Memorandum: Modified light petrol VKT forecasting models

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Introduction

The NLTF revenue forecasting model prepared earlier this year by Covec for the Ministry of Transport contained several econometric forecasting models, one of which was a model of light petrol VKT per capita. This model predicted quarterly light petrol VKT per capita as a function of:

- The quarterly average real petrol price
- Seasonally adjusted quarterly real GDP per capita
- A linear time trend to model changes in light petrol VKT per capita that are not due to changes in petrol prices or GDP, eg behavioural shifts between types of vehicles or transport modes
- Quarterly dummy variables to pick up seasonal effects; and
- A one-quarter lag of light petrol VKT per capita, to model dynamic adjustment.

The model was estimated using data from 2001Q1 to 2013Q3 and explained 99.5% of the variation in quarterly light petrol VKT per capita during that period. The estimated real petrol price elasticity in the short run (ie in the same quarter as a price change) was -0.044, with a 95% confidence range from -0.029 to -0.058. Taking account of the estimated lag effect, this was estimated to increase to -0.08 in the long run, with a 95% confidence range from -0.049 to -0.103.[1]

The Ministry has subsequently adapted the light petrol VKT model for use within its "Future demand quantification model". Peer review of that model noted that the estimated petrol price elasticity was somewhat low, ie that light petrol VKT per capita was relatively insensitive to price changes. To address this, the Ministry has asked Covec to re-estimate the model with restrictions imposed on the price elasticity.

Specifically, we have re-estimated the model with the same variables and data as above but assuming short-run price elasticities of -0.1, -0.2, and -0.3. For reasons that will become apparent below, we also tested a model with an elasticity of -0.15. Our approach was to estimate restricted regression models in which the coefficient on the petrol price

[1] The long run elasticity is equal to the estimated short run elasticity divided by one minus the estimated coefficient on the lag of per-capita VKT.

variable was set equal to one of the three values above. The other coefficients of the models were left free to best fit the per-capita light petrol VKT data given the elasticity constraint, using the usual least-squares approach. The results of these alternative models are presented below, and we have provided a modified version of the future demand model that includes these as well as the original model.

Results

Table 1 shows the estimated coefficients of the original model and the restricted models of per-capita light petrol VKT. The estimated long-run price elasticity in each case is also shown at the bottom of the table. In comparison with the original model:

- There is some loss of explanatory power caused by restricting the petrol price elasticity. This is to be expected because a constrained model cannot fit the data as well as a model where all coefficients are free to "best fit" the data. This loss is relatively minor for the e = -0.1 model, but restricting elasticity to -0.2 sacrifices around 5% of explanatory power and restricting to -0.3 reduces explanatory power by more than 12%.

- There are significant changes in some of the other estimated coefficients of the model. In particular the elasticity with respect to real GDP per capita increases from 0.3 in the original model to almost 1.2 in the e = -0.3 model. The coefficient on lagged VKT per capita also changes significantly, which will affect the dynamics of forecasts produced by the model. These other changes mean the impact of changing the petrol price elasticity on the VKT forecast is not straightforward to predict.

