Transformation of the Australian Car Fleet: Likely Responses to Current and Projected Petrol Price

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Abstract: Petroleum reserves appear to be adequate to meet a projected increase of 38% in world consumption by 2020. Current oil price is well below the spike in 1979-80 and, with an optimal OPEC strategy of supplying a little under half the market, price is likely to reach the October 2005 (real) price again by about 2020. Current petrol price is stimulating changes that were already rational at a much lower petrol price.

The two transparently rational changes are to LPG fuelled cars and to hybrid petrol-electric cars – perhaps both together. Ethanol and possibly methanol will also play a part. Hydrogen cars are still well into the future. A substantial change in the car fleet towards the more fuel-efficient vehicles has three aspects: new car purchases, LPG conversions and scrapping of inefficient cars. Now that the merits of LPG are more fully recognised, purchase of factory-fitted LPG cars will become more common.

For the new car market, this paper will revisit the complex demand relationships between the major car types and the major fuels. The topic is complicated by design acceptability, some more or less faulty perceptions and lags in response. Regardless of the speed of change in the new car market, the rate at which the whole fleet changes depends on the scrapping of used cars. A fairly simple analysis shows that the used car market's accelerated discounting of the resale price of inefficient cars is unlikely to remove them from the fleet in appreciable numbers.

INTRODUCTION: THE PETROLEUM MARKET

At the time of writing, people are still getting over the shock of steep rises in petrol price. To the end of the September Quarter of 2005, the trend in real price was as in Figure 1.

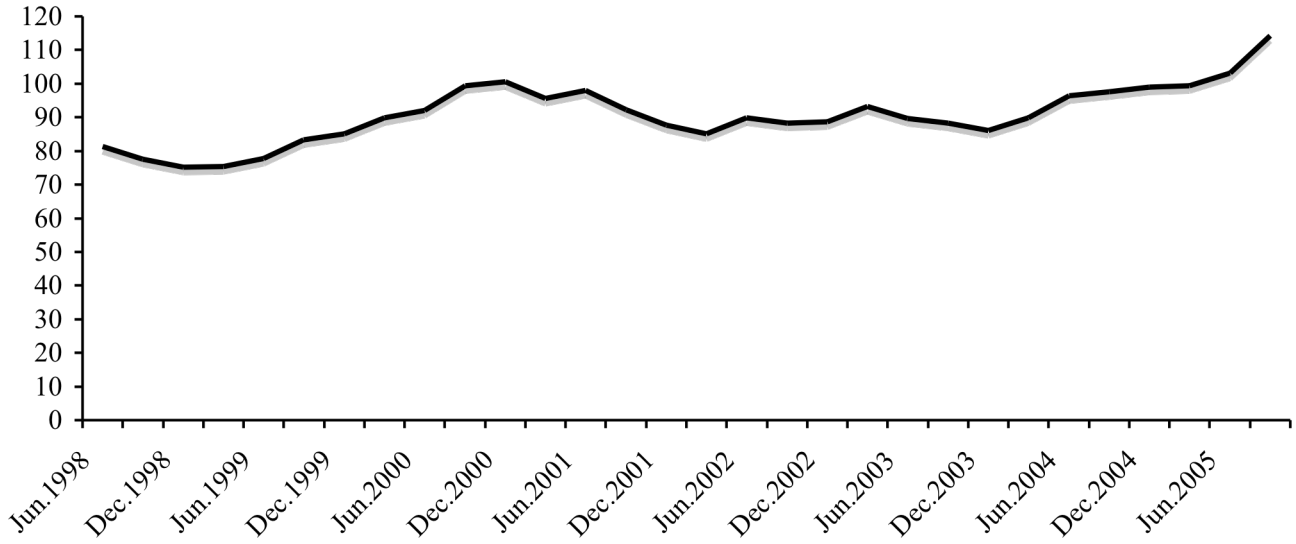
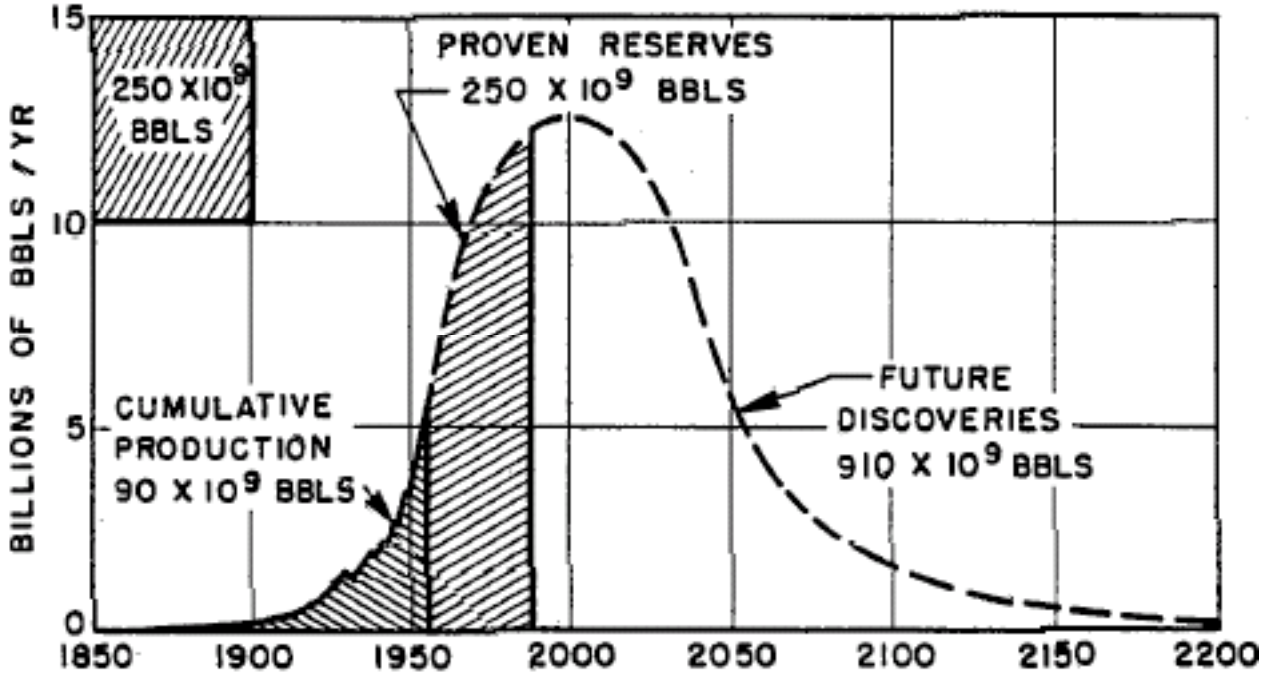


