
O Demand-side analysis for road transport

This appendix sets out the detailed calculations, assumptions and data sources that the Commission used to estimate the demand-side abatement and consumption costs for road transport in the study countries. The analysis covers fuel taxes and biofuel policies.

O.1 Data and assumptions

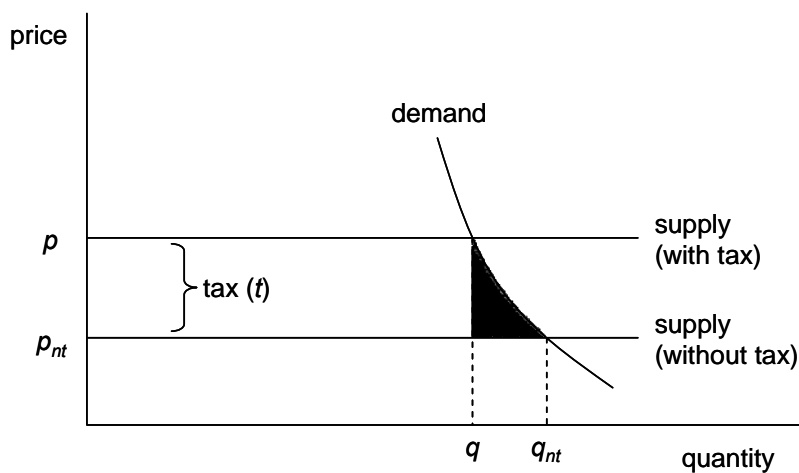
The Commission estimated the consumption cost, abatement, and average consumption cost (per tonne of CO₂-e) of road transport fuel policies in each country. The broad approach is outlined in chapter 3 and the specific application to fuel taxes is set out in box O.1.

For fuel taxes, this includes estimates of the three major types of fuels used for road transport — petrol, diesel and liquefied petroleum gas (LPG) — as well as an aggregate for each country (LPG was not included where it is not taxed). Only volumetric (per litre) taxes were included in the analysis, where levied specifically on fuels. Other taxes were not analysed, including broadly based sales or consumption taxes, and taxes that are not directly levied on fuels (such as vehicle taxes, road tolls or distance charges).

Emissions trading schemes (ETSs) that cover transport fuels were included in the analysis, as these are often levied on fuel suppliers in a similar way to fuel excise. Currently, the only ETS that covers transport fuels is in New Zealand. However, some taxes that may meet the above criteria were not included in the transport sector analysis due to insufficient data, such as the system of fuel price controls in China and the Petroleum and Coal Tax in Japan.

In the case of biofuels, the impact of policies on fuel prices was estimated, followed by demand-side abatement and consumption costs. This analysis is based on the analysis of biofuel policies in appendix N (for the supply side). Some policies that encourage the substitution of biofuels for conventional fuels (petrol or diesel) may lead to higher fuel prices.

Box O.1 Quantifying demand-side costs and abatement



The Commission estimated the consumption costs of fuel taxes and biofuel policies on the demand side. These costs are a measure of the value to consumers of forgone fuel consumption, minus the value of other goods and services that can be purchased instead (chapter 3). This is shown as the shaded area in the figure. For example, as a fuel tax (t) raises the price of fuel (from the price with no tax, p_{nt} , to p , with the tax), consumers reduce the amount of fuel they purchase (from q_{nt} to q), assuming a perfectly elastic fuel supply curve.

A constant-elasticity demand curve was used to estimate consumption costs. This takes the mathematical form $q = Cp^\varepsilon$, where q is the quantity of fuel consumed, p is the fuel price, ε is the own-price elasticity of demand, and C is a constant (a number that indicates the position of the demand curve for a given country).

This type of demand curve implies that the own-price elasticity of demand — the responsiveness to small changes in the price — is constant over all volumes of fuel (that is, over the entire demand curve). A different approach was used to estimate the demand-side impacts of policies in the electricity sector, which considered price changes of a much smaller magnitude than fuel taxes (appendix L). However, a constant-elasticity demand curve was used for road transport as it is presumed to provide a better indication of the responsiveness of fuel demand to the significant price increases that result from fuel taxes.

Using the constant-elasticity demand curve, the reduction in fuel consumption (Δq) is:

$$\Delta q = q \left(1 - \left(\frac{p-t}{p} \right)^\varepsilon \right)$$

and demand-side abatement can be expressed as $A = (-\Delta q)\beta$, where β is the life-cycle emissions intensity of the fuel. Consumption costs were calculated as:

$$\int_{p-t}^p Cp^\varepsilon dp - qt$$

and the average consumption cost (per tonne of CO₂-e abated) was calculated by dividing estimated consumption costs by estimated abatement.

Consumption costs and abatement were only calculated for biofuel policies where the cost of a policy was likely to be passed through to consumers in the form of higher fuel prices. In the majority of cases, costs are paid by taxpayers, either as government expenditure or forgone revenue (and thus are not expected to lead to higher fuel prices).

Thus, the analysis only covers three countries — Germany, the United Kingdom and the United States — that have ‘binding’ fuel content mandates. These mandates set requirements for the amount of biofuel that must be blended into transport fuels. Assuming that the cost of meeting these mandates is passed through to consumers through higher fuel prices, the amount of fuel consumed — and hence emissions — is expected to be lower.

Illustrative estimates of the increase in fuel prices are also provided for each country.

Assumptions used to analyse fuel taxes

Many assumptions were required in order to calculate the estimates of the cost and abatement from fuel taxes in each country. These assumptions reflect both the availability of data and the extent to which costs and abatement can be attributed to fuel taxes. As discussed in chapter 5, to the extent that fuel taxes are used to meet objectives other than emissions reductions (or raise revenue for particular purposes), the cost of taxes may not be fully attributable to any estimated abatement. Thus, the estimates provide only an illustration of the cost and abatement that could be induced by fuel taxes on the demand side, in the absence of offsetting benefits.

The key assumptions are:

- cost and abatement are estimated by comparing observed fuel prices and quantities in each country with a counterfactual scenario in which fuel tax had never been imposed
 - the analysis does not incorporate any offsetting benefits that may arise from the use of fuel taxes to meet other objectives (such as reducing congestion or urban air pollution)
 - the counterfactual does not include other policies that may have been in place to meet the objectives that are currently met by fuel taxes (for example, to raise general revenue)
- the estimates of abatement do not take into account the potential offsetting effects on emissions that could arise from consumers switching between transport modes (for example, abatement that arises from lower vehicle use may

be offset by higher emissions from rail, to the extent that demand for rail is increased).

Assumptions used to analyse biofuel policies

A number of assumptions also needed to be made to provide illustrative estimates of consumption costs and abatement for biofuel policies. The following assumptions were made, in addition to the assumptions used for fuel taxes.

- The subsidy equivalent of fuel content mandates is passed on in full to all fuel users, in the form of a price increase.
 - In addition, this price increase is spread evenly across all fuel consumed.
- All petrol and diesel used for road transport is subject to the fuel content mandate.
- The life-cycle emissions intensity of blended fuel is the average emissions intensity value of the biofuel and the conventional fuel it displaces (weighted by the volume of each that is consumed).

These assumptions mean that the results are likely to be over-estimates of the actual price uplift and average consumption costs.

Elasticity values

Key inputs to the demand-side analysis were estimates of the own-price elasticity of fuel demand, which measure the responsiveness of consumers to higher fuel prices (box O.2). The values used are based on a review of the literature (section O.11).

Given the large variation in estimates of fuel demand elasticities in the literature, it is difficult to identify a single value for a given country with confidence. As a result, the Commission has used a range of elasticity values for analysis of fuel taxes based on estimates of long-term elasticities in the literature. This range is -0.25 (the 'low' value) to -0.75 (the 'high' value).

Long-term estimates have been used, as fuel taxes have been in place for a considerable period of time in most study countries. It is likely that consumers have responded to these taxes by changing their transport choices over this period.

The same elasticity values have generally been used for each country and each fuel type. Although there is some variation in the specific values for any one country or fuel type, the range used here is expected to capture likely responses.

Box O.2 Responses to higher fuel prices

Higher fuel prices — whether due to fuel taxes or other factors, such as changes in world oil prices — reduce the demand for fuel by giving consumers an incentive to use less fuel.

Consumers can respond in a number of ways. For example, in the short term higher fuel prices could change driving behaviours (such as driving at different times of the day or reducing the number of trips made). Over the longer term, consumers could purchase more fuel-efficient vehicles or substitute towards other modes of transport (such as buses, trains or bicycles). In addition, freight companies could substitute away from road transport towards rail or air transport.