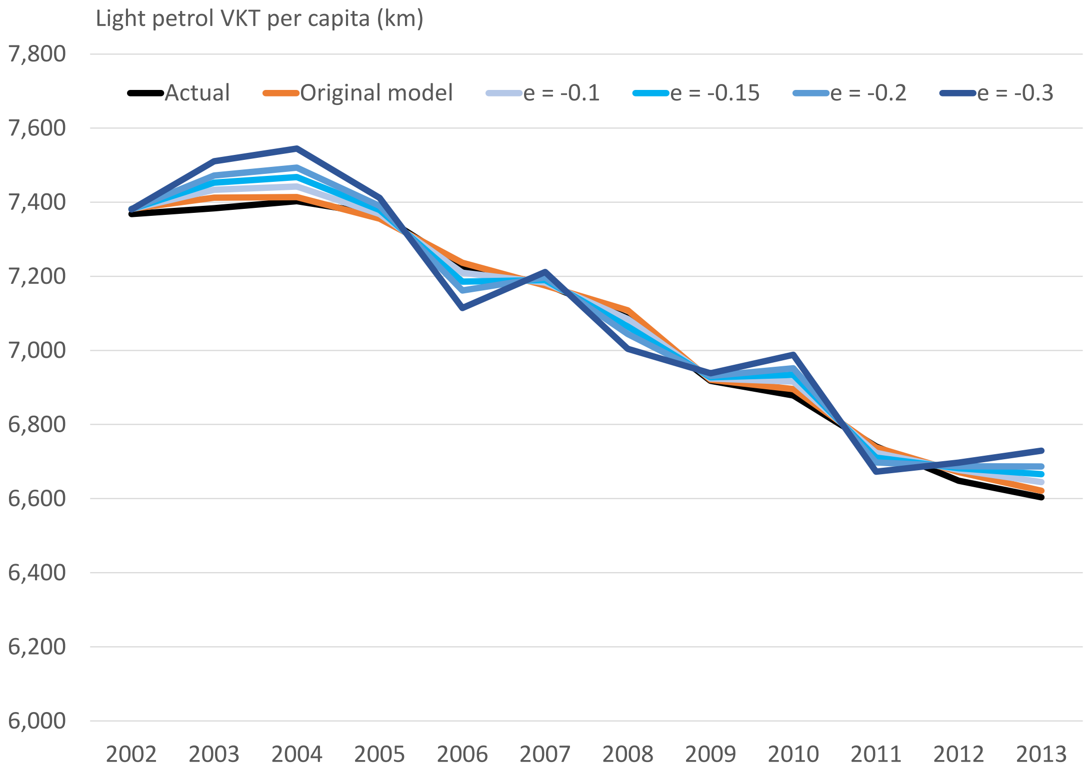
Table 1 Estimated coefficients of alternative regression models for light petrol VKT per capita. In all cases the dependent variable is the natural logarithm of quarterly light petrol VKT per capita.

Variable	Original	e = -0.1	e = -0.15	e = -0.2	e = -0.3
ln(Real petrol price)	***-0.043	-0.100	-0.150	-0.200	-0.300
ln(Real GDP per capita SA)	***0.303	***0.490	***0.657	***0.823	***1.155
Time trend	***-0.002	***-0.002	***-0.003	***-0.003	***-0.004
Q2 dummy	***-0.006	***-0.007	***-0.007	***-0.007	***-0.008
Q3 dummy	0.001	-0.002	**-0.005	***-0.007	***-0.013
Q4 dummy	***0.018	***0.012	***0.007	0.002	***-0.009
ln(lagged VKT per capita)	***0.427	***0.197	-0.007	***-0.211	***-0.619
Constant	***1.832	***2.171	***2.472	***2.773	***3.375
R-squared	0.995	0.988	0.970	0.943	0.869
Long-run price elasticity	-0.076	-0.125	-0.149	-0.165	-0.185

*** Significant at the 1% level ** Significant at the 5% level * Significant at the 10% level

The loss of explanatory power caused by restricting the petrol price elasticity is illustrated further in Figure 1 on an annual basis. However, the reduction in the goodness of fit may be considered to be acceptable if there is good reason to believe that the petrol price elasticity should be different from the level estimated in the original model, for example on the basis of other petrol price elasticity estimates in the literature.

Figure 1 Actual and fitted values of the alternative models (annual totals).



The forecasts of annual light petrol VKT per capita produced by the alternative models are illustrated in Figure 2 for the "medium" scenario in the future demand model. In the short term the models with higher price elasticity produce higher VKT per capita forecasts, because the medium scenario assumes real petrol prices fall until 2017. In the longer term real petrol prices are assumed to rise, but in the VKT per capita forecasts this is more than offset by growth in GDP per capita, due to the fact that the restricted models also imply a higher elasticity with respect to GDP as discussed above.

The change in the coefficient on lagged VKT per capita also has important implications if the models are to be used to analyse petrol price scenarios. Figure 3 shows how the elasticity of VKT with respect to a one-time petrol price shock changes over time in each of the models. The negative lag coefficients in the e = -0.2 and e = -0.3 models generate instability in the projections, and also imply that VKT is less price sensitive in the long-run than in the short-run.