Figure 1. Retail Price of Petrol in Australia in 2003-04 Cents per Litre

The real 2005 price was not a great deal more than it had been five years before and, as the oil companies like to remind us, it was less than it was 25 years ago. So the essential background for this study is some understanding of world petroleum reserves and production.

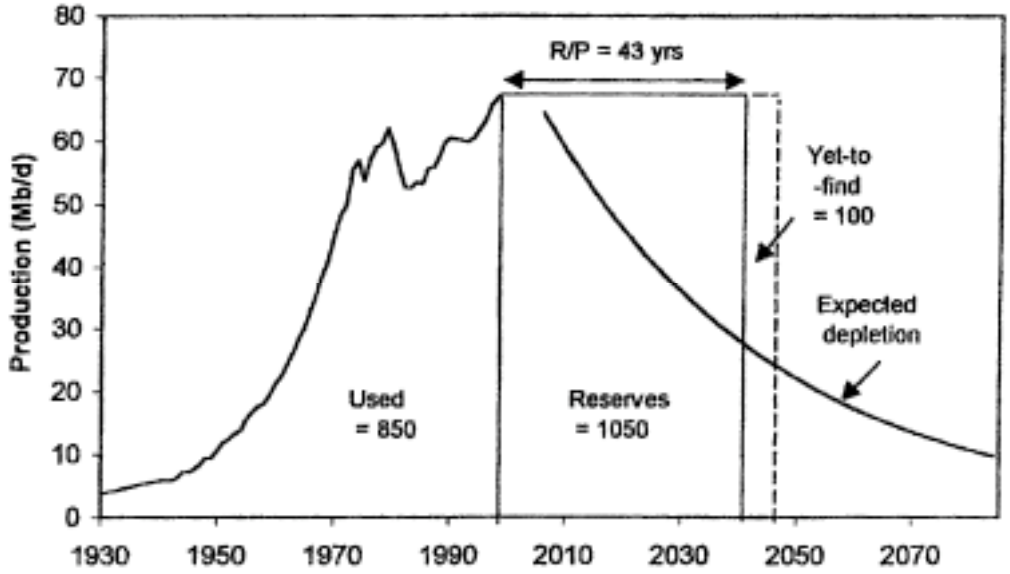
The views of Peak Oil (or Hubbert Peak or Association for the Study of Peak Oil & Gas, ASPO) advocates give important insights into our future. In his pioneering paper, Hubbert (1956) published the graph shown in Figure 2.



Source: http://en.wikipedia.org/wiki/Image%3AHubbert-fig-20.png

Figure 2. Hubbert Peak Graph from the 1956 Paper (Hubbert, 1956)

In a careful assessment, Bentley (2002) made the following summary comment: "The world contains large quantities of non-conventional oil, and various oil substitutes. But the rapidity of the decline in the production of conventional oil makes it probable that these non-conventional sources cannot come on-stream fast enough to fully compensate. The result will be a sustained global oil shortage." His 2002 projections of the production life of reserves and the expected depletion of reserves are shown in Figure 3.



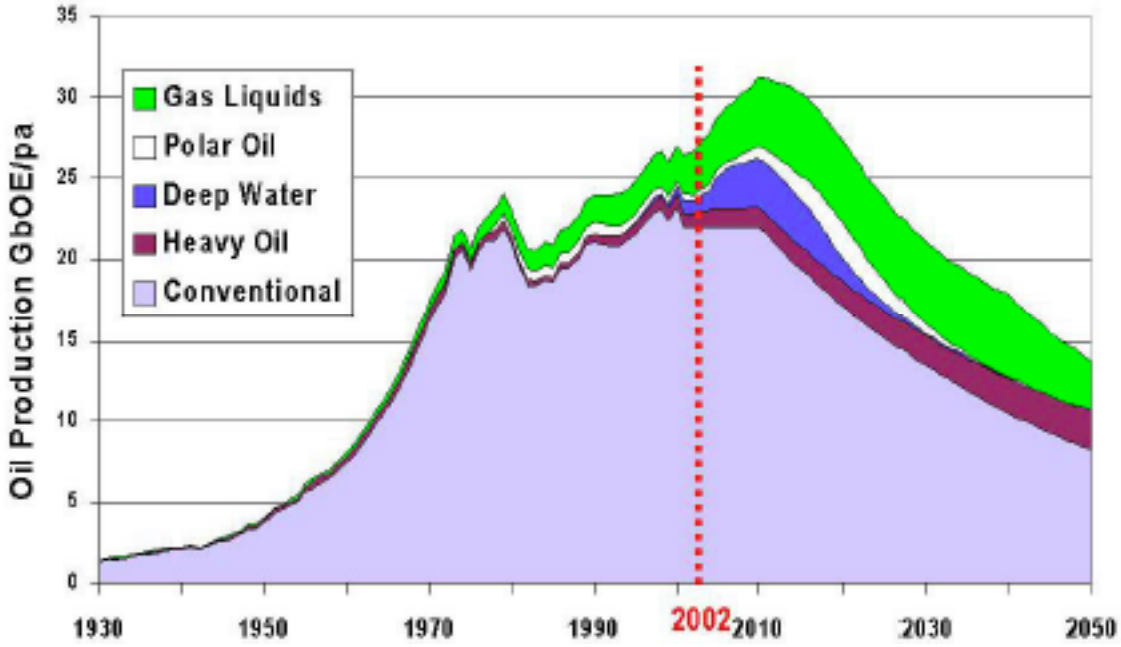
Note: Yet-to-find = Ultimate – (Cumulative production + Reserves)