The extent to which consumers respond to higher fuel prices can be influenced by many factors. For example, there may be greater substitution towards other modes of transport in more densely populated cities or countries, where public transport is more widely available. Other kinds of taxes — including vehicle taxes, road tolls and congestion charges — can also affect how consumers respond to higher fuel prices.

The overall responsiveness of consumers to higher fuel prices can be estimated using the own-price elasticity of fuel demand. This is a measure of the percentage change in the quantity of fuel demand in response to a small change in the fuel price. Demand for fuel is generally inelastic — a one per cent increase in the fuel price leads to a smaller percentage change in the quantity demanded. For example, an elasticity value of -0.5 indicates that a 1 per cent rise in the fuel price would reduce demand by 0.5 per cent.

However, measuring the overall price elasticity of fuel demand is complex. This typically requires data on fuel prices, fuel demand (consumption) and other factors such as income, vehicle ownership rates and the fuel efficiency of vehicles — which can also affect fuel demand.

Consequently, there is wide variation across studies, depending on the data sources and methodology used, as well as the country and time period considered (section O.11). Despite this variation, most studies find that consumers are more responsive to fuel prices in the longer term (that is, the elasticity value becomes larger, in absolute terms) than in the shorter term (where the elasticity value is closer to zero).

However, a different range was used for policies that have been in place for a shorter period of time. For example, the analysis of the proposed LPG excise in Australia uses elasticity values of -0.1 to -0.25, based on short-term estimates in the literature (section O.11).

The demand-side analysis of biofuel policies also used short-term estimates, since the biofuel mandates analysed have not been in place for as long as fuel taxes in these countries (table O.1). A range of -0.1 to -0.25 was used for the United States, and a range of -0.25 to -0.75 for Germany and the United Kingdom (as there is evidence in the literature that short-term elasticities in Europe are likely to be in this

range, with consumers being more responsive to changes in fuel prices than those in the United States).

Table O.1 Short-term fuel demand elasticity values

<i>Country</i>	<i>Year mandate implemented</i>	<i>Elasticity values</i>	
		low	high
Germany	2007	-0.25	-0.75
United Kingdom	2008	-0.25	-0.75
United States	2008	-0.1	-0.25

Data

Fuel taxes

The analysis of fuel taxes required the following ‘input’ data for each country and fuel type (petrol, diesel and LPG), as set out in box O.1.

- The tax rate (per litre).
 - This includes fuel excise as well as other volumetric taxes levied specifically on transport fuels.
- The quantity of fuel that is taxed and used for road transport.
 - Where possible, this was estimated by dividing total tax revenue by the tax rate.
 - Where revenue data were not available, fuel consumption data were used (in many cases these data are likely to be less accurate, as they often include fuel that is used outside of road transport or non-taxed uses of fuel).
- The average retail price (per litre).
 - An average was used where prices were only available for separate categories of fuel (such as regular and premium unleaded petrol), weighted by the share of each fuel type.
- Emissions of CO₂-e per litre of fuel, measured on a life-cycle basis (the values used for each country are set out in appendix M).

These data were obtained — or calculated using other data — on an annual basis in the local currency of each country. Data were collected for the most recent year available, with the same year used for all data for each country. Where key data varied over the year or across a country, the analysis was conducted for separate time periods or sub-national regions, and the results added together.

All quantity (fuel consumption) values are expressed in ‘litres of petrol equivalent’ to enable comparisons across different fuel types. This was done by using the energy content of each fuel to express amounts in an equivalent volume of petrol that contains the same amount of energy. Conversion rates differ slightly across countries and are set out in appendix M.

Further assumptions, data sources and detailed calculations are set out in the country sections below.

Biofuel policies

Consumption costs and abatement were calculated by first estimating the increase in fuel prices. This was done by dividing the central estimate of the subsidy equivalent (estimated in appendix N) by the volume of fuel that is consumed. The calculations and results are set out in section O.10.

Exchange rates

Results for each country were calculated in local currency, converted to 2010 values (using GDP deflators), and then converted to Australian dollars. This was done using the deflators and exchange rates listed in table O.2.

Table O.2 Exchange rates to 2010 Australian dollars

<i>Country</i>	<i>Currency</i>	<i>Data year used for analysis</i>	<i>Deflator to 2010^a</i>	<i>Exchange rate per A\$^b</i>
Australia	Australian dollar (A\$)	July 2009 – June 2010	1.03	1
China	Chinese yuan (CNY)	January – December 2010	1.00	6.2167
Germany	euro (€)	January – December 2009	1.01	0.6979
Japan	Japanese yen (¥)	April 2009 – March 2010	0.98	80.12
New Zealand	New Zealand dollar (NZ\$)	January – December 2010	1.00	1.2778
South Korea	Korean won (KRW)	January – December 2009	1.03	1065.08
United Kingdom	pound sterling (£)	January – December 2010	1.00	0.5963
United States	United States dollar (US\$)	January – December 2009	1.01	0.9199

^a Deflators to 2010 values (in local currency) are based on the GDP chain price index from the RBA (2011) for Australia, and from the IMF (2011) for all other countries (using the whole calendar year that covers most of the data analysis period). ^b Annual average exchange rates for 2010 are from the RBA (2011).

Sources: IMF (2011); RBA (2011).

O.2 Australia

Australia levies excise on petrol, diesel and most biofuels at the rate of 38.143 cents per litre. There is currently no excise on gaseous fuels (including LPG), although the government has recently introduced legislation to parliament that will impose excise on these fuels from 1 December 2011 (Treasury 2011; Shorten 2011).

Most businesses are eligible to receive a tax credit through the Fuel Tax Credit Scheme that effectively offsets the amount of excise paid. This scheme provides a tax credit for the use of certain vehicles for business purposes (vehicles with a gross weight of 4.5 tonnes or more and diesel vehicles acquired before 1 July 2006). The tax credit was provided at the rate of 16.443 cents per litre over 2009-10 (ATO 2010b), which effectively reduces the excise paid by this amount.

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in Australia were estimated for the 2009-10 financial year (July 2009 – June 2010). Average retail prices, excise rates, excise revenues and the reported level of taxed consumption for 2009-10 are provided in table O.3.

Table O.3 **Fuel taxes**
Australia, July 2009 – June 2010

<i>Fuel type</i>	<i>Average retail price</i>	<i>Excise rate</i>	<i>Gross excise revenue</i>	<i>Reported level of taxed consumption</i>
	A\$/L	A\$/L	A\$m (2009-10)	ML
Petrol	1.242 ^a	0.38143	6 285	16 477
Diesel	1.245	0.38143	6 862	17 991 ^b
LPG	0.593	..	..	..

^a Average price of regular unleaded petrol (ACCC 2010). ^b The level of taxed consumption used in the analysis is lower (4898 ML), to adjust for the Fuel Tax Credits Scheme. .. Not applicable.

Sources: ACCC (2010); ATO (2011a; 2011b); Productivity Commission estimates.

Fuel Tax Credits Scheme

The Fuel Tax Credits Scheme effectively reduces the amount of excise paid on some fuels. The total value of tax credits under this scheme was A\$4994 million in 2009-10 (ATO 2011b). However, the Australian Taxation Office does not collect data on the amount of credits provided to each fuel type, the volume of fuel for which credits are claimed, or the amount of fuel that is used for road transport (Treasury, pers. comm., 15 April 2011). The Commission thus assumed that all tax

credits applied to diesel vehicles used for road transport as most vehicles over 4.5 tonnes are likely to be diesel vehicles.¹

As a result, the level of taxed consumption of diesel used in the analysis has been reduced by offsetting the amount of fuel tax credits from diesel excise revenues. The estimated proportion of diesel use that receives the tax credit was calculated by dividing the value of tax credits by gross excise revenues (A\$4994 million divided by A\$6862 million, or 73 per cent). This was then multiplied by the taxed volume of fuel (17 991 ML, calculated by dividing gross excise revenues by the excise rate) to give a figure of 13 093 ML. Subtracting this from the total volume gives a figure of 4898 ML, which has been used in the analysis.

Proposed excise on LPG

As there is currently no excise on LPG, the main analysis is for petrol and diesel only. However, the Government has recently introduced legislation to Parliament that will impose excise on LPG and other ‘alternative’ fuels (Treasury 2011; Shorten 2011).