The e = -0.15 model has almost exactly the same elasticity in the short run and the long run, due to the coefficient on lagged VKT being almost zero.[2] This model represents the greatest price elasticity that can be imposed without generating instability in the response to price changes.

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[2] The estimated coefficient on lagged VKT is statistically insignificant and this variable could be dropped from the model, however we have retained it to maintain consistency with the other models.

Figure 2 Forecasts produced by the alternative models in the “medium” scenario.

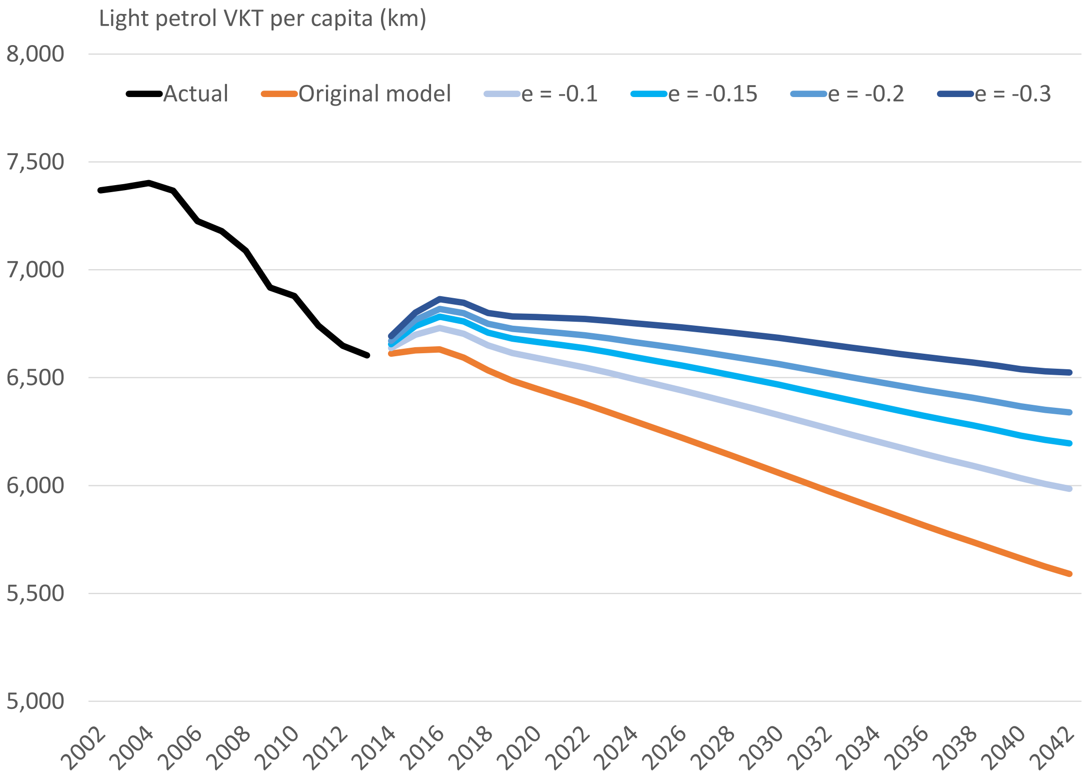

Figure 3 Dynamic price elasticity implied by the models.

Recommendations

The greater the departure from the original price elasticity that is imposed on the model, the larger is the loss of explanatory power. Larger departures also generate other problems including instability of the projected response to petrol price changes, and reduced sensitivity of VKT to petrol price changes in the long run.

For these reasons it is recommended that any adjustment to the petrol price elasticity in the light petrol VKT per capita model is as small as possible. The model with elasticity of -0.1 generates acceptable results but the models with elasticity of -0.2 and -0.3 become increasingly problematic. An elasticity of -0.15 is the greatest that can be imposed without generating instability in the long run, and if the elasticity is to be constrained, we recommend that it be at -0.15 or less.