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The price of petrol - past and future

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Abstract

Sharp increases in the price of petrol capture the community's attention and impact Australia's economy and way of life. This often manifests itself in calls for formal enquiries into how petrol is priced. This paper explores the relationship between a range of factors that determine the local pump price for unleaded petrol. An analysis of historical data is used to identify key drivers and their influence on local petrol prices. The results of this analysis are used to forecast local petrol prices under a "business as usual scenario".

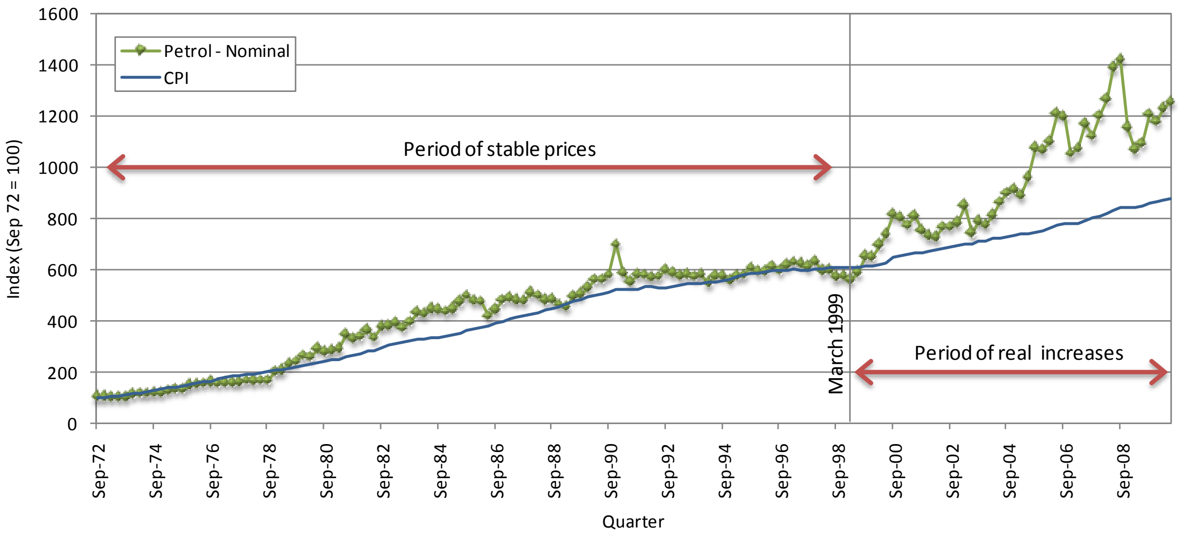
1. Introduction

1.1. Context

Australia is heavily dependent on petrol to meet its transport needs. Data from the latest edition of the Australian Transport Facts (Adam Pekol Consulting 2010) indicate that petrol vehicles satisfy 2.5% and 72.3% of the national road freight task (tkm) and passenger task (pkm) respectively. The significance of the price paid for petrol is reported by The Bureau of Transport and Regional Economics (BTRE 2010) in their online database of transport elasticities. According to this database, the average elasticity of consumption with respect to price for petrol in Australia is -0.12 in the short term and -0.52 in the long term. It is therefore not surprising that sharp increases in the price of petrol capture the community's attention and impact Australia's economy and way of life.

Figure 1 plots the change in Brisbane fuel prices since September 1972 (ABS 2010a), relative to the local Consumer Price Index (CPI). Following just over 26 years of relatively stable prices in real terms (ie September 1972 to March 1999), the last 11 years (ie March 1999 to June 2010) has been a period of real increases in local petrol prices.

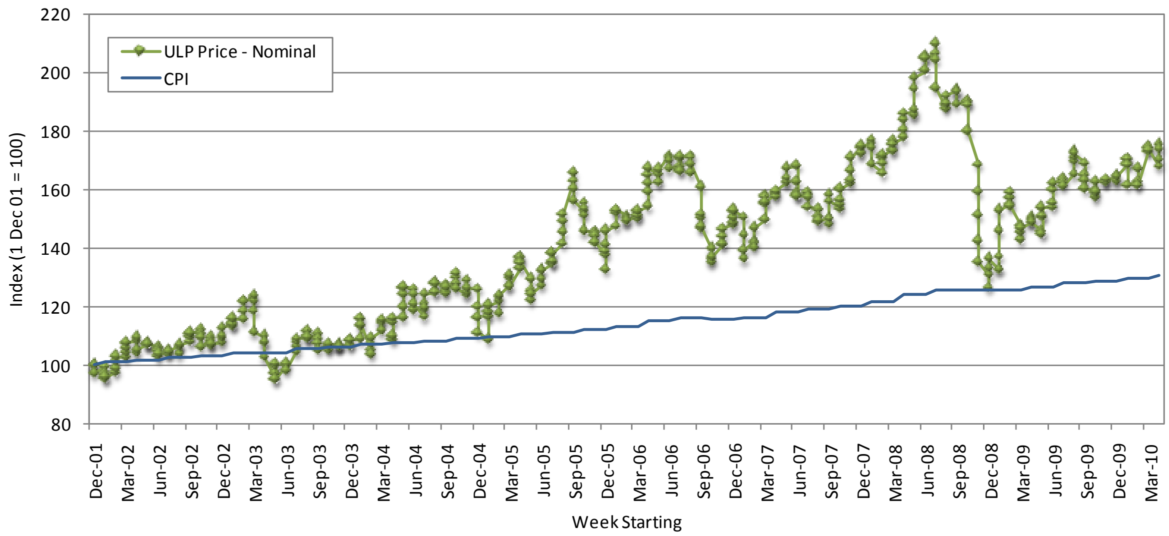
Figure 1: Growth in Brisbane petrol price (Sep 1972 – Jun 2010)



SOURCE: ABS 2010a

Between March 1999 and June 2010, the nominal petrol price in Brisbane has increased by 124%, compared to a 44% increase in the CPI, which implies a 55% increase in real terms. Such a sustained period of real growth in local petrol prices is unprecedented. This increase is echoed in the more detailed average weekly petrol price data derived from the daily prices published by the Australian Institute of Petroleum (AIP 2010a), as shown in Figure 2.