Source: Bentley (2002)

Figure 3. Projection of Years of Petroleum Production from Reserves and Depletion

Bentley (2002) noted that oil company statements of reserves should be viewed with caution and he commented as follows: "…proved reserves are expected to grow, and can do so without real oil being discovered, or recovery factors improving. This happens when reserves are simply re-categorised, coming out of probable reserves, and being placed in proved. Hence, booked replacement of proved reserves tells the analyst nothing about what is happening to the underlying, more realistic, (proved and probable) reserves. This is the heart of the 'reserves replacement' problem that, in our view, will become of great significance in the coming years."

Active supporters of the Peak Oil message present graphs like Figure 4. This is a reasonable representation of the situation as we know it. Some critics have suggested that the peak keeps drifting into the future but it is clear from Hubbert's original figure (Figure 2) that his timing of the peak, proposed fifty years ago, was only a little earlier than that of Figure 4. However, the scale of production has become much greater.



Source: Robinson (2003)

Figure 4. Forecast of World Oil Production (ASPO May 2002)

Our interest in the peak production question is with regard to its implications for consumer prices. As indicated by Bentley (2002) in Figure 3, it will take some time to deplete the reserves but once the rundown has clearly started there will inevitably be upward pressure on prices.

Key players in petroleum supply are the OPEC countries. Gately (2005) made calculations on the assumption that their production decisions are based on the net present value (NPV) of future profits. If OPEC seeks to balance the gains from output expansion against the losses from the resulting lower prices, taking into account investment and extraction costs, Gately's model indicates that OPEC's optimal market share is between 41-46%. Once non-OPEC production has peaked, prices can be expected to rise.

So our starting assumption is that upward pressure on retail petrol prices will continue, although the recent high prices will not necessarily be reached again for some time. It is an environment in which one can expect new car buyers to be concerned to keep operating costs down. Somewhat imponderable is the fact that the even higher real prices of 1979-80 caused little change in car choice but that was at least partly due to limited availability of economical alternatives. Also petrol price then fell fairly rapidly so that the occurrence was seen as a passing phenomenon.

There are two types of behavioural process to be taken into account in order to understand what is likely to happen to new car selection. One comprises the effects of changing awareness and the other embraces the fairly complex responses to price changes.

ARE PEOPLE PREPARED TO CHANGE ?

For quite a few years, it has been simple rationality to change to LPG fuel – but I didn't make the change and neither did most other people. Although LPG conversions have been the norm, as the merits of this fuel are more fully recognised, factory-fitted dedicated LPG cars will become more common. Ford, Mitsubishi and now Holden produce such cars.

Hybrid petrol-electric cars provide a more recent option which is not particularly attractive yet because the Prius hybrid is over-priced and there is a waiting list. The obvious next step is to have a hybrid car fuelled by LPG or at least a dual fuel conversion.

With regard to ethanol, there has been a great deal of misinformation, with people who should know better talking as if the effect on car engines is uncertain. As we know, ethanol has been long established as a fuel in Brazil, where 25% ethanol (E25) is the normal standard, many cars run on 100% ethanol and it provides 41% of the total fuel for internal combustion vehicles.

The recent price spike has certainly led to more publicity about the LPG and hybrid alternatives. Another contributor to awareness has been the media attention given to the projections of the Peak Oil (ASPO) advocates. They tend to present themselves as doomsayers but are doing a good job of encouraging people to consider alternatives that will reduce fuel expenditure and consequently reduce petroleum dependence.

It is not easy to deal with these factors quantitatively. One could make some kind of S-shaped or Markovian trend projection but it is hard to say what are the upper limits to the likely market shares. Australia consumes about two-thirds of its production of LPG, leaving considerable room for expanded consumption. It is priced at import parity so that a relatively favourable price could be expected to continue even if we became net importers. Taking account of lower energy density, at 50 cents a litre, LPG gives a running cost about a third less than petrol.

Adoption of hybrids may be slightly more predictable. Most people are already aware that a hybrid is not a 'funny car'. From the user's perspective, the Prius hybrid is simply a normal car that uses much less petrol in city running (Table 1).

Table 1 Petrol Consumption

Model	**City**: Litres/100 km	**Highway**: L/100 km
Toyota Camry (30 Series) Auto sedan 4dr	9.5	6.6
Toyota Corolla (120 Series) Auto sedan 4dr	7.8	5.4
Toyota Echo (10 Series)Auto sedan 4dr	6.4	4.8
Toyota Prius (10 Series) Auto sedan 4dr	**4.6**	**4.2**
Nissan N16 Pulsar (1.8L) Man sedan 4dr	7.4	5.2
Mitsubishi Magna Exec 3.0 MPl Man sedan 4dr	9.0	6.4
Mazda 6 Auto sedan 4dr	10.0	7.6
Honda Civic GLi Auto sedan 4dr	8.5	6.2
Holden VY Commodore Exec. V6 Auto sedan 4dr	11.0	6.6
Holden TS Astra CD Auto sedan & hatch 4dr & 5dr	8.0	5.6
Ford BA Falcon XT & Futura Auto sedan 4dr	11.5	7.2

Source: Fuel Consumption Guide, Australian Government 2003, ISBN 0 642549 354

If pressed, one could hazard a guess that sales of LPG powered cars may eventually reach about a quarter of new car sales and hybrids about half. But that is not a great help without some way of projecting the rate of convergence.

