Modelling New Zealand Road Deaths to 2025

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Abstract

New Zealand is developing an integrated road safety intervention logic model. This paper describes a core component of this wider strategic research: a baseline model that extrapolates New Zealand road deaths to 2025. The baseline will provide context to what the NZ Transport Agency is trying to achieve.

Several time-series models were investigated; these produced a range of forecasts of road deaths in the New Zealand context.

In the final modelling an Autoregressive integrated moving average (ARIMA) model and two differing autoregressive distributed lag (ARDL) models were developed. A preferred model was identified and used to forecast.

Background

The NZ Transport Agency is leading the development of an integrated road safety intervention logic model with sector partners including NZ Police, Ministry of Transport (MoT) and the Accident Compensation Corporation (ACC). The Integrated Intervention Logic Model (IILM) is a tool to inform strategies aimed at improving safety across the network. New Zealand is working hard to reduce road trauma by implementing current and proposed interventions. The model allows users to select a suite of actions and activities, the treatment and for them to prescribe the degree of each, the dose. The model then calculates potential deaths and serious injuries (DSI) savings from that combination of interventions. The dependency, union, dominance or independent nature of the interventions are used in determining the combined effect. The model also accounts for changes in effectiveness of an intervention dependent on the dose and using a projected baseline the effect of implementing over time.

The main aim of the study presented here was to model a baseline of road deaths in New Zealand from 2018 to 2025. It is considered that time-series models are appropriate for this purpose.

There is a large literature on factors that influence the underlying frequency of road trauma. A review (NZTA, 2019) of major studies carried out in New Zealand, Australia and selected overseas countries (BITRE, 2014; Chukwutoo et al., 2018; Commandeur et al., 2013; Ministry of Transport, 2017; Oreko et al., 2017; Sanusi et al., 2016).

Methodologies used to model road deaths vary widely and have included simple and multiple regression analyses, Poisson regression analyses, negative binomial regression models, logit and probit models, random parameters models, fuzzy logic models and ARIMA models.

Successful time-series forecasting depends on fitting an appropriate model to the underlying time-series.

Method

Quality data at set intervals over a reasonable timeframe is necessary for the best predictive models. Data was sought from 1990 to 2017. The range collected was extensive; over 50 variables were collected and correlations between pairings of the most promising variables were tested.

Several time-series models were investigated; these produced a range of forecasts of road deaths in the New Zealand context. ARIMA and ARDL models proved most successful in forecasting road deaths. In the final modelling an ARIMA model and two differing ARDL models were developed.

The explanatory variables used in the final modelling of road deaths as stated above were: petrol price, unemployment, young population and GDP. All have strong Pearson correlation coefficients.

Explanations for these relationships, although out of scope, are discussed in the research report (NZTA, 2019), as it is necessary to understand, especially regarding the relationships to road use.

Results

All three models show that both petrol prices and unemployment are negatively/inversely related to road deaths. In other words, if petrol prices and unemployment decrease, road deaths increase.

The ARIMA model (1,0,1) forecast indicates that road deaths will continue to rise from 2018 to 2025, influenced by the recent rising trend from 2014 to date and the spike in 2017. These recent factors do not reflect the time-series. The results show that the ARIMA model underestimated road deaths, on average by around five percent.

Both ARDL models forecast a flattening trend in road deaths: a slow rise early in the forecast period followed by a decline. This has now been seen to have happened since completing the modelling to date. The ARDL model 2 differs from ARDL model 1 as it includes a demographic variable: population of persons aged 15 to 24. ARDL model 2 shows that, in addition to the economic variable (petrol prices) and socio-economic variable (unemployment), the number of people aged 15 to 24 in the population acts positively on road deaths. ARDL model 2 is the preferred model because of this.

ARDL Model 2 is summarised in Table 1 and Figure 1. It should be noted that the Adjusted R-squared of both ARDL models is around 0.8. All variables in both models have the correct signs.

Table 1: ARDL Model 2 summarised

Variable	Coeff.	Std. Err	P-Value	95% CI
Lag 1 log road deaths seasonally adjusted	0.2952571	0.0921223	0.002	0.1126157 0.4778984
Lag 1 log petrol price real and seasonally adjusted	-0.5380974	0.1360431	0.000	-0.8078161 -0.2683786
Lag 1 log unemployed seasonally adjusted	-1.171861	0.2040765	0.000	-1.576463 -0.7672598
Lag 1 log population aged 15-24 years	1.308681	0.4113065	0.002	0.4932258 2.124136
Constant	15.62295	2.421833	0.000	10.82143 20.42447
Adjusted R-squared	0.8008			

Engle-Granger Cointegration Test

Test Statistic	**1% Critical Value**	**5% Critical Value**	**10% Critical Value**
Z(t) -11.029	-3.507	-2.889	-2.579