Figure 2: Growth in Brisbane petrol price (Dec 2001 – Apr 2010)



SOURCE: AIP 2010a and ABS 2010a

1.2. Objective

The aim of this paper is to:

- explore the relationship between a range of factors that determine average weekly petrol prices;
- identify the key drivers and their influence on average weekly petrol prices; and
- prepare 10 year forecasts of petrol prices under a “business as usual” scenario.

1.3. Previous research

A range of techniques have been applied by academics, economists and forecasters in an attempt to better understand various aspects of the petrol market. These include linear regression models (Carlson and Umble 1980, McManus 2007), logarithmic regression models (Wong et al 1977), ARIMA models (Liu 1991), structural vector autoregressive models (Kilian 2010) and neural network models (Malliaris and Malliaris 2008). The data used to develop these models has included both supply side variables, such as:

- crude oil price;
- petrol price; and
- petrol stockpiles.

as well as demand side variables, such as:

- personal income;
- vehicle purchase price, fuel economy, power or curb weight;
- vehicle registrations, sometimes by vehicle type or size;

- average annual VKT; and
- petrol consumption.

Liu (1991) concluded that petrol prices in the US were mainly influenced by the crude oil price and that the influence of petrol stockpiles was not significant. This finding was echoed by Malliaris M and Malliaris S (2008), who reported a 0.965 correlation between crude oil prices and US petrol prices. Honarvar (2007) goes further to suggest that petrol prices are more responsive to increases in the price of crude oil price than decreases, which suggests a degree of asymmetry in the petrol price market. While Kilian (2010) opined that fluctuations in petrol price are determined almost exclusively by supply side factors, McManus (2007) was able to confirm a weak relationship between fuel prices and demand side factors (eg vehicle sales).

1.4. General approach

The paper builds on this previous research by undertaking a statistical analysis of historical petrol price data for the author's home city of Brisbane (Australia). A series of regression models are used to identify key factors that influence the average weekly pump price for petrol in Brisbane. Models are developed using data from the period of real increases in local petrol prices (ie post-March 1999), as this era is fundamentally different to the preceding 26 year period of stable petrol prices (refer Figure 1). The best performing model is then used to forecast local petrol prices over the next ten years under a "business as usual" scenario, taking into account the observed error in forecasts of key input variables.

2. Factors that influence the price of petrol

The pump price of ULP in Brisbane depends on a range of factors relating to the supply, taxation and consumption of the raw material (ie crude oil) and the final product. Some of these factors are discussed below.

2.1. The industry perspective

According to the Australian Competition and Consumer Commission (2009), the pump price of ULP is influenced by the international benchmark price for crude oil, taxes and margins, and other costs. They estimate that these three components respectively account for 49%, 39% and 12% of the price of ULP. Of course, the relative proportions change with the price of crude oil, the level of taxation (discussed below) and the final pump price.

2.1.1. Crude oil prices

The Australian Institute of Petroleum (AIP) (2010b) explains that crude oil is traded in regional markets and that Australia's regional market is the Asia-Pacific market. Accordingly, the relevant international benchmark price for crude oil for the Australian market is Tapis crude and not West Texas crude. While widely reported in the local media, West Texas crude is the regional benchmark for the US market, not the Australian market.

2.1.2. Taxes and margins

The Federal Government imposes an excise on all petrol sold in Australia, which has remained constant at 38 cents per litre since 2001. Petrol is also subject to the Goods and Services Tax (GST), which has been levied at a flat rate of 10% since its introduction in 2000. The GST also applies to the Federal Government excess component. Between 1 November 1997 and 30 June 2009, Queensland motorists received an 8.35 cents per litre fuel subsidy, which was paid directly to fuel retailers. The aim of the subsidy was to reduce the local pump price of petrol. Finally, the AIP (2010b) suggests that due to competition within the Australian market, the average profit margin on petrol over the last 10 years equates to about 1.2 cents per litre.

2.1.3. Other costs

The AIP go further to explain that the ULP price in regional markets can be volatile and can move in different directions from each other. This volatility is evident in the weekly price cycles commonly observed in most parts of Australia, as demonstrated in Figure 3. The daily variation in local fuel prices can be removed by focussing on average weekly prices.

Figure 3: Brisbane average ULP price (Apr 2010)

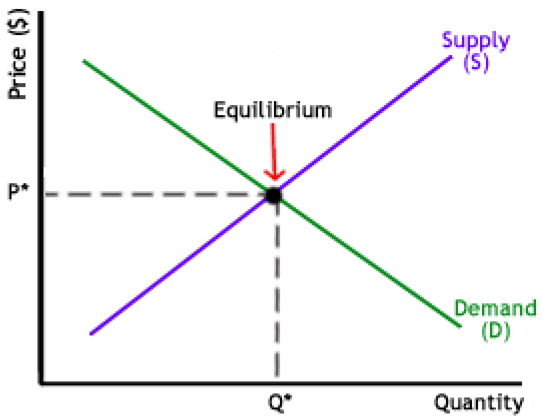
Source: AIP (2010b)

2.2. The economic theory

The laws of supply and demand are probably the most fundamental concepts in economics and form the backbone of a market economy. The relationship between these two laws is shown in Figure 4, which implies that all other things being equal:

- demand varies inversely with price; and
- supply increases with price.

Figure 4: Supply and demand



Source: Investopedia (2010)

Given a basic understanding of the industry perspective (see above) and an appreciation of the underlying drivers of demand for petrol, it is possible to explore the broader spectrum of factors that determine the pump price of ULP at any given point in time.