This tentative discussion has been about recognising and responding to known possibilities. The next section is more positive in that it deals with more or less quantifiable responses to relative price changes. How great the price changes will be is largely unknown but it may be useful to

hypothesize reasonable scenarios.

PRICE RESPONSES

Little is known about responses to changes in prices of alternative fuels. To fill some of the gaps, we are undertaking a stated preference study (Abdoolakhan et al., 2005) of reactions to reasonable scenarios involving hybrid cars, LPG conversions (to dual fuel) and factory fitted LPG cars. Early results are from a pilot survey, giving 156 observations. Figure 5 gives some insight into the relatively obscure cross relationship between petrol price and LPG conversion. The plotted points have been simulated from the LIMDEP results.

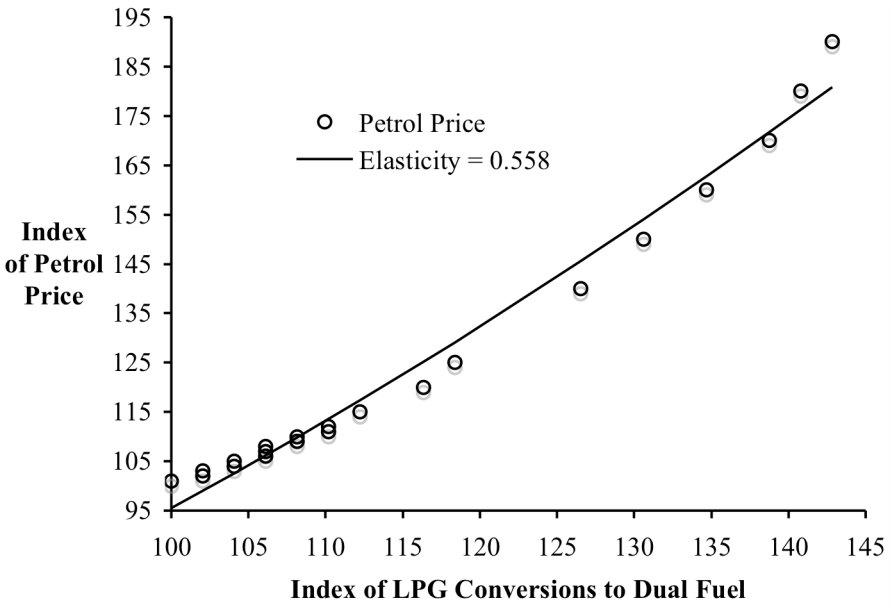


Figure 5. Cross-elasticity of LPG Conversion (Dual Fuel) with Respect to Petrol Price: Pilot Stated Preference Survey Data

Whereas a constant elasticity curve gives a fairly plausible approximation in Figure 5, the plotted response to LPG price in Figure 6 is linear. Even the semi-log curve is not a very good fit. In either the linear or semi-log case, the response becomes less elastic as price falls (Figure 6). At the base point where each index is 100, the elasticity of the straight line is -0.8.

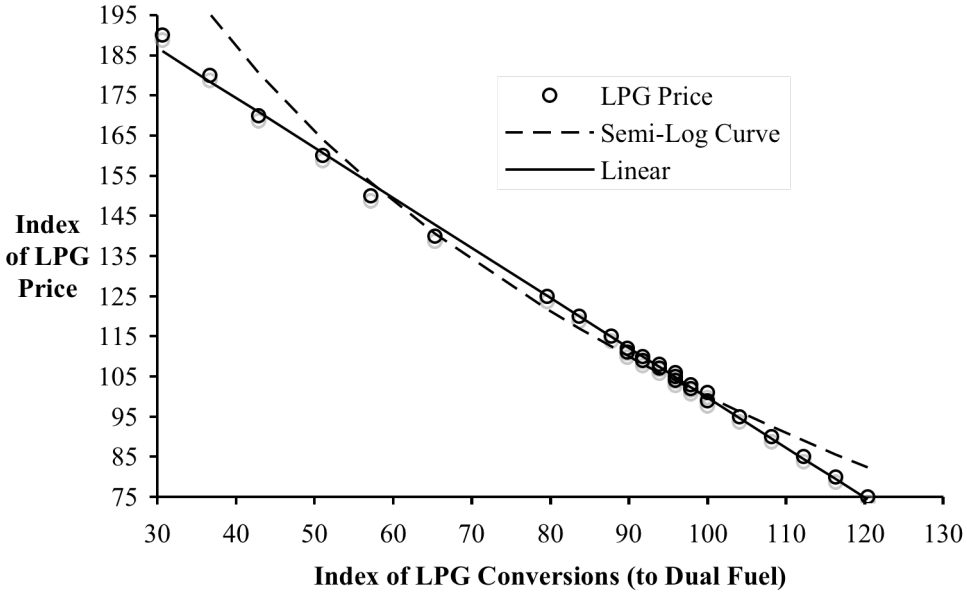


Figure 6. LPG Conversion (Dual Fuel) and LPG Price: Stated Preference Data

As discussed in a previous CAITR paper (Taplin, 2004), likely responses to varying prices of hybrid cars have been approached through fuzzy logic. A fresh study using this method has generated the fuzzy rating curve shown in Figure 7, which is an aggregate over 19 respondents.