The Commission has calculated illustrative estimates of the consumption costs and abatement for this excise. As the rate is scheduled to be raised over time, estimates are provided for the initial tax rate (2.5 cents per litre, from 1 December 2011 to 30 June 2012) and the ‘final tax rate’ (12.5 cents per litre, from 1 July 2015) (Treasury 2011).

This analysis involved several assumptions:

- average retail LPG prices remain the same as in 2009-10
- annual LPG consumption for road transport remains at its current level of 2083 ML (Department of Resources, Energy and Tourism 2010)
 - estimates for the initial tax rate use seven-twelfths of this figure (1215 ML) as the rate is to apply only over a seven month period
 - estimates for the final tax rate are for an entire year
- the price level in Australia remains at the 2010 level (no inflation).

In addition, a lower range of elasticity values (-0.1 to -0.25) was used than in the analysis of petrol and diesel excise. These lower values are short-term values that

¹ The reported volume of fuel subject to excise (ATO 2011b) does not distinguish between on-road and off-road uses of fuel. For consistency, it has been assumed that all taxed fuel — and all fuel for which tax credits are received — is used for road transport.

are more likely to reflect the initial responses by consumers to the LPG excise, as set out in the introduction to this appendix.

Results

Estimated consumption costs and abatement for fuel taxes in Australia (petrol and diesel) are presented in table O.4. Average consumption costs (per tonne of abatement) are presented in table O.5.

Table O.4 Consumption costs and abatement

Australia, July 2009 – June 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>		<i>Consumption cost</i>	<i>Abatement</i>
	ML	ML petrol equivalent	A\$m (2010)	Mt CO ₂ -e
Petrol				
Low	1 583	1 583	287	5
High	5 219	5 219	917	16
Diesel				
Low	469	529	85	2
High	1 546	1 745	272	5

Source: Productivity Commission estimates.

Table O.5 Average consumption costs

Australia, July 2009 – June 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>	<i>Consumption cost</i>	<i>Abatement</i>	<i>Average consumption cost</i>
	ML petrol equivalent	A\$m (2010)	Mt CO ₂ -e	A\$/t CO ₂ -e
Low	2 112	373	6	59
High	6 964	1 189	21	57

Source: Productivity Commission estimates.

LPG excise

Estimated consumption costs and abatement for the proposed LPG excise are presented in table O.6 for two scenarios: a rate of 2.5 cents per litre (over a seven month period) and a rate of 12.5 cents per litre (over a one year period).

Table O.6 Average consumption costs, LPG excise

Australia, data for July 2009 – June 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>		<i>Consumption cost</i>	<i>Abatement</i>	<i>Average consumption cost</i>
	ML	ML petrol equivalent	A\$m (2010)	Mt CO ₂ -e	A\$/t CO ₂ -e
2.5 cents per litre					
Low	5	4	0.07	0.01	6
High	13	10	0.16	0.03	6
12.5 cents per litre					
Low	50	37	3	0.10	30
High	127	95	8	0.25	30

Source: Productivity Commission estimates.

O.3 China

China taxes petrol and diesel at the national level through the ‘Consumption Tax’ (there is no volumetric tax on LPG used for road transport). The rates are CNY 1.0/L of petrol and CNY 0.8/L of diesel (ERI (China) pers. comm., 20 April 2011). There are also retail price controls in China that could offset the effects of fuel taxes at times. However, the impact of these price controls is difficult to quantify (box O.3).

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes on petrol and diesel in China were estimated for the 2010 calendar year. Data on fuel taxes, average retail prices and the volume of taxed fuel used for road transport were provided to the Commission by the Energy Research Institute (ERI).

Average retail prices, tax rates and the volume of taxed consumption are provided in table O.7. The price of petrol grade 93 (that is, petrol with an octane number of 93) was used in the analysis as this is the most widely used grade in China (ERI (China) pers. comm., 26 April 2011).

Box O.3 Fuel price controls in China

China has a system of fuel price controls that regulates the prices of refined oil products, such as petrol and diesel. Fuel prices are fixed and adjusted when the average price of crude oil on international markets undergoes a sustained change (defined as an increase or decrease that exceeds 4 per cent and lasts for 22 consecutive days).

These price controls could offset — or increase — the effect of excise on fuel consumption. This could effectively subsidise or tax domestic consumption. If the price controls act like a tax because crude oil prices have fallen but this has not yet been reflected in domestic fuel prices, there could be some abatement. However, if the price controls act like a subsidy, there could be an increase in emissions (relative to a counterfactual scenario where there are no price controls).

The impact of price controls on retail prices could be assessed using a ‘price-gap’ approach. For example, the International Energy Agency (IEA) has estimated fossil fuel subsidies by comparing the average consumer price of a fuel with the corresponding ‘reference’ price. This reference price is an estimate of what the domestic fuel price would have been without subsidies or regulations. It is calculated using the prevailing import parity price for crude oil, adjusted for differences in fuel quality and the costs of freight, insurance, distribution, marketing and value-added taxes (IEA 2010n).

However, the IEA did not analyse price controls for road transport fuels in China, as it did not consider these to have a significant effect on fuel prices.

Source: IEA (2010n).

Table O.7 Fuel taxes

China, 2009

<i>Fuel type</i>	<i>Average retail price^a</i>	<i>Tax rate</i>	<i>Level of taxed consumption</i>
	CNY/L	CNY/L	ML
Petrol	..	..	81 554 ^b
Grade 90	6.0	1.0	na
Grade 93	6.5	1.0	na
Grade 97	7.0	1.0	na
Diesel	6.3	0.8	82 931

^a Price data are for 2010 as national average prices for 2009 were not available. ^b Total taxed consumption of all petrol grades. **na** Not available. .. Not applicable.

Source: ERI (China) (pers. comm., 20 April 2011).

Results

Estimated consumption costs and abatement for fuel taxes in China are presented in table O.8. Average consumption costs (per tonne of abatement) are presented in table O.9.

Table O.8 Consumption costs and abatement
China, 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>		<i>Consumption cost</i>		<i>Abatement</i> Mt CO ₂ -e
	ML	ML petrol equivalent	CNY m (2010)	A\$m (2010)	
Petrol					
Low	3 478	3 478	1 679	270	10–11
High	10 886	10 886	5 178	833	32–36
Diesel					
Low	2 866	3 259	1 114	179	10–11
High	8 898	10 118	3 418	550	30–33

Source: Productivity Commission estimates.

Table O.9 Average consumption costs
China, 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>	<i>Consumption cost</i>		<i>Abatement</i>	<i>Average consumption cost</i>
	ML petrol equivalent	CNY m (2010)	A\$m (2010)	Mt CO ₂ -e	A\$/t CO ₂ -e
Low	6 737	2 792	449	20 – 22	20 – 23
High	21 003	8 596	1 383	62 – 68	20 – 22

Source: Productivity Commission estimates.

O.4 Germany

Excise is levied on road transport fuels at the federal level in Germany. Rates vary by the type of fuel and its sulphur content, and have been at current levels since July 2006 (table O.10).

Table O.10 Fuel excise rates

Germany, 2011

<i>Fuel type</i>	<i>Excise rate</i>
	€/L
Unleaded petrol with sulphur content of 10 milligrams per kilogram (mg/kg) or less	0.6545
Unleaded petrol with sulphur content greater than 10 mg/kg	0.6698
Diesel with sulphur content of 10 mg/kg or less	0.4704
Diesel with sulphur content greater than 10 mg/kg	0.4857
LPG	0.1803 ^a
Liquefied natural gas	0.4090 ^a
Other liquid gases	0.1217 ^a

^a Rates are per kilogram.

Source: Federal Customs Administration (Germany) (2011).

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in Germany were estimated for the 2009 calendar year. Average retail prices, excise rates and consumption volumes for 2009 are provided in table O.11. Data for the volume of fuels consumed for road transport were used, as revenue data include biofuel blended with petrol and diesel.

Table O.11 Fuel taxes

Germany, 2009

<i>Fuel type</i>	<i>Average retail price</i>	<i>Excise rate</i>	<i>Fuel consumption</i>
	€/L	€/L	ML
Petrol ^a	1.28	0.6545	25 562
Diesel ^a	1.09	0.4704	31 174
LPG	0.59 ^b	0.0992	942

^a Excise rates on petrol and diesel with a sulphur content of 10 mg/kg or less has been used in the analysis as most diesel used in Germany is of this type. ^b The LPG price is a simple average of weekly price data from the European Commission (2011a).

