an average 9.7% per annum since 1994, but with substantial volatility – the standard deviation of the annual changes is 26.4%.

Figure 2: PPI Output for NMMP and All Industries

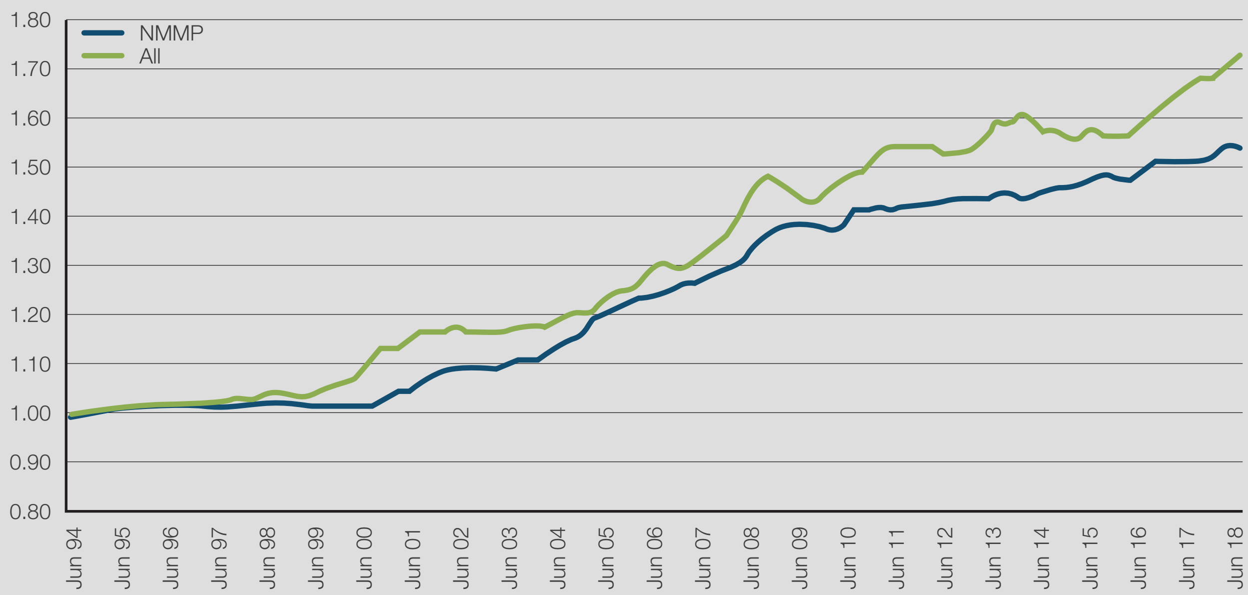
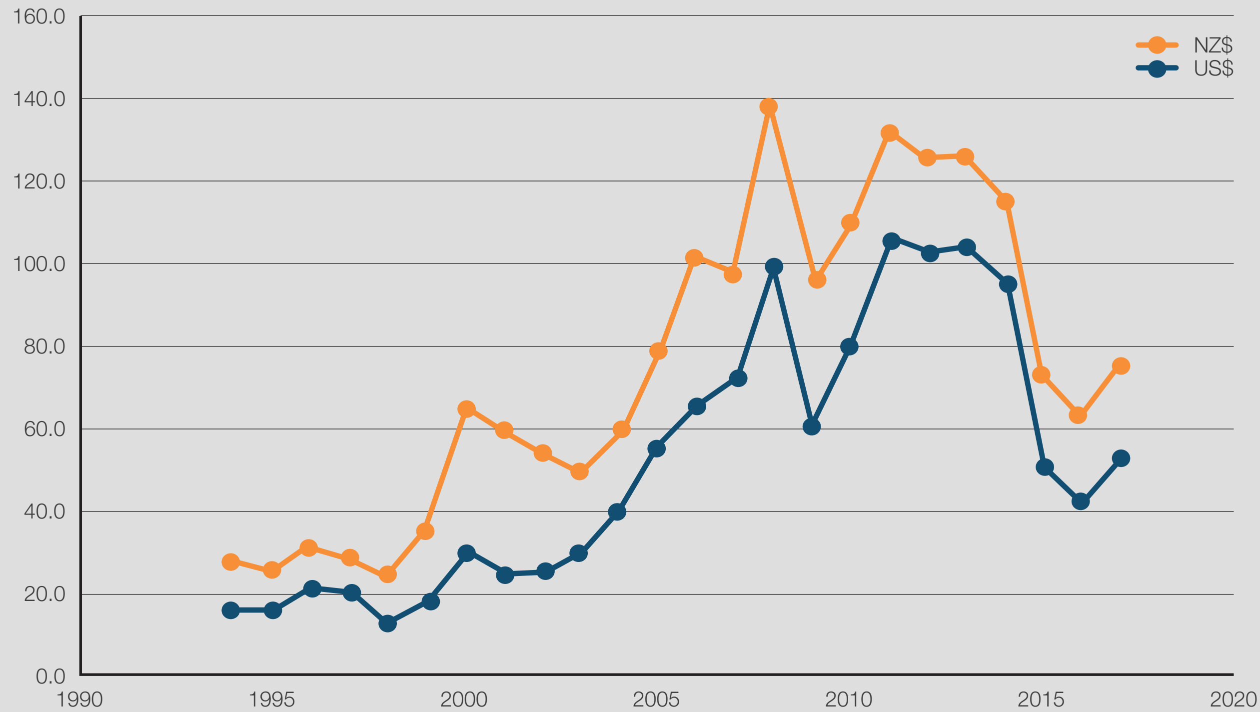


Figure 3: Oil Prices - Brent Crude ($/bbl)



There are many projections of oil prices, depending on assumptions about influences such as political conflict, future fuel substitution in transport (notably electric vehicles) and the marginal cost of supply.