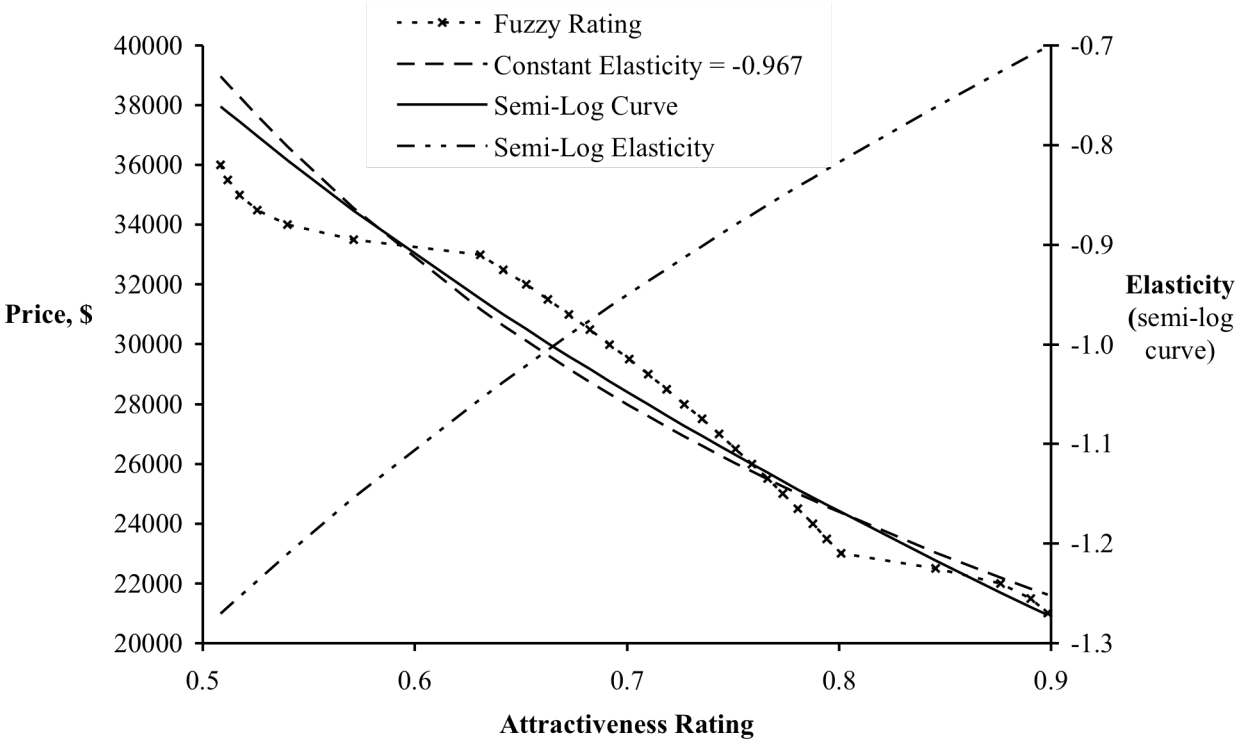


Figure 7 Fitted Demand Attractiveness Rating Curves for the Hybrid Car over a Range of Prices with Corresponding Price Elasticities

Putting the Demand Pieces Together

When the stated preference and fuzzy results are combined with already available estimates (Taplin, 2003), one has a basis for constructing a tentative matrix of price elasticities. Not only are there own-price elasticity estimates but also some for the usually inaccessible cross-elasticities. Although the matrix in Table 2 has many gaps, they can be filled by a combination of symmetry and homogeneity (rows summing to zero) together with reasonable judgements.

Table 2 Available Estimates of Private Motoring Sector Elasticities

	Elasticity of Demand with Respect to:					
Demand for:	Petrol Price	LPG Price	Standard Car Price	LPG Car Price	Hybrid Car Price	Income
Petrol	-0.7		*	*		0.65
LPG				*		
Standard Cars	-0.10		-0.40			0.45
LPG Conversions & Cars	0.56	-0.9				
Hybrid Cars					-0.97	

* indicates that the value can be estimated by symmetry from the corresponding element below the diagonal

Symmetry means that the cross-elasticity of demand for an item taking a small share of the budget with respect to the price of an item with a larger share is proportionally smaller than the matching cross-elasticity. Homogeneity says that if income and all prices change by the same percentage then there will be no change in demand.

An augmented and completed matrix of elasticities is shown in Table 3. A column has been added for all other prices, with negative elasticities on the conventional grounds that the items in our limited sector and all other consumption items are gross complements for each other.

The major additions are a row and column for holiday travel. Without the resulting positive cross-elasticity in the petrol demand row, it is impossible to reconcile the own-price and income elasticities of demand for petrol under the homogeneity condition that the row must sum to zero. Holiday travel by air and other modes is an important substitute for petrol, even though the proportion of total household fuel consumption used for holiday travel is only about 6% (ABS, 2000). A re-work of Taplin (1980) indicates that the cross-elasticity of demand for vacation car trips with respect to air fare may be in the range 0.2 to 0.3.

A number of other judgements are reflected in Table 3.

- The cross-elasticities of demand for LPG cars with respect to prices of petrol and standard cars have been scaled down from the 0.56 and -0.9 of Table 2 to 0.4 and -0.6 on the grounds that stated preference results are excessively responsive (cf. Aadland *et al.*, 2005)
- The assumed cross-elasticity of demand for hybrid cars with respect to petrol price is set at half of the fairly firm value estimated for standard cars.
- The cross-elasticity of demand for hybrid cars with respect to conventional car price is set at an arbitrary 0.25, in the belief that demand for hybrids will be highly responsive to the price of the dominant car type.
- The expenditure shares of LPG fuel and hybrid and LPG cars are projections somewhat above present shares of sector expenditure.

When symmetry is applied to the cross-elasticities of demand for hybrid and LPG cars, their small shares result in very small cross-elasticities in other rows, except for the LPG fuel row which also has a small share.