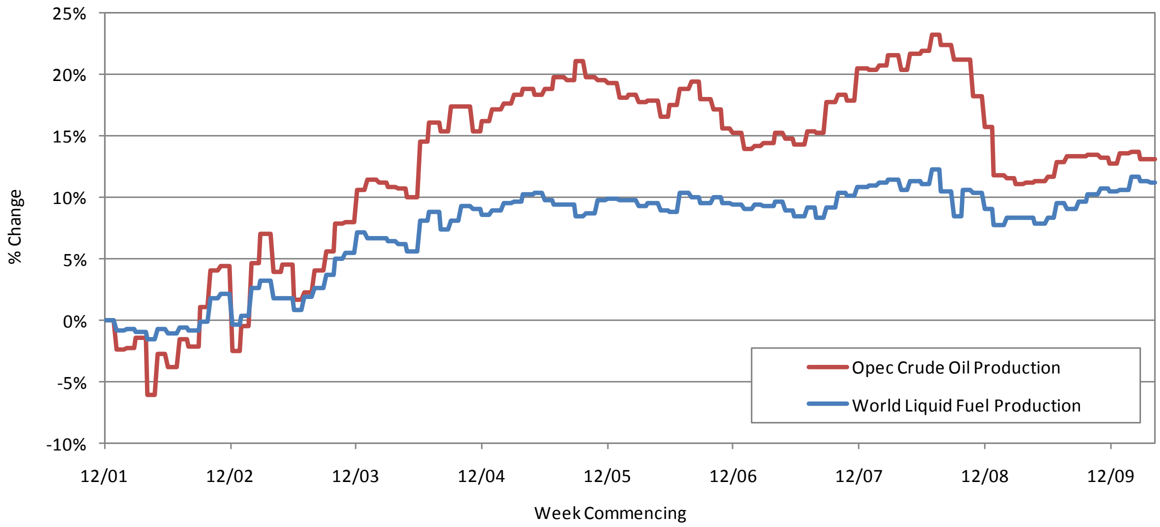
2.2.1. Supply side factors

As petrol is refined from crude oil, we start by identifying factors that determine the supply of crude oil. We already know that one of these factors is the price that consumers are prepared to pay. However, according to the US Energy Information Administration (EIA) (2010a) the supply of crude oil in the Australian market is also influenced by:

- the rate and cost of production, which in turn depends on the technology used;
- the size of crude oil stockpiles, which can buffer the impact of large price changes;
- the size of remaining crude oil reserves and the cost of proving new wells;
- unplanned interruptions to production due to war, extreme weather or catastrophe;
- cartel policies, such as OPEC's production quota and target price; and
- the global demand for crude, which is heavily influenced by seasonal factors and the sustained growth of the Chinese economy and car ownership.

The detailed analysis of each of these factors is beyond the scope of this paper. However, their cumulative effect can be seen in the rate of crude and petroleum production, which as shown in Figure 5 have increased by 11-13% over the past eight years.

Figure 5: Change in OPEC crude oil production (Dec 2001 – Apr 2010)



Source: US EIA (2010b)

2.2.2. Demand side factors

The two factors that underpin the demand for petrol are the number of consumers and the rate of consumption. The number of consumers is function of the number of vehicles and the number of drivers. Both of these increase with population, although average car ownership levels and driver licence availability also play a role. The latter can be affected by:

- the cost of purchasing and maintaining a motor vehicle price;
- an individual's disposable income;
- the availability and cost of alternative transport modes;
- taxation incentives for purchasing and running motor vehicles; and
- car parking availability.

For a given number of consumers (ie motor vehicles), the rate of petrol consumption depends on:

- the fleet mix (eg vehicle type, number of cylinders and engine size);
- the vintage profile, as newer vehicles are generally more fuel efficient;
- how well vehicles are maintained;
- the land use pattern;
- the level of network connectivity;
- the level of congestion on the road network;
- the demographic and economic characteristics of drivers;
- vehicle loading patterns (ie for freight vehicles); and
- the level of economic activity.

The above have both short and long term impacts and these are likely to vary both geographically and temporally. The impact of demand side factors on petrol price has been reported by McManus (2007), who states that:

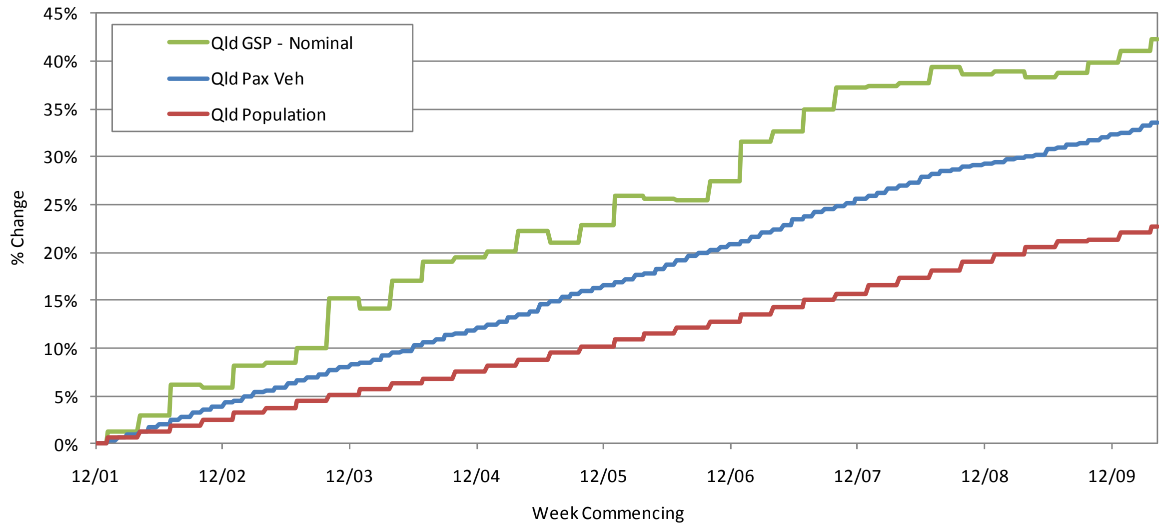
> *"economic theory predicts a direct link between fuel prices and vehicle sales"*

and Kilian (2010), who states that:

> *"it is evident that the (mid-2008) collapse of gasoline prices must have been associated with a reduction in the global demand for crude".*

While it is beyond the scope of this paper to consider the impact of each of the above factors, Queensland level information is available for a number of them. Figure 6 plots the growth in the State's population (ABS 2009a), registered passenger vehicles (ABS 2009b and 2010b) and gross State product (Access Economics 2009). Given that two-thirds of the State's population reside in and around Brisbane, these State level statistics were considered a suitable surrogate for Brisbane specific data.