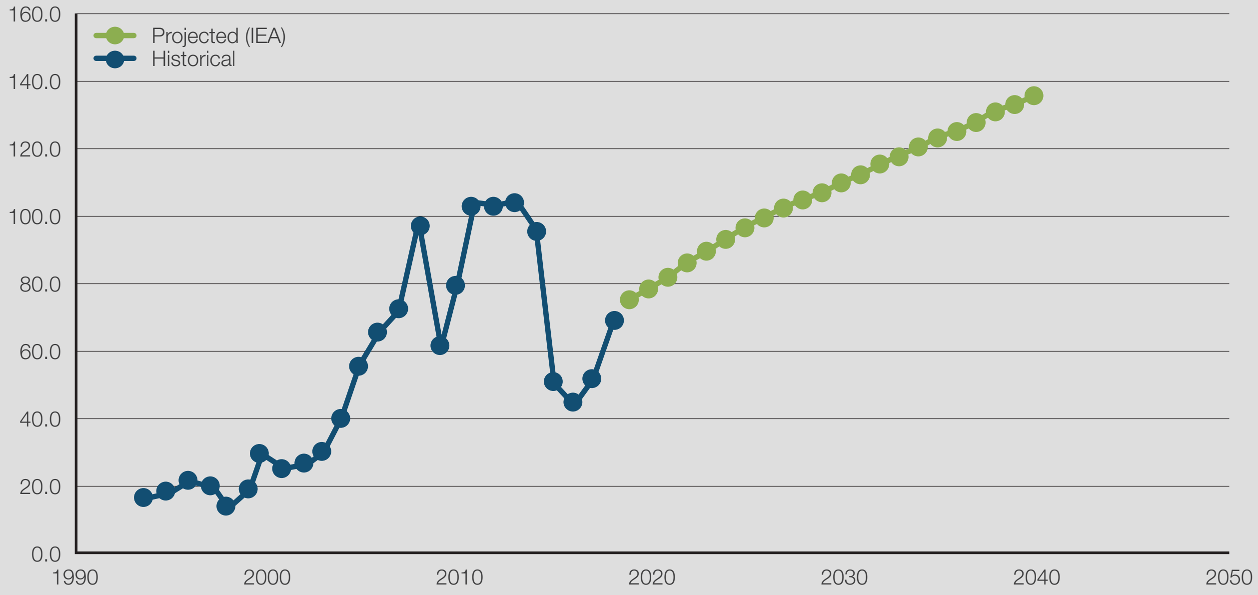
The projection in Figure 4 is based on forecasts from the International Energy Agency[6]. We use their Current Policies scenario, under which the price increases from US$75/bbl in 2019 to US$136/bbl in 2040. The average rate of increase is 2.9% pa.

Clearly there is very likely to be considerable volatility around this trend, but that is even more difficult to predict than the trend. For example, in the month preceding the date of this report the price has fallen by more than US$20.

With regard to the value of the New Zealand dollar, since 1994 it has averaged about US$0.66, but ranging between US$0.42 and US$0.83. We think that US$0.65 is a reasonable trend value to project forward. Again, however, volatility is to be expected. As at the date of this report the exchange rate is around US$0.69, so a small depreciation is implied.

6. International Energy Agency (2018) World Energy Outlook.

Figure: 4 Oil Price Projections (US$/bbl)



A factor that may be important is the potential for refineries to process the heavier waste components of crude oil into transport fuel, which is more valuable than bitumen. Additional pressure on bitumen prices could result, but the size of any effect is not known at this stage.

There are also two institutional issues that could be affecting the price of asphalt pavement:

1. *We understand that some roading contracts include an escalation clause for the price of bitumen or oil. This transfers risk from the supplier to NZTA and can have the effect at the tendering stage of making asphalt pavement look cheaper than it really is. While there is an argument for this type of risk re-allocation, it does need to be properly costed which means that NZTA must undertake the type of scenario testing described above if road users are to receive value for money.*
2. *Quite independently of the direct cost impact of an escalation clause, a possible indirect effect is that a segment of the road construction industry could be artificially priced out of the market, implying less competition and (ceteris paribus) higher tender prices.*

To understand the price impacts of these issues more fully requires discussion with industry and NZTA.