Sources: EC (2011a); Energy Balances Working Group (2011); Federal Ministry of Economics and Technology (Germany) (2010); Productivity Commission estimates.

Results

Estimated consumption costs and abatement for fuel taxes in Germany are presented in table O.12. Average consumption costs (per tonne of abatement) are presented in table O.13.

Table O.12 Consumption costs and abatement

Germany, 2009

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>		<i>Consumption cost</i>		<i>Abatement</i> Mt CO ₂ -e
	ML	ML petrol equivalent	€m (2009)	A\$m (2010)	
Petrol					
Low	5 011	5 011	1 397	2 017	14
High	18 174	18 174	4 722	6 813	50
Diesel					
Low	4 728	5 272	982	1 417	15
High	16 445	18 335	3 236	4 669	52
LPG					
Low	45	35	2	3	0.1
High	141	111	7	10	0.3

Source: Productivity Commission estimates.

Table O.13 Average consumption costs

Germany, 2009

<i>Elasticity</i>	<i>Reduction in fuel consumption</i> ML petrol equivalent	<i>Consumption cost</i>		<i>Abatement</i> Mt CO ₂ -e	<i>Average consumption cost</i> A\$/t CO ₂ -e
		€m (2009)	A\$m (2010)		
Low	10 318	2 382	3 437	29	119
High	36 619	7 964	11 492	102	113

Source: Productivity Commission estimates.

O.5 Japan

Japan levies excise on road transport fuels at the national level. The tax on petrol consists of two components (the Gasoline Tax and the Local Gasoline Tax) (table O.14). The tax on diesel is collected at the prefectural level.

In addition, the Petroleum and Coal Tax has been identified as an emissions-reduction measure in Japan (chapter 2). This tax is levied on the petroleum (crude oil) used as an input by refineries, as well as on imports of refined products (such as petrol and diesel) (box O.4). As most transport fuels in Japan are either directly imported or produced from imported petroleum, this tax is likely to impact most fuel sold. That said, it has not been included in the analysis below, as Japan imports substantially more petroleum (for domestic refining) than it does refined products (IEA 2010e). This suggests that the Petroleum and Coal Tax is mostly an input tax that is not directly levied on retail sales of road transport fuels.

Moreover, the effect on retail prices is uncertain and could depend on refining processes and the ability of refiners and importers to pass the costs through to consumers.

Table O.14 Fuel excise rates
Japan, 2011

<i>Tax</i>	<i>Excise rate</i>
	¥/L
Gasoline Tax	48.6
Local Gasoline Tax	5.2
Diesel Handling Tax	32.1
Liquefied Petroleum Gas Tax	17.5 ^a

^a Rate is per kilogram.

Sources: JAMA (2010); Ministry of Finance (Japan) (2010a).

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in Japan were estimated for fiscal year 2009 (April 2009 to March 2010). Some tax, revenue and price data were provided to the Commission by the Institute of Energy Economics, Japan (IEEJ).

Average retail prices, excise rates and excise revenues for Japan are provided in table O.15, along with the implied level of taxed consumption for each fuel (calculated by dividing the revenue values by the excise rates).

Box O.4 Petroleum and Coal Tax

The Petroleum and Coal Tax in Japan taxes imports of petroleum (crude oil) at ¥2.04/L (A\$0.02/L) and imports of petroleum gas at ¥1.08/kg (A\$0.01/kg) (Ministry of Finance (Japan) 2010a). This tax is levied on imports of both petroleum and refined fuels (such as petrol or diesel). Since Japan produces only a small amount of oil domestically (IEA 2010e), most transport fuel would be affected.

Under a current legislative proposal — the ‘Special Provision on Taxation for Global Warming Countermeasure’ — the rate of tax will be increased based on the emissions content of fuels (that is, the volume of carbon dioxide that would be generated when combusting each type of fuel). The amount of the increase will gradually increase between April 2013 and April 2015, to a rate of ¥289/t CO₂ (A\$3.53). This will translate to a tax of ¥0.76/L (A\$0.01/L) of refined petrol or diesel imports, and ¥0.78/kg (A\$0.01/kg) of imported LPG.

Sources: Ministry of Finance (Japan) (2010a); Ministry of Environment (Japan) (pers. comm., 25 April, 2 May and 19 May 2011); IEEJ (pers. comm., 14 April 2011); IEA (2010e).

Table O.15 Fuel taxes

Japan, April 2009 – March 2010

<i>Fuel type</i>	<i>Average retail price</i>	<i>Excise rate</i>	<i>Excise revenue^a</i>	<i>Implied level of taxed consumption</i>
	¥/L	¥/L	¥b (2009)	ML
Petrol	134.8	53.80	2 948	54 796
Diesel	112.7	32.10	908	2 830
LPG	79.3 ^b	9.63	26	2 701

^a Excise revenue data for petrol and LPG are from Ministry of Finance (Japan) (2010a). The figure for diesel was provided by the IEEJ (pers. comm., 14 April 2011). ^b Average of prices, for every second month, from April 2009 to March 2010 provided by the IEEJ (pers. comm., 14 April 2011).

Sources: IEEJ (pers. comm., 14 April 2011); Ministry of Finance (Japan) (2010a; 2010b); Oil Information Center (2011); Productivity Commission estimates.

Results

Estimated consumption costs and abatement for fuel taxes in Japan are presented in table O.16. Average consumption costs (per tonne of abatement) are presented in table O.17.

Table O.16 Consumption costs and abatement

Japan, April 2009 – March 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>		<i>Consumption cost</i>		<i>Abatement</i>
	ML	ML petrol equivalent	¥b (2009)	A\$m (2010)	
Petrol					
Low	7 441	7 441	179	2 188	20
High	25 492	25 492	585	7 143	70
Diesel					
Low	247	273	4	45	0.7
High	809	892	12	143	2.3
LPG					
Low	89	70	0.4	5	0.2
High	275	217	1.3	16	0.5

Source: Productivity Commission estimates.

Table O.17 Average consumption costs

Japan, April 2009 – March 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>	<i>Consumption cost</i>		<i>Abatement</i>	<i>Average consumption cost</i>
		¥b (2009)	A\$m (2010)			Mt CO_{2}-e	A$/t CO_{2}-e
	ML petrol equivalent				
Low	7 784	183	2 238	21	105
High	26 601	596	7 301	73	100

Source: Productivity Commission estimates.

O.6 New Zealand

New Zealand levies several taxes on transport fuels, including excise and levies, as well as the New Zealand ETS.

Excises on petrol consist of the Excise Duty on Motor Spirits, the Accident Compensation Corporation Levy, the Petroleum or Engine Fuels Monitoring Levy and the Local Authority Petroleum Tax (table O.18). Since 1991, the excise on diesel has been considerably lower than that on petrol. This is due to changes to taxation arrangements so that diesel vehicles are now primarily taxed through the Road User Charges system (where permits must be purchased for each 1000 kilometres travelled, with the charge depending on the type and weight of the vehicle).

Table O.18 Excise on road transport fuels

New Zealand, 2011

<i>Fuel type</i>	<i>Excise Duty on Motor Spirits</i>	<i>Accident Compensation Corporation Levy</i>	<i>Petroleum or Engine Fuels Monitoring Levy</i>	<i>Local Authority Petroleum Tax</i>	<i>Total excise</i>
	NZ\$/L	NZ\$/L	NZ\$/L	NZ\$/L	NZ\$/L
Petrol	0.48524	0.099	0.00045	0.0066	0.59129
Diesel	–	–	0.00045	0.0033	0.00375
LPG	0.104	–	–	–	0.104
CNG	0.105	–	–	–	0.105
Methanol	0.302	–	–	0.0066	0.3068

– Nil or rounded to zero.

Source: MED (NZ) (2011c).

The New Zealand ETS covers liquid fossil fuels, which includes most road transport fuels. Fuel suppliers (which purchase fuels from refineries or import fuels) are

required to surrender permits to cover the ‘downstream’ emissions of fuels when they are combusted by purchasers of fuel, such as businesses or consumers.

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in New Zealand were estimated jointly for both fuel excise and the New Zealand ETS for the 2010 calendar year.

Fuel prices and tax rates

Excise rates and New Zealand ETS obligations have varied over 2010. As a result, the reduction in fuel consumption and consumption costs were estimated on a ‘quarterly’ basis (for four three-month periods in 2010). These estimates were then summed to provide annual figures (table O.19).