Figure 6: Change in selected demand factors (Dec 2001 – Apr 2010)



Source: ABS (2009a, 2009b, 2010b) andAccess Economics (2009)

2.3. Summary of available data

The average weekly ULP price for Brisbane was calculated from daily figures published by the AIP, so as to negate the impact of weekly price cycles shown in Figure 3. A range of variables related to the supply, demand, taxation and indexation were then collated from published sources. These variables are listed and described in Table 1, together with their:

- temporal frequency (eg weekly, monthly or quarter);
- geographic scope (eg Brisbane, Queensland or Australia);
- unit of measure; and
- source.

Overall, information on four supply related, 16 demand related, one taxation related and four indexation related variables was assembled, for the period 1 December 2001 to 24 April 2010 (ie 438 weeks worth of data). All price related variables were expressed in real terms using local (ie US, Singapore or Australian) CPI indices. USD variables were converted to AUD based on the corresponding average weekly exchange rate.

Table 1: Analysis variables

Variable	Description	Units	Source
ULP$	Real average weekly pump price for ULP in Brisbane	cents / L	AIP
Supply related variables			
USCrude$	Real average weekly price for West Texas crude	US$ / bbl	US EIA
TapisCrude$	Real average weekly price for Tapis crude	US$ / bbl	US EIA
CrudeProd	Monthly crude oil production rate for OPEC countries	M.bbl / day	US EIA
FuelProd	Monthly liquid fuel production rate for all countries	M.bbl / day	US EIA
Demand related variables			
Pop	Quarterly population of Queensland	M.persons	ABS
PVeh	Monthly registered passenger vehicles in Queensland	M.veh	ABS
GSP	Real quarterly gross state product for Queensland	B.$	Access Economics
AllOrd	Average weekly all ordinaries index for the Australian stock market	-	ASX
Jan, Feb etc	Dummy variable = 1 for weeks in the corresponding month of the year = 0 otherwise	-	-
Taxation related variables			
Sub	Dummy variable = 1 for weeks up to 30 June 2009 = 0 there after	-	-
Price indexation / conversion variables			
USCPI	Monthly consumer price index for US	-	US DOL
SingCPI	Annual / monthly consumer price index for Singapore	-	Sing Stat
CPI	Quarterly consumer price index for Brisbane	-	ABS
USD	Average weekly AUD to USD exchange rate	-	RBA

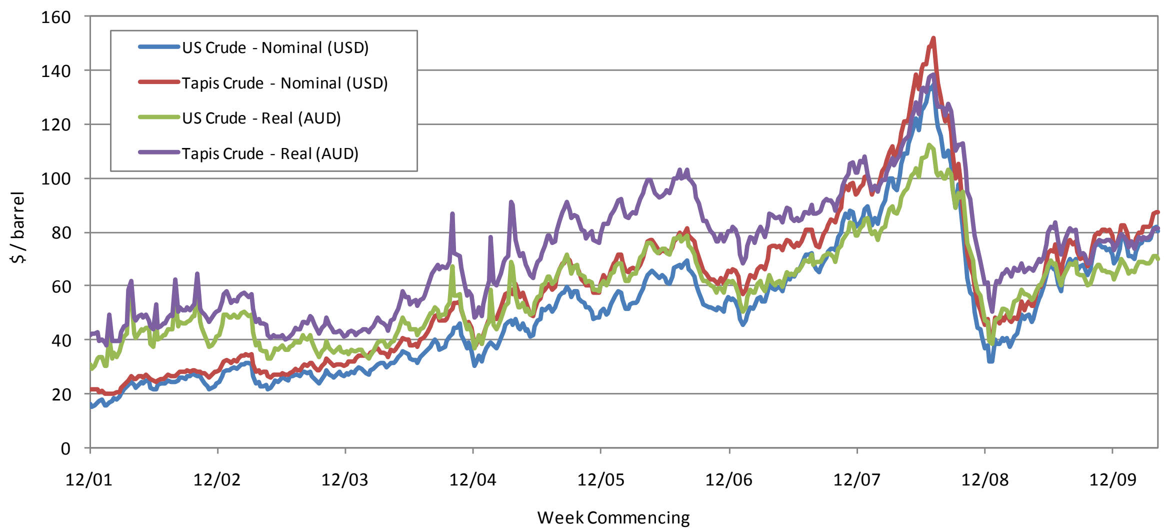
3. Statistical analysis

A series of statistical analysis were undertaken, including the generation of correlation coefficients, linear regression equations, dummy variable regression equations and logarithmic regression equations. Generally speaking, slightly better model performance (in terms of higher R^2 and F statistics) was obtained using log-transformed versions of the input variables. As suggested by Cohen et al (2003), this approach is commonly used in regression analyses to maintain the conditions required for accurate statistical inference (ie linearity). The use of log-transformed variables is also common in the study of the petrol / crude oil market (Wong et al 1977 and Liu 1991). Accordingly, all of the models presented in this paper are based on the log-transformed versions of the dependent and independent variables.

3.1. Supply related variables

The average weekly US and Tapis crude oil price between December 2001 and April 2010 is presented in Figure 7, in nominal US and real AUD terms. While the patterns in Figure 7 differ significantly from the graph of crude oil production presented in Figure 6, they echo the movement in local fuel prices over the same period plotted in Figure 2.

Figure 7: Average weekly crude oil prices (Dec 2001 – Apr 2010)



Source: US EIA (2010b), US DOL (2010), Sing Stat (2010) and RBA (2010)

Table 2 lists the correlation coefficients of the four supply related variables against ULP$. Malliaris and Malliaris (2008) reported a slightly stronger correlation between petrol and crude oil prices (ie 0.965), although the results are comparable. The relationship between petrol price and crude oil production is less strong, as supported by Kilian (2010).