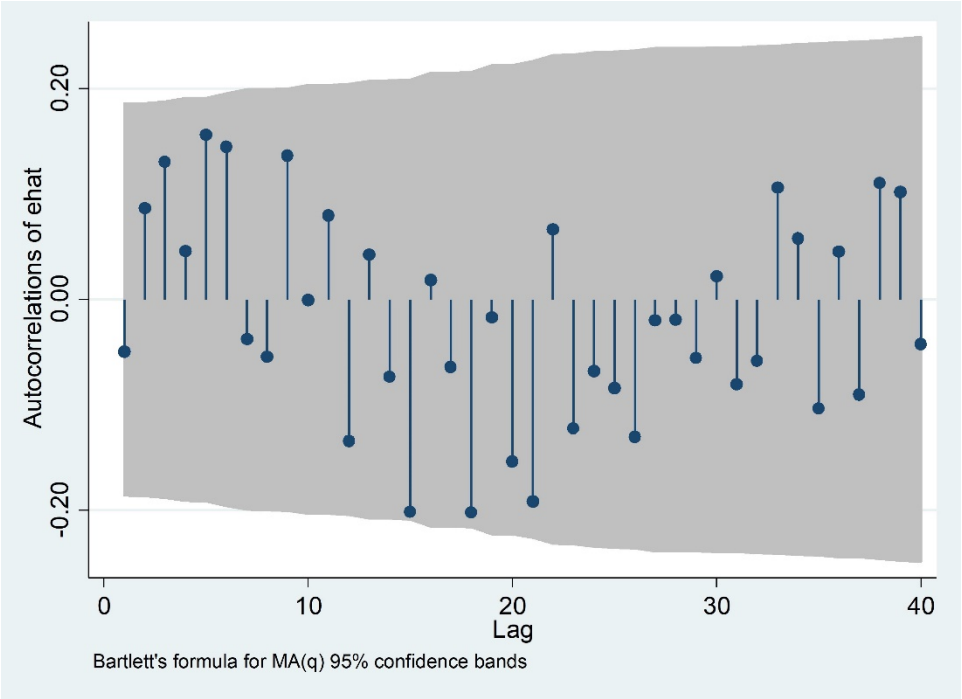
Breusch-Godfrey LM test for autocorrelation

Lags (p)	**chi^2**	**Df**	**Prob > chi^2**
1	1.585	1	0.2080

Durbin's alternative test for autocorrelation

Lags (p)	**chi^2**	**Df**	**Prob > chi^2**
1	1.521	1	0.2174

Residual Correlogram of ARDL Model 2



Results of ARDL Model 2 Quarterly Road Deaths 1990 to 2025

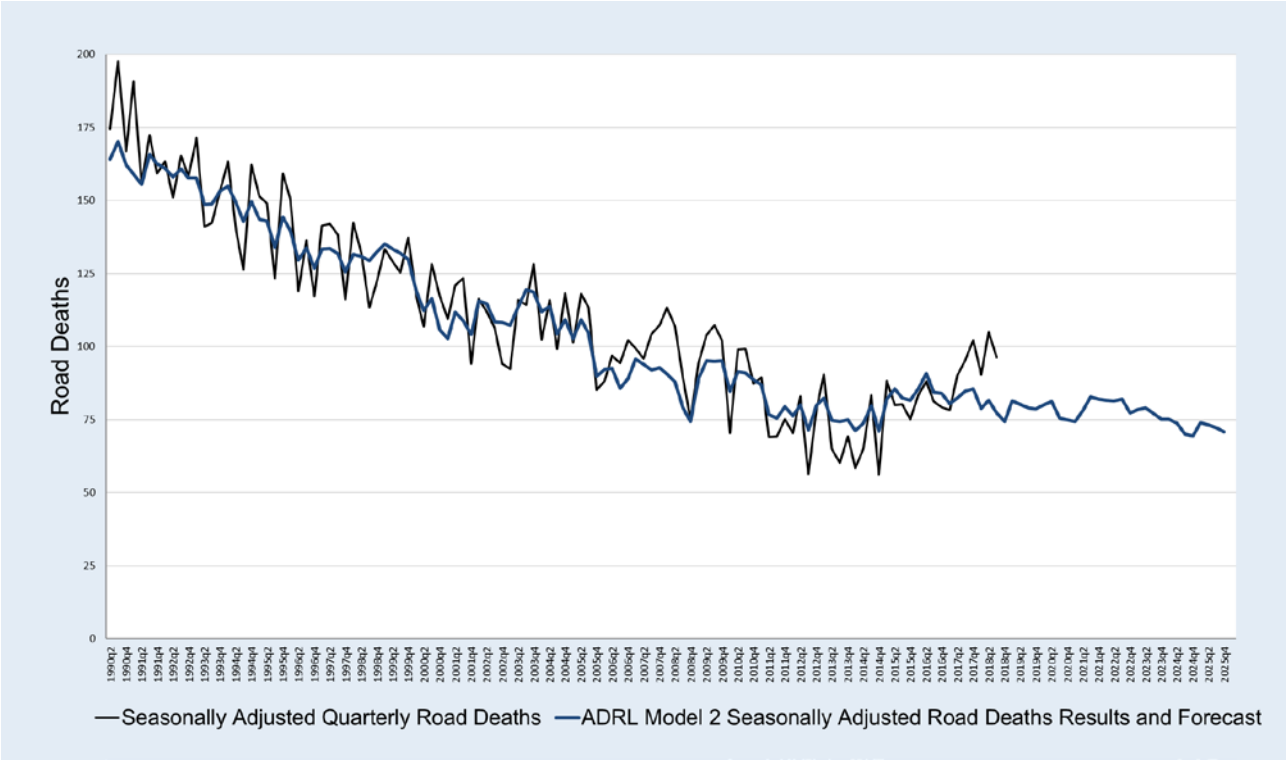


Figure 1: Residual Correlogram and Results of ARDL Model 2

Forecast

The reliability of the forecast is dependent on the accuracy of forecasting future youth population, petrol prices and unemployment. The approach taken in forecasting these explanatory variables was to use the Holt-Winters algorithm, a seasonal exponential smoothing algorithm (ETS AAA) and harmonic analysis of unique longer waveform periods of each variable. The forecast variables were used in conjunction with the ARDL model 2 coefficients to forecast quarterly road deaths to 2025.

Conclusion

The selected ARDL model was, after much trial and experimentation, identified as the preferred time-series approach for forecasting road deaths in New Zealand. The predicted results will in time be exposed with hindsight, but at this early stage the forecast from this ARDL model looks to be valid and is being used for predicting the baseline of the integrated road safety intervention logic model being developed in New Zealand.

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