Key changes throughout 2010 were:

- The Excise Duty on Motor Spirits was increased by three cents per litre on 1 October 2010 (from NZ\$0.45524/L to NZ\$0.48524/L) (MED (NZ) 2011c). This means that the rate was higher in the fourth quarter (October to December) than in the first three quarters (January to September).
- Transport fuel suppliers have been liable to surrender ETS permits since 1 July 2010. This means that, in 2010, the ETS effectively taxed transport fuels only between July and December (third and fourth quarters). This is reported by MED (NZ) (2011e) for petrol and diesel on a weekly basis as an ‘ETS charge’ — the average amount that is passed on to the retail prices of petrol and diesel.

Quantity of taxed fuels used in road transport

In order to estimate the quantity of taxed road transport fuels consumed, several assumptions were required. Total fuel consumption data (MED (NZ) 2011d) were not used as these include the use of fuels outside of road transport.

Instead, excise revenue data were used to estimate the volume of taxed fuel in each quarter. Revenue data for domestically refined fuels are published by month for 2010 but not by fuel type (New Zealand Treasury 2010b). Revenue data for the customs duty on imported fuels (the duty is at the same rate as the excise) is only available as an annual figure, for financial year 2009-10 (July 2009 to June 2010) (New Zealand Treasury 2010a).

Table O.19 Fuel excise, 'ETS charges' and average fuel prices^a
New Zealand, 2010

	<i>Excise</i>	<i>Average 'ETS charge'^b</i>	<i>Total</i>	<i>Average fuel price^c</i>
	NZ\$/L	NZ\$/L	NZ\$/L	NZ\$/L
First quarter (January – March)				
Petrol	0.56129	..	0.56129	1.77
Diesel	0.00375	..	0.00375	1.12
LPG	0.104	..	0.104	1.21
Second quarter (April – June)				
Petrol	0.56129	..	0.56129	1.78
Diesel	0.00375	..	0.00375	1.18
LPG	0.104	..	0.104	1.21
Third quarter (July – September)				
Petrol	0.56129	0.0207	0.58199	1.76
Diesel	0.00375	0.0239	0.02765	1.19
LPG	0.104	0.0147	0.1187	1.23
Fourth quarter (October – December)				
Petrol	0.59129	0.0235	0.61479	1.89
Diesel	0.00375	0.0272	0.03095	1.27
LPG	0.104	0.0160	0.1200	1.26

^a Fuel prices and average 'ETS charges' for petrol and diesel are simple averages based on weekly data for each quarter from MED (NZ) (2011e). ^b An 'ETS charge' has not been reported for LPG, hence the value has been estimated by multiplying an estimate of the direct emissions from LPG (1793 g CO₂-e/L; appendix M) by half the average quarterly permit price in each quarter (AEA Technology pers. comm., 24 March 2011) (as one permit could be surrendered to cover two tonnes of transport fuel emissions in 2010). ^c Petrol prices are for 'regular petrol'. The LPG price is a simple average of monthly data for Wellington, provided by the New Zealand Automobile Association (Ministry for the Environment (New Zealand) pers. comm., 27 April 2011). .. Not applicable.

Sources: MED (NZ) (2011c; 2011e); AEA Technology (pers. comm., 24 March 2011); Ministry for the Environment (New Zealand) (pers. comm., 27 April 2011); Appendix M; Productivity Commission estimates.

Estimates of revenues for each fuel type were calculated by first estimating total revenues in each quarter. This was done by summing excise revenues from domestically-refined fuels for the three months in each quarter, then adding an amount for the excise from imported fuels (calculated by dividing the customs duty revenue figure for 2009-10 by four, and assuming that revenues would be the same over calendar year 2010).

These quarterly estimates were then apportioned across fuel types by assuming that the proportion of total fuel use that was taxed and used for road transport was the same for each fuel type. (That said, a greater proportion of diesel fuel may be used

outside of road transport than other fuel types, and thus the revenue from diesel may be overestimated.) The estimates of revenue by fuel type were then divided by the excise rate to impute the quantity of taxed fuel used for road transport (table O.20).

Table O.20 Estimated quantities of taxed road transport fuels
New Zealand, 2010

	<i>Total excise</i>	<i>Supply from wholesalers^a</i>	<i>Imputed weight (share of revenue)^b</i>	<i>Estimated excise revenue^c</i>	<i>Estimated quantity of taxed road transport fuel</i>
	NZ\$/L	ML	%	NZ\$m (2010)	ML
First quarter (January – March)					
Total	..	..	..	353	..
Petrol	0.56129	802.7	0.98	347	6 186
Diesel	0.00375	659.2	0.01	2	507
LPG	0.104	49.0	0.01	4	38
Second quarter (April – June)					
Total	..	..	..	358	..
Petrol	0.56129	766.3	0.98	351	625
Diesel	0.00375	642.2	0.01	2	523
LPG	0.104	58.8	0.01	5	48
Third quarter (July – September)					
Total	..	..	..	396	..
Petrol	0.56129	766.0	0.97	385	685
Diesel	0.00375	669.5	0.01	2	599
LPG	0.104	93.7	0.02	9	84
Fourth quarter (October – December)					
Total	..	..	..	348	..
Petrol	0.59129	812.6	0.98	342	578
Diesel	0.00375	747.4	0.01	2	531
LPG	0.104	53.8	0.01	4	38

^a 'Total domestic consumption' data from MED (NZ) (2011d), derived from a survey of the five fuel wholesalers in New Zealand. ^b The weights used to apportion quarterly revenue between fuel types were constructed by calculating what the revenue share of each would have been if all fuel supplied by wholesalers was subject to excise. For each quarter, this was done by multiplying the excise rate of each fuel type by the wholesale supply of that fuel (this gives the numerators for the weights; the sum of these values over all fuels gives the denominator). ^c Quarterly total excise revenues are based on monthly data from the New Zealand Treasury (2010a) for excise on domestically refined fuels, and an estimate based on an annual figure for 2009-10 for duty on imported fuels, also reported by the New Zealand Treasury (2010a). Consumption data for CNG and methanol used for road transport were not available. It was assumed that revenue from tax on these fuels was negligible. .. Not applicable.

Sources: MED (NZ) (2011c; 2011d); New Zealand Treasury (2010a; 2010b); Productivity Commission estimates.

Results

Estimated consumption costs and abatement for fuel taxes in New Zealand are presented in table O.21. Average consumption costs (per tonne of abatement) are presented in table O.22.

Table O.21 Consumption costs and abatement
New Zealand, 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>		<i>Consumption cost</i>		<i>Abatement</i> Mt CO ₂ -e
	ML	ML petrol equivalent	NZ\$m (2010)	A\$m (2010)	
Petrol					
Low	259	259	69	54	0.7
High	859	859	221	173	2.3
Diesel					
Low	8	8	0.1	0.1	0.02
High	23	25	0.3	0.2	0.07
LPG					
Low	5	4	0.3	0.2	0.01
High	16	12	0.9	0.7	0.03

Source: Productivity Commission estimates.

Table O.22 Average consumption costs
New Zealand, 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i> ML petrol equivalent	<i>Consumption cost</i>		<i>Abatement</i> Mt CO ₂ -e	<i>Average consumption cost</i> A\$/t CO ₂ -e
		NZ\$m (2010)	A\$m (2010)		
Low	271	69	54	0.7	73
High	896	222	174	2.4	71

Source: Productivity Commission estimates.

O.7 South Korea

South Korea levies several taxes on petrol and diesel: the Transportation, Energy, Environment Tax; the Education Tax; and the Motor Fuel Tax (table O.23).

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in South Korea were estimated for the 2009 calendar year. Data on fuel taxes, average retail prices and the volume of

taxed fuel used for road transport were provided to the Commission by the Korean Energy Economics Institute (KEEI).

Table O.23 Fuel tax rates^a
South Korea, 2011

<i>Fuel type</i>	<i>Transportation, Education Tax, Motor Fuel Tax</i>	<i>Other volumetric taxes</i>	<i>Total</i>
	<i>Transportation, Energy, Environment Tax</i>		
	KRW/L	KRW/L	KRW/L
Petrol	529.00	79.35	745.89
Diesel	367.50	55.13	518.18
LPG	..	24.09	221.06

^a These tax rates have applied since 21 May 2009. .. Not applicable.

Source: KEEI (pers. comm., 26 April and 27 April 2011).