Table 2: Correlation coefficients - supply variables

Variable	Coefficient
USCrude$	0.934
TapisCrude$	0.952
CrudeProd	0.754
FuelProd	0.723

3.1.1. Simple supply side model

Two simple supply side models were developed, the first based solely on USCrude$ and the second based solely on TapisCrude$. These models, which explain 88-90% of the observed variation in weekly petrol prices in Brisbane, are presented in Equations 1 and 2 respectively.

Equation 1: Simple US Crude model

Variable	Coefficient	t statistic
Independent variable	ln(ULP$)	
Intercept	2.79	90.4
ln(USCrude$)	0.428	55.9
Adjusted R^2	0.877	
F (1, 436)	3,120	

Equation 2: Simple Tapis Crude model

Variable	Coefficient	t statistic
Independent variable	ln(ULP$)	
Intercept	2.78	103
ln(TapisCrude$)	0.409	64.3
Adjusted R^2	0.904	
F (1, 436)	4,140	

The signs of the coefficients in both of these models appear logical, with ULP$ increasing with crude oil price. All variables are significant at the 5% level and the overall model performance is significant.

The TapisCrude$ based model (Equation 2) performs slightly better than the USCrude$ based model (Equation 1), in terms of R^2 and F statistics. This result is to be expected, given that Tapis crude is the benchmark price adopted in Australia (AIP 2010b). However, the difference between these two equations is only marginal and reflects the strong correlation between USCrude$ and TapisCrude$ (ie 0.981), which is a product of the global oil market. However, given that the US EIA does not prepare forecasts of Tapis crude oil prices, the USCrude$ based model (Equation 1) is considered more useful for forecasting purposes.

3.1.2. Full supply side model

A fuller version of the supply side model was developed using a stepwise regression process to identify the more significant supply side factors. The resulting model, shown in Equation 3, incorporates an additional term for the monthly crude oil production rate for OPEC countries (CrudeProd). All variables are significant at the 5% level and the overall model performance is significant. The signs of both coefficients appear logical, with ULP$ increasing with USCrude$ and supply (ie CrudeProd) increasing with price (ie ULP$).

Equation 3: Full supply side equation

Variable	Coefficient	t statistic
Independent variable	ln(ULP$)	
Intercept	1.80	14.1
ln(USCrude$)	0.369	36.1
ln(CrudeProd)	0.364	8.01
Adjusted R^2	0.893	
F (2, 435)	1,820	

3.1.3. Time lags

The AIP state that "generally, there is a short time lag of 1-2 weeks between changes in Singapore prices and changes in Australian wholesale prices" (AIP 2010a). To test the impact of such a time lag on model performance, four new equations were developed with the ULP$ offset (ie delayed) by 1-4 weeks respectively. This necessitated the re-estimation of Equation 3, using a slightly smaller 435 week dataset, for comparison purposes. The overall performance of these equations, relative to the re-estimated original (3b), is summarised in Table 3.

Table 3: Full supply side equation with time lags

Equation	Adjusted R^2	F statistic
3b: No lag	0.893	1,810
4: 1-week lag	0.904	2,050
5: 2-week lag	0.902	1,990
6: 3-week lag	0.881	1,610
7: 4-week lag	0.854	1,270

As predicted by the AIP, model performance is improved by incorporating a 1-2 week time lag between USCrude$ and ULP$, with the model based on a one week time lag performing marginally better. The revised model is shown in Equation 4.

Equation 4: Full supply side equation with a one-week time lag

Variable	Coefficient	t statistic
Independent variable	$\ln(ULP\$_{+1Week})$	
Intercept	1.91	15.9
ln(USCrude$)	0.380	39.1
ln(CrudeProd)	0.318	7.39
Adjusted R^2	0.904	
F (2, 432)	2,050	

3.2. Demand related variables

The correlation between the 16 demand related variables and ULP$ are summarised in Table 4. ULP$ is most strongly correlated to the two measures of economic activity (ie GSP and AllOrd) than the two market size related variables (ie Pop and PVeh). This is consistent with basic economic theory and the results reported by McManus (2007) and Kilian (2010), as discussed in Section 2.2.2.

Nevertheless, care should be taken not to apply the models presented in this paper out of context. For example, it is plausible that a negative correlation between population and fuel price might be found for other regions experiencing a declining population. This paper is not advocating the use of the models discussed herein to such regions.

The statistical analysis also identified strong inter-correlations between Pop and PVeh (correlation coefficient = 0.998), between GSP and PVeh (0.989) and between GSP and Pop (0.982). These inter-correlations have implications for models based on more than one of these variables.

Table 4: Correlation coefficients - supply variables

Variable	Coefficient
Pop	0.667
PVeh	0.698
GSP	0.719
AllOrd	0.760
Jan – Dec	0.00247–0.0941

The correlation coefficients summarised in Table 4 also suggest that seasonal (ie monthly) variations do not play a major role in determining ULP$. The monthly based dummy variables that are most strongly correlated to ULP$ are Jan (0.0941) and Dec (0.0926). While the former is significant at the 5% level, the later is not.

3.2.1. Market size

Basic economic theory dictates that there is a direct link between the demand for a good and the price paid for a good. To test for this relationship in the subject data, two new models were developed by adding Pop and PVeh separately to Equation 4. This was done to avoid having two highly correlated independent variables in the model. The performance of these two new models, relative to the starting equation (4), is summarised in Table 5.

Table 5: Equation 4 plus market size factors

Equation	Adjusted R^2	F statistic
4: As above	0.904	2,050
8: Eqn 4 + Pop	0.905	1,380
9: Eqn 4 + MVeh	0.905	1,370

Both models explain only marginally more (ie 0.1%) of the variation in the dependent variable. Furthermore, a negative coefficient was returned for both Pop and MVeh, which is inconsistent with basic economic theory. While the Pop variable in Equation 8 was statistically significant at the 5% level, the MVeh variable in Equation 9 was only significant at the 10% level. Accordingly, it was concluded that neither Pop nor Mveh were significant factors in determining ULP$ for Brisbane.