Table 3 Estimated and Hypothetical Private Motoring and Travel Sector Elasticities

	Elasticity of Demand with Respect to:								
Demand for:	Petrol Price	LPG Price	Standard Car Price	Air etc. Travel	LPG Car Price	Hybrid Car Price	Other Prices	Income	Expenditure Share
Petrol	-0.70	*0.08* [c]	*-0.16* [c]	*0.14* [c]	*0.10* [c]	*-0.01* [c]	-0.10	**0.65**	0.25
LPG Fuel	**0.42**	-0.70	*0.30* [c]	*0.10* [c]	*-0.72* [c]	*0.04* [c]	-0.10	**0.66**	0.05
Standard Cars [a]	**-0.10**	**0.04**	-0.40	*0.05* [c]	*0.04* [c]	*0.03* [c]	-0.10	0.45	0.40
Air etc Travel [b]	**0.17**	**0.02**	**0.10**	-1.10	*0.04* [c]	*0.02* [c]	-0.25 [e]	1.00	0.20
LPG Cars	**0.40**	**-0.60**	**0.25**	**0.12**	-0.75	*0.08* [c]	-0.10	0.60	0.06
Hybrid Cars	**-0.05**	**0.05**	**0.25**	**0.10**	**0.12**	-0.97	-0.10	0.60	0.04

[a] Includes large, medium and small cars

[b] Domestic and international holiday travel by modes other than car

[c] Italics: derived by symmetry

[d] Bold: derived by homogeneity

[e] Cross-elasticity of demand for holiday travel with respect to other prices is estimated to be approximately -0.25 because holiday accommodation is a significant complement (Taplin, 1980)

Projected Impacts of Price Changes

Table 4 is based on the elasticity matrix in Table 3 and shows the projected consumption impacts of changing selected prices. Both of the scenarios tested include 10% growth in real income. The second scenario includes a 25% reduction in real hybrid car price – about what can be expected when the market for this type of car becomes fully competitive.

An important modification is that each own-price elasticity has been treated as lying on a semi-logarithmic curve, so that it increases or decreases in absolute magnitude in proportion to real price (Glaister and Graham, 2005). The response calculations have also taken account of the effects of changed expenditure shares on the cross-elasticities.

Table 4. Hypothetically Projected Impacts of Price Changes: Two Scenarios

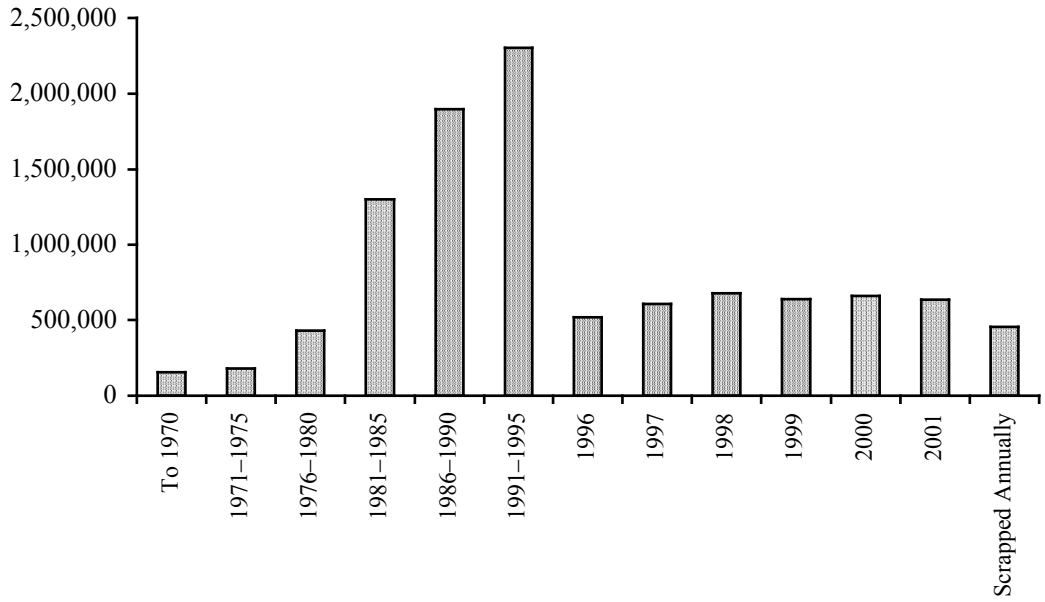
		Scenario 1	**Scenario 2**
		Petrol Price +40% Air etc Travel Cost +15% Income +10%	Petrol Price +40% Air etc Travel Cost +15% LPG Car Price -5% Hybrid Car Price -25% Income +10%
		Quantity Sold	**Quantity Sold**
Petrol		-20%	-20%
LPG Fuel		+27%	+30%
Standard Cars		+1%	+1%
Air etc Travel		+1%	no change
LPG Cars		+23%	+27%
Hybrid Cars		+6%	+28%
Own-Price Elasticity:	**Original**	**Modified (semi-log)**	**Modified (semi-log)**
Petrol	-0.7	-0.98	-0.98
Air etc Travel	-1.1	-1.27	-1.27
LPG Cars	-0.75	-0.75 (no change)	-0.71
Hybrid Cars	-0.97	-0.97 (no change)	-0.73

TRANSFORMATION OF THE WHOLE CAR FLEET: A SLOW PROCESS

As already noted, the changing specific fuel consumption of cars in the vehicle fleet depends on the rate at which more fuel efficient cars are purchased and the rate at which existing cars are scrapped. The following assessment considers whether the scrapping rate is likely to change appreciably.

Some facts about the Australian passenger vehicle fleet provide material for an understanding of the way in which scrapping occurs and the likelihood of any change in the scrappage rate. Figure 8 shows the composition of the passenger vehicle fleet in 2002 by year of manufacture. For comparison, the approximate number scrapped annually is shown at the right hand end of the figure. There are no surprises in the figure but it is important to note that there were more than two million passenger vehicles, about 20 percent of the fleet, which were more than sixteen years old.