Fuel prices, taxes and the level of taxed consumption are provided in table O.24. The fuel tax rates on petrol and diesel increased on 21 May 2009 to the levels shown in the table. However, data were not available on average prices and taxed consumption for the separate periods either side of this tax change (1 January to 20 May, and 21 May to 31 December). The higher (more recent) rates have been used in the analysis since they applied for a longer period of time, although in consequence, the results reported below may be overestimates.

Table O.24 Fuel taxes
South Korea, 2009

<i>Fuel type</i>	<i>Average retail price</i>	<i>Tax rate</i>	<i>Level of taxed consumption</i>
	KRW/L	KRW/L	ML
Petrol	1 601	745.89	10 132
Diesel	1 398	518.18	15 855
LPG	829	221.06	7 782

Sources: KEEI (2010b; pers. comm., 26 April and 27 April 2011).

Results

Estimated consumption costs and abatement for fuel taxes in South Korea are presented in table O.25. Average consumption costs (per tonne of abatement) are presented in table O.26.

Table O.25 Consumption costs and abatement

South Korea, 2009

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>		<i>Consumption cost</i>		<i>Abatement</i> Mt CO ₂ -e
	ML	ML petrol equivalent	KRW b (2009)	A\$m (2010)	
Petrol					
Low	1 720	1 720	558	541	5
High	6 087	6 087	1 859	1 801	17
Diesel					
Low	1 947	2 203	456	442	6
High	6 588	7 453	1 477	1 432	20
LPG					
Low	628	515	65	63	1
High	2 039	1 674	205	199	4

Source: Productivity Commission estimates.

Table O.26 Average consumption costs

South Korea, 2009

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>	<i>Consumption cost</i>		<i>Abatement</i>	<i>Average consumption cost</i>
	ML petrol equivalent	KRW b (2009)	A\$m (2010)	Mt CO ₂ -e	A\$/t CO ₂ -e
Low	4 438	1 079	1 046	12	87
High	15 214	3 541	3 432	41	83

Source: Productivity Commission estimates.

O.8 United Kingdom

The United Kingdom levies excise on fuels for road transport at the rates set out in table O.27.

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in the United Kingdom were estimated for the 2010 calendar year. As rates of fuel duty changed twice during this year, in April and October (table O.28), the reduction in fuel consumption and consumption costs were estimated on a monthly basis for the United Kingdom. Estimates were then summed to provide annual figures.

Table O.27 Fuel duty rates
United Kingdom, 2011^a

<i>Fuel type</i>	<i>Duty rate</i>
	£/L
Unleaded petrol	0.5795
Leaded petrol	0.6767
Diesel	0.5795
Bioethanol	0.5795
Biodiesel / blended	0.5795
Natural gas	0.2470 ^b
All other gases	0.3161 ^b

^a Rates were effective from 23 March 2011. ^b Rates are per kilogram.

Source: HM Revenue and Customs (UK) (2011).

The quantity of each fuel consumed was imputed using monthly revenue data (HM Revenue and Customs (UK) 2011). Detailed revenue data were not available for LPG, although revenue data are published for ‘road fuel gases’, which consists mostly of LPG but also includes natural gas used by road transport. Therefore, some results for LPG in the analysis may be overstated.

Table O.28 Dates of fuel duty rate changes
United Kingdom, 2009–2011

<i>Fuel type</i>	<i>1 September 2009</i>	<i>1 April 2010</i>	<i>1 October 2010</i>	<i>1 January 2011</i>
	£/L	£/L	£/L	£/L
Petrol	0.5619	0.5719	0.5819	0.5895
Diesel	0.5619	0.5719	0.5819	0.5895
LPG ^a	0.1496	0.1651	0.1728	0.1787

^a Rates are for ‘all other gases’ under the road fuel gases category.

Source: HM Revenue and Customs (UK) (2011).

Average fuel prices, excise rates and fuel duty revenues are shown in table O.29. Average prices for petrol were available only for two separate grades (super unleaded and premium unleaded), and for each month an average price was used, weighted using quarterly consumption data of each fuel type (DECC (UK) 2011a).

Table O.29 Fuel taxes^a
United Kingdom, 2010

<i>Fuel type</i>	<i>Average retail price</i>	<i>Excise rate</i>	<i>Excise revenue</i>
	£/L	£/L	£m (2010)
Petrol	1.17 ^b	0.5721	11 430
Diesel	1.19	0.5722	14 119
LPG	0.64	0.1635	32

^a Prices and excise rates are averages based on monthly data, weighted using the implied level of taxed consumption in each month. ^b Average of super unleaded and premium unleaded prices, weighted using quarterly data on consumption of each fuel type (DECC (UK) 2011a).

Sources: HM Revenue and Customs (UK) (2011); DECC (UK) (2011a; 2011b); Automobile Association (2011); Productivity Commission estimates.

Results

Estimated consumption costs and abatement for fuel taxes in the United Kingdom are presented in table O.30. Average consumption costs (per tonne of abatement) are presented in table O.31.

Table O.30 Consumption costs and abatement
United Kingdom, 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>		<i>Consumption cost</i>		<i>Abatement</i>
	ML	ML petrol equivalent	£m (2010)	A\$m (2010)	Mt CO ₂ -e
Petrol					
Low	3 641	3 641	897	1 504	10
High	13 037	13 037	3 008	5 044	36
Diesel					
Low	4 379	4 793	1 083	1 816	14
High	15 610	17 085	3 622	6 074	50
LPG					
Low	15	12	1.1	1.9	0.02
High	48	37	3.6	6.0	0.08

Source: Productivity Commission estimates.

Table O.31 Average consumption costs

United Kingdom, 2010

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>	<i>Consumption cost</i>		<i>Abatement</i>	<i>Average abatement cost</i>
		£m (2010)	A\$m (2010)			Mt CO_{2}-e	A$/t CO_{2}-e
	ML petrol equivalent				
Low	8 446	1 981	3 323	24	139
High	30 159	6 634	11 125	85	130

Source: Productivity Commission estimates.

O.9 United States

Fuel taxes in the United States are levied at the federal, state and local levels. Federal excise taxes are listed in table O.32. State tax rates are listed in table O.38 in the annex, although fuel tax systems differ between states (box O.5). In addition, there are also consumption taxes (at state and local levels), and local-level excise taxes.

At the federal level and in most states, petrol blended with ethanol — termed ‘gasohol’ in the United States, and usually containing 10 per cent ethanol (E10) — is taxed at the same rate per litre as petrol. However, the tax is lower in some states, which effectively subsidises the consumption of ethanol (appendix N).

Table O.32 Federal fuel excise

United States, December 2010

<i>Fuel type</i>	<i>Excise rate</i>
	US\$/gallon
Gasoline ^a	0.184
Diesel	0.244
LPG	0.183
‘P series’ fuel	0.184
Compressed natural gas	0.183
Liquefied hydrogen	0.184
Liquid fuel derived from coal (including peat) through the Fischer-Tropsch process	0.244
Liquid fuel derived from biomass	0.244
Liquefied natural gas	0.243

^a Includes blends of petrol with alcohol (such as ethanol).

Source: IRS (US) (2011).

Box O.5 State fuel tax systems in the United States

Fuel tax systems differ in design between states. On average, volumetric taxes are approximately US\$0.21/gallon (A\$0.06/L) of petrol and diesel, and US\$0.10/gallon (A\$0.03/L) of LPG. Some states also impose consumption taxes ('sales taxes') or Local Option Taxes on fuel (the latter are levied at the county or city level).

In addition, many states provide exemptions to state-level volumetric taxes.

- Ten states do not impose volumetric taxes on LPG, and nine states (plus the District of Columbia) have a lower tax rate on E10 'gasohol' than on petrol (as of December 2010).
- LPG vehicles that are registered in some states pay an annual fee instead of the volumetric fuel tax (and thus not all LPG fuel sold for use in road transport is subject to state-level fuel taxes).
- Several states impose additional volumetric taxes for 'motor carriers' (such as freight companies), or vehicles above a certain weight or number of axles.
- Some states adjust fuel tax rates on a periodic basis, whereas others states have not changed rates for several years or even decades.
- Some states exempt fuels from state-wide consumption taxes if the fuel is subject to the volumetric fuel tax.

As consistent data were not available on the full extent of such exemptions across states, the Commission has used the full excise rate in its analysis.

Source: FHWA (US) (2011b).