3.2.2. The economy

The significance of the two economic based variables, GSP and AllOrd, was assessed by adding each one separately to Equation 4. As above, this was done to eliminate the potential for multicollinearity, as these variables are strongly correlated to one another (ie correlation coefficient = 0.724). The performance of these two new models, relative to the starting equation (4), is summarised in Table 6.

Table 6: Equation 4 plus economic factors

Equation	Adjusted R^2	F statistic
4: As above	0.904	2,050
10: Eqn 4 + GSP	0.905	1,380
11: Eqn 4 + AllOrd	0.910	1,450

In both cases, model performance was marginally improved with the addition of one of these variables. However, when ln(GSP) is added to the model, its coefficient is negative (which is counter-intuitive), even though it was significant at the 5% level (ie t statistic = -2.11). Conversely, when ln(AllOrd) is added to the model, its coefficient is positive and significant at the 5% level. While, the practicality of a model that relies on forecasts of the stock market is questionable, the resulting Equation 11 is described below.

Equation 11: Demand equation with economic variable

Variable	Coefficient	t statistic
Independent variable	$\ln(ULP\$_{+1Week})$	
Intercept	1.72	14.0
ln(USCrude$)	0.347	30.6
ln(CrudeProd)	0.240	5.40
ln(AllOrd)	0.0698	5.14
Adjusted R^2	0.910	
F (3, 431)	1,450	

3.2.3. Seasonal variations

The hypothesis presented earlier that seasonal variations do not play a major role in determining ULP prices in Brisbane was tested by adding 11 of the twelve, month based dummy variables to a stepwise regression process, based on the preceding equation (11). The dummy variable for April was excluded to eliminate the potential for multicollinearity between these variables. It transpires that some, but not all, of these dummy variables are significant at the 5% level, as summarised in Equation 12.

The additional variables in Equation 12 suggest that, all other things being equal, ULP prices in Brisbane a generally lower in October and November. The latter period corresponds to Autumn in North America, a period during which fuel use for heating has not yet reached its Winter peak, while fuel use associated with the summer driving season has abated.

Equation 12: Demand equation with economic and seasonal variables

Variable	Coefficient	t statistic
Independent variable	$\ln(ULP\$_{+1Week})$	
Intercept	1.67	13.8
ln(USCrude$)	0.346	30.8
ln(CrudeProd)	0.264	5.96
ln(AllOrd)	0.0671	5.01
Oct	-0.0250	-3.50
Nov	-0.0149	-2.07
Adjusted R^2	0.912	
F (4, 429)	903	

3.3. Taxation related variables

The marginal impact of the one taxation related variable, a dummy variable for the Queensland Fuel Subsidy, was assessed by adding it to Equation 12, as is summarised below. The addition of this variable does not add significantly to the model's overall performance, resulting in no net change to the R^2 statistic. The new variable is not significant at the 5% and has a negative coefficient.

Equation 13: Marginal impact of Queensland fuel subsidy

Variable	Coefficient	t statistic
Independent variable	$\ln(ULP\$_{+1Week})$	
Intercept	1.68	13.8
ln(USCrude$)	0.347	30.3
ln(CrudeProd)	0.261	5.82
ln(AllOrd)	0.0673	5.01
Oct	-0.0248	-3.46
Nov	-0.0147	-2.04
Sub	0.00311	0.449
Adjusted R^2	0.912	
F (6, 428)	751	

The implication of this result is that the 8.35 cents per litre that the State Government remitted to the oil companies prior to 30 June 2009, was not reflected in the average weekly fuel prices observed in Brisbane.

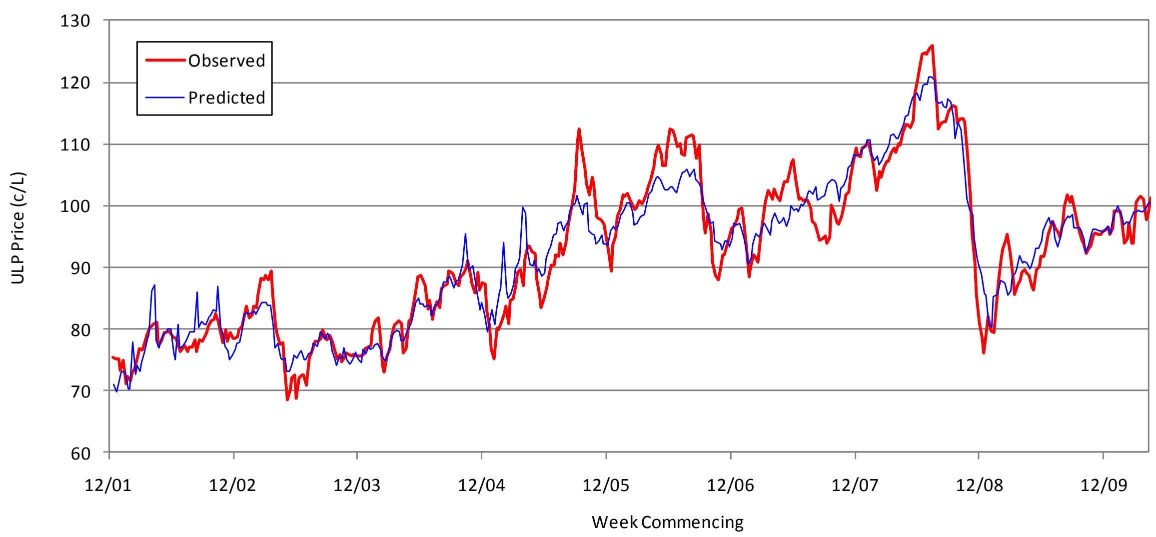
3.4. The final model

The final model (ie Equation 13) explains over 90% of the weekly variation in more than eight years of observed fuel prices for Brisbane. The variables used in the model are consistent with the underlying economic theory and, for the most part, are statistically significant at the 5% level. The performance of this model over the range of input data is shown graphically in Figure 8.