Climate Change

Both bitumen and concrete are relatively high in CO_2 emissions, although the CO_2 released in the construction and maintenance of roads is about two orders of magnitude smaller than the emissions released by vehicles that use the road. The following data is from Eupave.[7]

Table 3: kt of CO_2e /km (30 years)

	Concrete	Asphalt
Construction	2.1 – 2.8	1.4 – 1.7
Maintenance	0.1 – 0.2	0.9 – 1.4
Total	2.2 – 3.0	2.1 – 3.1

While concrete roads emit more emissions in their construction than asphalt roads (driven by the calcination of lime and the high use of energy – often coal – in the production of cement), the excess is cancelled out by the much lower amount of maintenance required for concrete roads.

Overall the difference in emissions is not significant, with the relative net effect depending on the amount of recycled material used and on the specifics of the road's composition and structure.

A 40 year horizon rather than the assumed 30 year horizon would presumably tilt the balance somewhat in concrete's favour.

There is evidence that because concrete roads are harder than asphalt roads they generate less tyre rolling resistance, implying less fuel use, especially by trucks. They may also require less lighting at night due to greater light reflection. However, whether these effects are large enough to outweigh the uncertainty range in Table 1 is not known.

Given these results we expect that the pure impact of a price on emissions is roughly neutral between the two options, and indeed is likely to depend more on the allowances and special treatment that each industry receives under the New Zealand Emissions Trading Scheme (ETS) than on the actual carbon price.

The Marsden Point refinery is largely exempt from the ETS, coming under a Negotiated Greenhouse Agreement which obliges it to move to 'world best practice' production technology – an arrangement that preceded the ETS and is likely to be extended. Cement production in New Zealand currently receives a generous allocation of free emission units. Thus neither concrete nor asphalt is currently significantly exposed to a carbon price.

Broadly speaking we do not expect a carbon price to favour one road construction option over another, unless contracting authorities take a particularly short-sighted view.

7. European Paving Concrete Association (date unspecified): Life Cycle Assessment for Road Construction and Use.

Scenario Analysis

We present the results of a number of scenarios based on the points raised above. For our baseline we adopt the numbers in URS (2009) for two options for the SH20 Mt Roskill project; Structural Asphaltic Pavement and Continuously Reinforced Concrete Pavement (CRCP) with Exposed Aggregate finish – this being the most expensive of the four concrete options presented. Thus we deliberately weight the analysis against concrete pavement.

The following scenarios are tested:

1. *Baseline scenario with a discount rate of 8% and a 30 year horizon.*
2. *A lower discount rate (7%) to reflect a lower cost of capital in line with updated parameter values in the CAPM model, or reflecting the desire not be relatively capital-shallow with regard to infrastructure, compared to Australia. Arguably 7% is still too high. The value of β is not changed from Treasury's assumption.*
3. *An extension of the horizon to 40 years to better capture the longer life of concrete pavement, although this is probably still too short.*
4. *For congestion caused by road maintenance, a reduction of the discount rate to a rate approaching the social rate of time preference, in line with the benefit of leisure travel being an intangible consumption benefit. (Note that not all travel is leisure travel, so the result could be over-stated).*
5. *For the projects as a whole, a reduction of the discount rate to a rate approaching the social rate of time preference, in recognition that NZTA funding comes largely from displaced consumption rather than displaced investment.*

Table 4 summarises the results. As may be seen in the first two lines, the URS calculations can not be replicated exactly, but the differences are immaterial.

Table 4: Cost of Asphalt v Concrete Pavement

	Scenario	Discount Rate (%)	Horizon (years)	Asphalt ($m)	CRCP (EAP) ($m)	Difference
	Cost as per URS	8.0	30	52.725	39.483	-25.1%
1	Our 'replication' (baseline)	8.0	30	52.720	39.482	-25.1%
2	Change cost of capital	7.0	30	55.442	40.623	-26.7%
3	& change horizon	7.0	40	57.325	41.580	-27.5%
4	& maintenance discounted at 4%	7.0/4.0	40	58.318	41.580	-28.7%
5	All discounting at 4%	4.0	40	72.197	47.746	-33.9%

In the baseline scenario the concrete option is 25.1% cheaper than the asphalt option. Lowering the discount rate by one percentage point raises the cost difference to 26.7%.

Extending the time horizon has a small additional effect on the cost difference, but in the main illustrates the point that extending the time horizon for the analysis is a largely academic exercise as long as the discount rate sits around the social cost of capital.

With the discount rate set closer to the theoretically more appropriate social rate of time preference, the cost difference widens to 28.7% if the lower rate is applied only to maintenance disruption costs, and to 33.9% if it is applied to all cost components.

With these sorts of differences the so-called uncompetitiveness of concrete pavement is a mystery.

As discussed above, expected price volatility is likely to further enhance the case for concrete, simply because the oil price is likely to be more volatile than the cement price.

Because the cost of asphalt pavement is as sensitive to the price of oil/bitumen as the cost of CRCP is to the price of cement/concrete, there is no additional relative advantage or disadvantage to either type of pavement. For example, if the cost share of concrete in CRCP was less than the cost share of asphalt in asphalt pavement, volatility in raw material prices would be more of an issue for the latter.

Infometrics