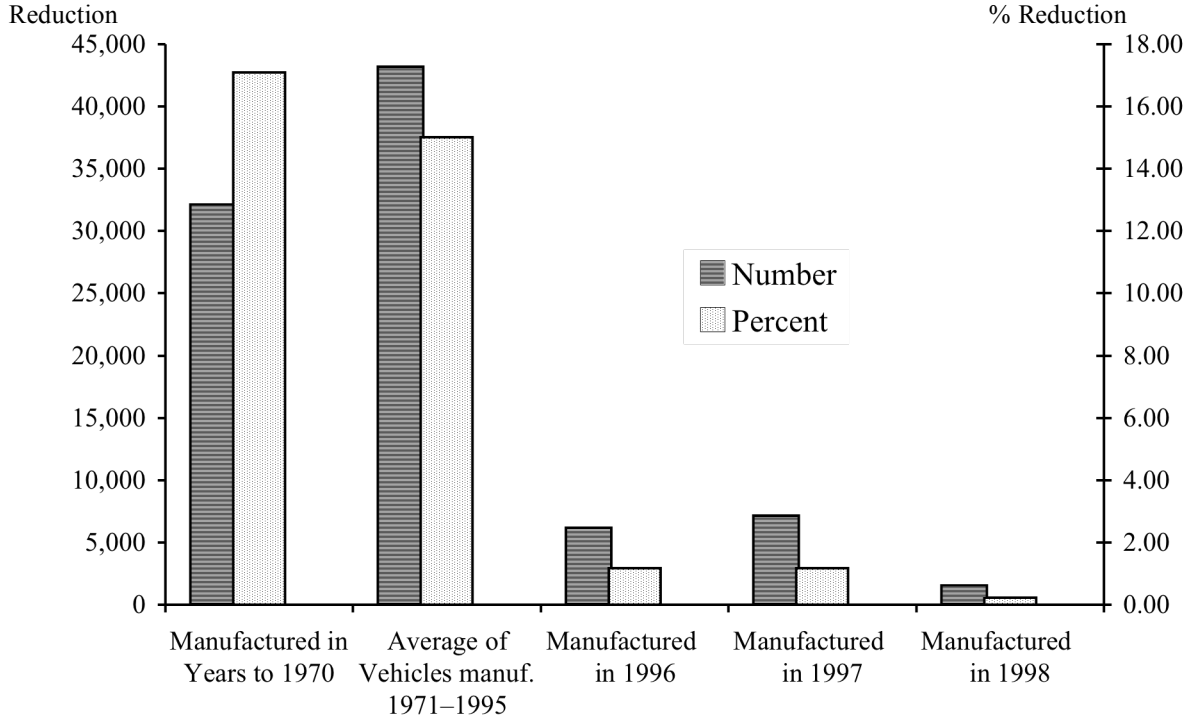
It can be demonstrated that the movements in sales of new passenger motor vehicles are matched approximately by new passenger motor vehicle registrations.



Source: Australian Bureau of Statistics, Motor Vehicle Censuses, 9309.0, 31 March 2002

Figure 8. Passenger Vehicles at 31 March 2002 by Year of Manufacture: Australia

Figure 9 shows the apparent disappearance of passenger vehicles by year of manufacture between late 1999 and early 2002. About one and a quarter percent of year models that were only a few years old disappeared during this period of some two and a half years – presumably because of damage too severe to repair. Seventeen percent of the old vehicles and fifteen percent of those manufactured from 1971 to 1995 disappeared over the period – apparent scrapping rates of seven and six percent a year.



Source: Australian Bureau of Statistics, Motor Vehicle Censuses, 9309.0, 31 October 1999 and 31 March 2002

Figure 9. Disappearance of Passenger Vehicles 31 Oct 1999 to 31 March 2002: Australia

The primary question is the effect of a rise in petrol price on used cars and their lives. Would the loss in value due to a substantial fuel price price be enough to cause some fairly elderly cars to be scrapped? The actual depreciation of cars, in market terms, has been studied by Storchman

(2004), using prices of a sample of 54 car models in 30 countries. His best estimate for Australia is represented in the depreciation curve of Figure 10, which shows where 10-year old, 8-year old and 6-year old cars would be expected to lie on the curve. The theoretical written down values in Figure 10 are 15% of new price for a 10-year old car, 22% for an 8-year old car and 33% for a 6-year old car.

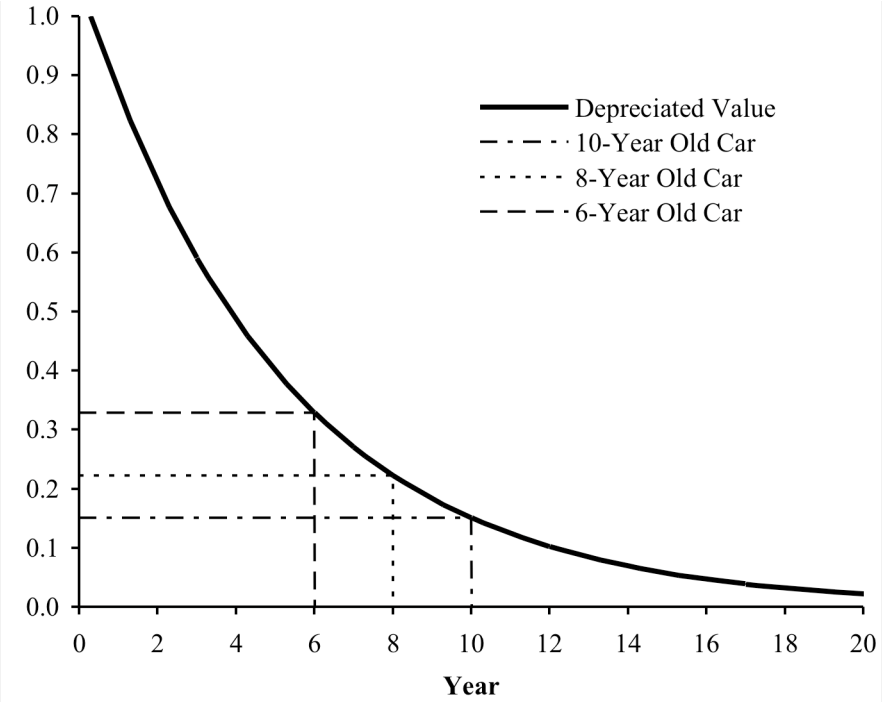


Figure 10. Theoretical Depreciated Values of Cars: Australia

To provide some comparisons with the theoretical depreciated values in Figure 10, a number of dealers' prices, taken from a newspaper, are shown in Table 5. The focus is on remaining life because that is the period during which any higher fuel price will have to be paid. All have at least ten years remaining before they reach 20 years of age. The used cars in Table 5 corresponding to the hypothetical examples in Figure 10 are the 10-year old Statesman, the 8-year old Hyundai and the 6-year old Holden and Ford. Their depreciated values are not the 15%, 22% and 33% of new price indicated by Figure 5. In fact, they have depreciated less – in two cases by appreciably less. The particular vehicles were evidently in very good condition.