As good as this model appears to be, its reliance on certain input variables limit its potential as a forecasting tool. For example, the process of forecasting worldwide crude oil production (CrudeProd) is not an exact science and in recent years has been further "muddied" by the debate about peak oil. A quick search on the internet finds at least 15 different peak oil depletion scenarios. Similarly, predicting the future state of the stock market (AllOrd) is something best left to the purveyors of get-rich-quick schemes.

Forecasts for the other key input variables (ie USCrude$ and USD) are available from reputable sources. For example, the US EIA produces ten year forecasts of crude oil prices as part of their annual Energy Outlook report. Similarly, Access Economics (2009) publish forecasts of the USD exchange rate as part of their Business Outlook series.

Figure 8: Final model performance (Dec 2001 – Apr 2010)



4. Future prices

Equation 13 represents the best in the series of models presented here, in terms of its ability to explain the observed variation in average weekly ULP price in Brisbane. A more practical version is required for forecasting purposes – one that it is not dependent on inputs that are themselves difficult to predict with a sufficient level of accuracy. Furthermore, given that forecasts of key input variables are generally made on a yearly basis, there is little point in retaining the seasonal (ie monthly) dummy variables in the forecasting model.

4.1. The forecasting model

The simplified forecasting model is presented in Equation 14. The more difficult to predict input variables (CrudeProd and AllOrd) have been dropped. In their place, another economic based variable (GSP) has been included. The monthly dummy variables and the fuel subsidy dummy variable have also been excluded.

The form of this model is appealing in that it includes variables related to the supply and demand for ULP, as well as local economic activity. All of the variables are significant at the 5%, except for ln(GSP). The coefficients are consistent with basic economic theory. The R^2 statistic is only marginally (1.9%) less than that of the best theoretical model presented earlier (ie Equation 13). Finally, the F statistic is highly significant.

Equation 14: Forecasting model

Variable	Coefficient	t statistic
Independent variable	ln(ULP$_{+1Week}$)	
Intercept	2.64	28.1
ln(USCrude$)	0.418	37.5
ln(GSP)	0.0503	1.57
Adjusted R^2	0.893	
F (2, 432)	1,810	

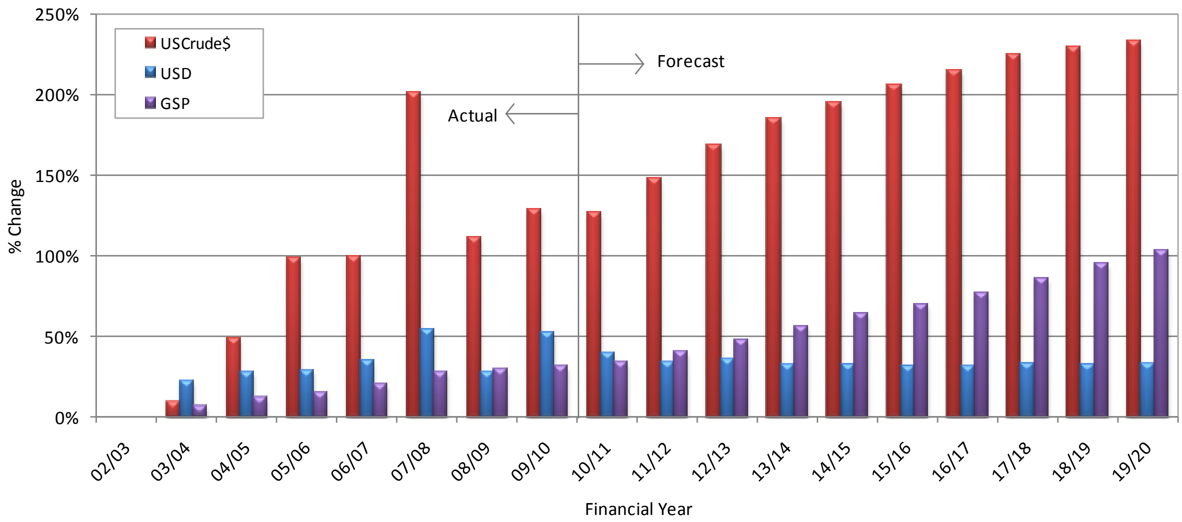
4.2. The input variables

10 year forecasts of the key input variable were obtained from the following sources:

- USCrude$: US EIA Annual Energy Outlook (2010c);
- USD: Access Economics Business Outlook (2009); and
- GSP: Access Economics Business Outlook (2009).

The forecast input variable are presented in Figure 9 and imply a 46% increase in USCrude$ in real terms, a 13% decrease in the USD exchange rate and a 55% increase in Queensland's GSP over the next 10 years (ie 2010-2020).