Transport fuels may also be subject to emissions trading schemes in the future. For example, the Californian ETS is scheduled for implementation in 2012 and will cover transport fuels from 2015. Obligations for fuel suppliers to surrender permits are likely to lead to higher prices for petrol, diesel and LPG in California.

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in the United States were estimated for the 2009 calendar year using a separate analysis for each state (plus the District of Columbia), by fuel type. These results were then summed to provide national-level estimates.

The following data were used for each state, by fuel type.

- The total (federal plus state) volumetric tax rate per litre (FHWA (US) 2011a).
- The average retail fuel price (EIA (US) 2011n).

-
- These estimates are based on average pre-tax prices calculated by the Energy Information Administration, and include federal and state volumetric taxes but not sales taxes (EIA (US) 2010e). As a result, the price estimates are likely to be lower than observed retail prices, although this is not expected to significantly affect the results of the analysis as the excluded taxes are similarly excluded from the tax rate data used.²
 - The taxed volume of each fuel (that is consumed for road transport).
 - Values for petrol are taxed volumes of gasoline used as a motor fuel in each state (FHWA (US) 2011a). (These volumes include the consumption of ‘gasohol’, and thus are likely to overstate the actual amount of taxed petrol consumption.)
 - Values for diesel and LPG in each state were estimated as taxed volumes of other fuels are reported by the Federal Highway Administration only as a combined (aggregated) value for each state (‘special fuels’). The taxed volume of special fuels in each state was divided by the sum of diesel and LPG used in all forms of transport in that state (EIA (US) 2011n) to estimate the proportion of these fuels that were taxed. These values were then multiplied by the volumes of diesel and LPG (respectively) that were consumed in all transport to estimate the taxed volumes that were consumed in road transport.

The Commission has not included the impact of the California ETS in its estimates as detailed information on the estimated impact of this scheme on the price of each fuel type (in the initial year of 2015) were not available. However, it is likely that this ETS will raise fuel prices in California, and thus reduce fuel consumption and emissions (box O.6).

² In other words, the two effects ‘cancel out’ mathematically. In the formulae for the change in quantity and consumption costs (as set out in box O.1), scaling both the counterfactual price p and tax rate t by a common factor does not change the result for the change in quantity or change in consumer surplus.

Box O.6 California Cap-and-Trade Scheme

The California Cap-and-Trade ETS (part of the Western Climate Initiative) is expected to commence in California in 2012. Transport fuels will be included in the scheme from 2015.

The California Air Resources Board (CARB) has conducted economic modelling of the scheme to estimate the impact on covered sectors over the period 2012–2020. This analysis includes transport fuels (petrol and diesel) over the period 2015–2020.

The ETS was compared to a ‘reference’ case or counterfactual where it is not implemented. This reference case includes two other transport-sector policies: the Federal Renewable Fuel Standard and the Pavley I Vehicle Standards (fuel efficiency standards for new cars and light trucks).

The central projection is the CARB’s estimate of the most likely outcome over the period 2012–2020. This used an ETS ‘allowance’ (permit) price of US\$25/t CO₂-e in 2020 — where emissions in all covered sectors are capped at 1990 levels — and assumed that allowances can be banked and offsets can be used for compliance.

This projection also included several ‘complementary’ policies in addition to the ETS — Pavley II Vehicle Standards, the Low Carbon Fuel Standard and the Vehicle Miles Travelled Reduction Measure (which consists of urban planning policies) (CARB (US) 2010). Overall, it was estimated that complementary policies would account for around two-thirds of abatement over the 2012–2020 period, with the remainder due to the ETS (CARB (US) 2010).

Some modelling results for 2020 under the central projection are presented in the table (these results include the complementary policies in addition to the ETS on transport fuels from 2015). Overall, passenger-miles travelled in 2020 are expected to be 4 per cent lower than the reference case, and freight tonne-miles 2 per cent higher.

In addition, the modelling results also suggest that the allowance price will be around US\$18/t CO₂-e (in 2007 dollars) in 2015 (equivalent to A\$20 in 2010 dollars), the first year in which transport fuels will be covered by the scheme (calculated using a formula published by CARB (US) (2010)).

<i>Fuel type</i>	<i>2020 reference price</i>	<i>2020 fuel price increase from reference</i>	<i>2010 fuel demand decrease from reference</i>
	2007 US\$/gallon	%	%
Petrol	3.20	5.4	18
Diesel	6.02	3.0	17

Source: CARB (US) (2010).

Results

Estimated consumption costs and abatement for fuel taxes in the United States are presented in table O.33. Average consumption costs (per tonne of abatement) are presented in table O.34.

Table O.33 Consumption costs and abatement
United States, 2009

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>		<i>Consumption cost</i>		<i>Abatement</i> Mt CO ₂ -e
	ML	ML petrol equivalent	US\$m (2009)	A\$m (2010)	
Petrol					
Low	24 183	24 183	1 226	1 346	70
High	76 159	76 159	3 801	4 171	221
Diesel					
Low	6 586	7 406	365	401	20
High	20 780	23 366	1 133	1 243	70
LPG					
Low	45	31	2	2	0.1
High	140	98	6	7	0.3

Source: Productivity Commission estimates.

Table O.34 Average consumption costs
United States, 2009

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>	<i>Consumption cost</i>		<i>Abatement</i>	<i>Average consumption cost</i>
	ML petrol equivalent	US\$m (2009)	A\$m (2010)	Mt CO ₂ -e	A\$/t CO ₂ -e
Low	31 621	1 594	1 749	92	19
High	99 623	4 940	5 421	291	19

Source: Productivity Commission estimates.

O.10 Demand-side abatement from biofuel policies

This section provides illustrative estimates of demand-side abatement, the reduction in fuel consumption, and consumption costs for the biofuel policies that are analysed in appendix N (for the supply side). Key data ‘inputs’ are presented in table O.35, including any calculations that were required (such as the estimated price uplift).

Table O.35 Estimated price impact, biofuel policies

Germany (2009), United Kingdom (April 2009 – March 2010), United States (2009)

<i>Country</i>	<i>Subsidy equivalent</i>	<i>Quantity of biofuel</i>	<i>Estimated price uplift^a</i>	<i>Quantity of blended fuel^b</i>	<i>Life-cycle emissions intensity^c</i>
	A\$m (2010)	ML petrol equivalent	A\$/L	ML	g CO ₂ -e/L
Germany					
Ethanol	533	754	0.02	26 506	2 722
United Kingdom					
Ethanol	209	296	0.01	21 516	2 709
Biodiesel	465	1 123	0.02	27 576	2 844
United States					
Ethanol	7 321	28 016	0.01	513 004	2 859
Biodiesel	472	1 256	0.002	150 889	2 642

^a Estimated increase in the price of biofuel-blended petrol (in the case of ethanol) or diesel (in the case of biodiesel) due to fuel content mandates. ^b The quantity of blended fuel in Germany and the United Kingdom was calculated as the sum of biofuel consumption and conventional fuel consumption (for example, ethanol plus petrol consumption), and expressed in either litres of petrol (for ethanol) or litres of diesel (biodiesel), after adjustment for the energy content of biofuels. For the United States, reported volumes of petrol sold include ethanol (blended with petrol). It was assumed that reported volumes of diesel similarly include biodiesel. ^c Average of the emissions intensity values for biofuels used for each country in the supply-side analysis (appendix N), weighted by the energy-adjusted volume of each fuel type consumed.

Source: Productivity Commission estimates.

Results

The results are set out in table O.36. In general, the estimates are low (relative to those for fuel taxes) because the total subsidy equivalent for biofuel mandates in each country is being divided by a large volume of total fuel consumption (this is reflected by the small increase in fuel prices).

Table O.36 **Average consumption costs, biofuel policies**

Germany (2009), United Kingdom (April 2009 – March 2010), United States (2009)

<i>Elasticity</i>	<i>Reduction in fuel consumption</i>	<i>Consumption cost</i>	<i>Abatement</i>	<i>Average consumption cost</i>
	ML petrol equivalent	A\$m (2010)	Mt CO ₂ -e	A\$/t CO ₂ -e
Germany				
Ethanol				
Low	105	2	0.3	5
High	317	5	0.9	5
United Kingdom				
Ethanol				
Low	53	0.4	0.1	3
High	159	1	0.4	3
Biodiesel				
Low	95	1	0.3	5
High	285	4	0.8	5
United States				
Ethanol				
Low	988	8	3	3
High	2 473	19	7	3
Biodiesel				
Low	47	0.1	0.1	0.46
High	118	0.2	0.4	0.46

Source: Productivity Commission estimates.