Table 5. Prices of Used Cars: Effect of Deducting Present Value of $1/Litre over Remaining Life (7% discount rate)

Used Car	Year Model	Remaining Life, Yrs	Price $	L/100 km, City	Loss of Value $	Reduced Price $
Statesman 5.0 litre V8	1995	10	12,500	11.5	-8,077	4,423
Hyundai Lantra 1.8 litre	1997	12	8,000	8.5	-6,751	1,249
Daihatsu Applause	1998	13	9,000	7.0	-5,850	3,150
Nissan Pulsar	1998	13	10,000	7.4	-6,185	3,815
Holden Berlina	1999	14	17,000	10.5	-9,183	7,817
Ford Falcon	1999	14	11,000	11.5	-10,057	943
Toyota Camry Altise V6	2002	17	21,000	9.5	-9,275	11,725
Holden Commodore V6	2003	18	29,000	11.0	-11,065	17,935
Mitsubishi Magna	2003	18	20,000	9.0	-9,053	10,947

The pattern of depreciation shown in Figure 10 is realistic in average terms but clearly a car which has retained its value better than indicated is much less likely to be scrapped as a result of rising fuel price than one which is heavily depreciated.

The final and crucial step is shown in the last three columns of Table 5. The average driving distance has been assumed at 10,000 kilometres per year and the city fuel consumption in litres per 100 km has been applied to this to give the average annual fuel consumption. The assumed rise in fuel cost of $1/litre is arbitrary and large but has been chosen to test for potential effect on scrappage of used cars.

The assumed additional fuel cost of $1/litre applied to the calculated average annual fuel consumption gives the added annual cost. When this additional cost is capitalised over the remaining life of the car, by discounting at 7% per annum, the theoretical loss in market value is obtained. The loss in value calculated in this way is deducted from the current used car market price to give the resulting reduced price (last column of Table 5).

The results in the last column of Table 5, also plotted in Figure 11, indicate that none of these cars would be scrapped as a result of the substantial $1 rise in fuel price. However those with high fuel consumption would suffer the greatest reductions. These calculations make sense in terms of the situation of a used car buyer. A 'battler' might well find the Ford Falcon an attractive buy at about $1,000 because it would give him a reasonably prestigious car for little outlay and he could face the higher running cost as it eventuates.

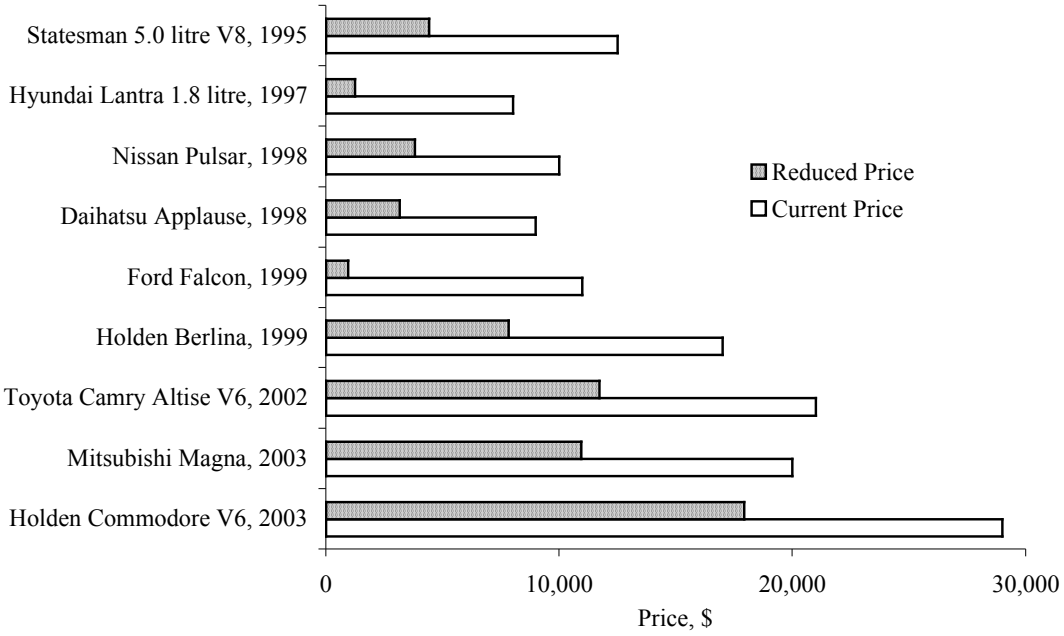


Figure 6. Estimated Falls in Used Car Prices if Petrol Price Rises by $1/Litre

CONCLUSIONS

There are three parts to our conclusions. The first is that awareness of the true market situation and the possible steps available to the ordinary motorist will be a major contributor to an orderly transition to a sustainable world of private cars.

The second conclusion is that price responses appear to be strong enough to ensure that petrol consumption will fall appreciably if there is a substantial (40%) rise in the real price of petrol. Also the choice of new car will be affected considerably, with potential increases of as much as 30% in sales of hybrid and LPG cars.

The third conclusion is that even a $1 increase in the price of petrol will do very little to hasten the scrapping of existing cars. Such an increase would lead to substantial write-downs in the value of many used cars but rarely enough to lead to scrapping.

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