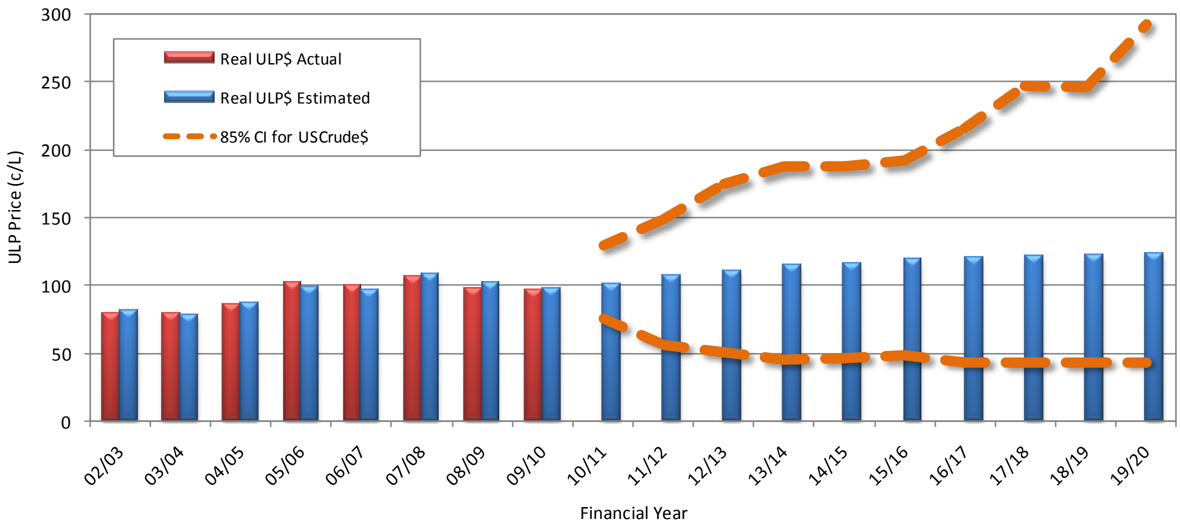
Figure 9: Forecast input variables



4.3. ULP price forecast for Brisbane

Inputting these variables into Equation 14 yields the forecasts of ULP prices for Brisbane presented in Figure 10. The model performs well over the last eight years and predicts a real increase in ULP prices for Brisbane between 2010 and 2020 of 27%. This equates to an annual increase of 2.4%, compared to 2.7% for the preceding seven years. However, a review of historic crude oil price forecasts prepared by the EIA over the last 26 years indicates that actual prices may vary by as much as -24% to + 29% from a one year forecast, and by as much as -64% to + 137% from a 10 year forecast. This means that by 2020, Brisbane consumers could pay up to three times more for ULP than in 2010.

Figure 10: Forecast ULP prices for Brisbane



5. Conclusion

This paper explores the relationship between a range supply, demand and taxation related factors and petrol prices in Brisbane, Australia. Together, the following factors were found to explain over 90% of the observed variation in average weekly petrol prices over an eight year period:

- the real price of US crude oil in AUD;
- the worldwide rate of crude oil production;
- the status of the Australian stock market; and
- seasonal variation in demand in October and November.

A logarithmic regression equation was developed to forecast petrol prices in Brisbane using a sub-set of the above input variables. This equation performed well in reproducing historical petrol prices and predicts a 27% increase in petrol prices for Brisbane by 2020 in real terms.

Care should be taken not to apply the models presented here out of context, given that they were developed specifically using Brisbane ULP price data. It is plausible that other factors may prove more significant in influencing fuel price in other regions. It is hoped that as part of ongoing research, the geographical stability of the model and its parameters can be verified by developing similar models for other States and Territories around Australia. Similarly, the temporal stability of the recommended model could be assessed by “backcasting” pre-March 1999 fuel prices and comparing these with observed values.

References

Access Economics (2009) Business Outlook, Canberra

Adam Pekol Consulting (2010) Australian Transport Facts (unpublished)

Australian Bureau of Statistics (2009a) Australian Demographic Statistics, Cat No. 3101.0, Table 4, Canberra

Australian Bureau of Statistics (2009b) Motor Vehicle Census, Australia, Cat No. 9309.0, Canberra

Australian Bureau of Statistics (2010a) Consumer Price Index, Cat No. 6401.0, Table 5, Canberra

Australian Bureau of Statistics (2010b) Sales of New Motor Vehicles, Australia, Cat No. 9314.0, Table 2, Canberra

Australian Competition and Consumer Commission (2009) Fuel Facts: What Influences the Price of Unleaded Petrol, Commonwealth of Australia, Canberra

Australian Institute of Petroleum (2010a) Facts about Petrol Prices, Canberra, viewed 25 May 2010, <http://www.aip.com.au/pricing/pdf/Facts%20About%20Petrol%20Prices.pdf>

Australian Institute of Petroleum (2010b) Queensland Retail Petrol Prices, Canberra, viewed 25 May 2010, <http://www.aip.com.au/pricing/retail/ulp/index.htm>

Bureau of Infrastructure, Transport and Regional Economics (2010) Estimates of Elasticity of Petrol Consumption with Respect to Petrol Price, Table 1B07, BITRE, Canberra, viewed 28 May 2010, <http://www.bitre.gov.au/tedb/pdf/table1B07.pdf>

Carlson R and Umble M (1980) Statistical Demand Functions for Automobiles and their use for Forecasting in an Energy Crisis, The Journal of Business, Vol 53, No 2, pp 193-204, The University of Chicago Press

Cohen J, Cohen P, West S and Aiken L (2003) Applied Multiple Regression / Correlation Analysis for the Behavioural Sciences, Lawrence Erlbaum Associates

Investopedia (2010) Economics Basics: Demand and Supply, viewed 25 May 2010, <http://www.investopedia.com/university/economics/economics3.asp>

Kilian L (2010) Explaining Fluctuations in Gasoline Prices: A Joint Model of the Global Crude Oil Market and the US Retail Gasoline Market, The Energy Journal, Vol 31, No2, pp 103-128

Liu L (1991) Dynamic Relationship Analysis of US Gasoline and Crude Oil Prices, Journal of Forecasting, Vol 10, pp 521-546, John Wiley and Sons

Malliaris M and Malliaris S (2008) Forecasting Inter-Related Energy Product Prices, The European Journal of Finance, Vol 14, No 6, pp 453-468

McManus W (2007) The Link Between Gasoline Prices and Vehicle Sales, Business Economics, Vol 42, No 1

Reserve Bank of Australia (2010) Exchange Rates, viewed 29 May 2010, http://www.rba.gov.au/statistics/frequency/exchange-rates.html

Singapore Department of Statistics (2010) CPI and Inflation Rate, viewed 22 August 2010, http://www.singstat.gov.sg/stats/themes/economy/hist/cpi.html

US Department of Labor (2010) Consumer Price Index, viewed 29 May 2010, http://www.bls.gov/cpi/

US Energy Information Administration (2010a) Oil Market Basics: Prices, US EIA, Washington, viewed 29 May 2010, <http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/oil_market_basics/>

US Energy Information Administration (2010b) International Energy Statistics, US EIA, Washington, viewed 25 May 2010, <http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=50&pid=53&aid=1>

US Energy Information Administration (2010c) Annual Energy Outlook, US EIA, Washington

Wong E, Venegas E and Antiporta D (1977) Simulating the Consumption of Gasoline, Simulation, Vol 28, No 5, pp 145-152