O.11 Review of the literature on fuel demand elasticities

There is an extensive literature that has estimated the own-price elasticity of demand for transport fuels. The results of different studies vary significantly, depending on the country or countries analysed, the data set used, the period of analysis and the methodology.

This section provides an overview of the literature, including estimates from selected studies. Given the volume of literature and the wide range of estimates, the estimates that are cited below are provided as illustrative of that literature. While they are intended to reflect general findings, these values do not necessarily reflect all available estimates for a given country or time period.

Meta-analyses and cross-country studies

Several studies have examined the findings of a range of literature and drawn comparisons between results. A summary of results from meta-analyses — which

collate the findings of other studies and undertake statistical analysis — is presented in table O.37.

Table O.37 Elasticities of fuel demand
Estimates published in selected meta-analyses

<i>Source</i>	<i>Short term</i>	<i>Long term</i>
Brons et al. (2008)	-0.34	-0.84
Dahl (2011)	-0.11 to -0.33	..
Espey (1998)	-0.26	-0.58
Goodwin, Dargay and Hanly (2004)	-0.25 to -0.43	-0.64
Graham and Glaister (2002)	-0.2 to -0.3	-0.6 to -0.8
Graham and Glaister (2004)	-0.25	-0.7

.. Not applicable.

The meta-analysis by Goodwin, Dargay and Hanly (2004) reviewed 69 empirical studies of transport elasticities. While there was a large range of results across studies, the overall assessment of the authors was that a 10 per cent rise in fuel prices leads to a reduction in fuel consumption of 2.5 per cent within a year, and a reduction of at least 6 per cent in the longer term. Graham and Glaister (2002) used a similar approach to conclude that the elasticity of fuel demand is less elastic in the short term (-0.2 to -0.3) than in the long term (-0.6 to -0.8). However, they also note that the results of different studies are not strictly comparable due to differences in the methodologies used.

A different approach was used by Brons et al. (2008) to analyse the literature by examining three factors that influence the demand for fuel: the fuel-efficiency of vehicles, the distance travelled by each vehicle (mileage), and the rate of vehicle ownership. Overall, they found that the average elasticity of fuel is around -0.34 in the short term and -0.84 in the long term. In the short term, they found that fuel efficiency and mileage can explain most of the responsiveness of fuel demand to changes in price, whereas in the longer term changes in vehicle ownership have a relatively greater effect on fuel demand.

However, the elasticity values reported by these meta-analyses are averages across a number of other studies. The range of estimates is thus considerably larger across individual studies than across meta-analyses.

Country-specific studies

Elasticity values that were estimated in various studies tend to differ depending on the country being analysed. For example, Hensher and Li (2010) found that petrol demand is more responsive to price changes in Europe than in Australia and the

United States, which they suggest is due to higher fuel prices (due to fuel taxes) and a greater prevalence of public transport in Europe. Other studies have found that fuel demand is relatively less inelastic in Germany compared to other countries, and within the range -0.45 to -0.67 (Frondel, Peters and Vance 2008; Frondel and Vance 2010).

Estimates for the United States suggest the demand for fuel is relatively inelastic, over both the short and long term. For example, Hughes, Knittel and Sperling (2008) estimated elasticity values of -0.03 to -0.08 over the period 2001–2006. Over the longer term, Small and van Dender (2007) estimated an elasticity of -0.36 (covering the period 1966–2004). That said, Hughes, Knittel and Sperling (2008) also provide some evidence that fuel demand has become less elastic over time in the United States, due to increased dependence on vehicles, changes in settlement patterns and increases in the fuel efficiency of vehicles.

Studies have also found that fuel demand is relatively inelastic in Australia and New Zealand. For example, the Bureau of Infrastructure, Transport and Regional Economics (BITRE 2009) estimated a short-term elasticity of -0.16 and a longer-term elasticity of -0.45 for Australia. Similarly, Breunig and Murphy (2009) estimated that short-term elasticities range from -0.13 to -0.14 for Australia, while long-term elasticities range from -0.2 to -0.3. Similar figures have been found for New Zealand, with Kennedy and Wallis (2007) reporting estimates of -0.15 in the short term and -0.2 over longer time periods.

There is less evidence available for China, Japan and South Korea, and estimates vary across these countries. For example, Cheung and Thomson (2004) examined petrol demand in China over the period 1980–1999, estimating the short-term elasticity of demand at -0.19 and the long-term elasticity at -0.56. This short-term estimate is comparable to those reported by Dahl (2011) for China (-0.26) and Japan (-0.15), and by Clerides and Zachariadis (2008) for Japan (-0.17). The long-term estimate for China is similar to long-term estimates for South Korea reported by Kim, Han and Moon (2011) (-0.44 to -0.88).

Fuel types

Few studies report estimates of the elasticity of fuel demand for separate fuel types (such as petrol, diesel or LPG). The majority of studies provide estimates only for all transport fuels combined (for example, Frondel and Vance 2010; Goodwin, Dargay and Hanly 2004). However, figures cited by Dahl (2011) suggest that the demand for diesel is relatively more elastic than that for petrol in Australia, Germany, Japan, New Zealand and the United Kingdom, but relatively less elastic in China, South Korea and the United States.

Annex

Table O.38 **State volumetric fuel taxes^a**

United States, December 2010

<i>State</i>	<i>Petrol</i>	<i>Gasohol (E10)^b</i>	<i>Diesel</i>	<i>LPG</i>
	US\$/gallon	US\$/gallon	US\$/gallon	US\$/gallon
Alabama	0.1800	0.1800	0.1900	–
Alaska	0.0800	0.0800	0.0800	–
Arizona	0.1800	0.1800	0.2600	–
Arkansas	0.2150	0.2150	0.2250	0.1650
California	0.1800	0.3530	0.1800	0.0600
Colorado	0.2200	0.2200	0.2050	0.2050
Connecticut	0.2500	0.2500	0.3960	–
Delaware	0.2300	0.2300	0.2200	0.2200
District of Columbia	0.2350	0.2000	0.2000	0.2000
Florida	0.1600	0.1600	0.1600	0.1450
Georgia	0.0750	0.0750	0.0750	0.0750
Hawaii	0.1700	0.1600	0.1700	0.0520
Idaho	0.2500	0.2500	0.2500	0.1810
Illinois	0.1900	0.1900	0.2150	0.1900
Indiana	0.1800	0.1800	0.1600	–
Iowa	0.2100	0.1900	0.2250	0.2000
Kansas	0.2400	0.2400	0.2600	0.2300
Kentucky	0.2560	0.2560	0.2260	0.2420
Louisiana	0.2000	0.2000	0.2000	0.1600
Maine	0.2950	0.2300	0.3070	–
Maryland	0.2350	–	0.2425	–
Massachusetts	0.2100	0.2100	0.2100	0.2500
Michigan	0.1900	–	0.1500	0.1500
Minnesota	0.2750	0.2750	0.2750	0.2063
Mississippi	0.1840	0.1840	0.1840	0.1700
Missouri	0.1700	0.1700	0.1700	0.1700
Montana	0.2775	0.2375	0.2850	–
Nebraska	0.2710	0.2710	0.2710	0.2710
Nevada	0.2400	0.2400	0.2700	0.2200
New Hampshire	0.1800	0.1963	0.1800	–
New Jersey	0.1050	0.1050	0.1350	0.0525
New Mexico	0.1888	0.1888	0.2288	0.1200
New York	0.2435	–	0.2255	0.0805
North Carolina	0.3215	0.3215	0.3215	0.2710
North Dakota	0.2300	0.2300	0.2300	0.2300
Ohio	0.2800	0.2800	0.2800	0.2800
Oklahoma	0.1700	0.1700	0.1400	0.1700

(Continued next page)

Table O.38 (continued)

<i>State</i>	<i>Petrol</i>	<i>Gasohol (E10)^b</i>	<i>Diesel</i>	<i>LPG</i>
	US\$/gallon	US\$/gallon	US\$/gallon	US\$/gallon
Oregon	0.2400	0.2400	0.2400	0.1850
Pennsylvania	0.3120	0.3120	0.3810	0.2280
Rhode Island	0.3200	0.3200	0.3200	0.3200
South Carolina	0.1600	0.1600	0.1600	0.1600
South Dakota	0.2200	0.0800	0.2200	0.2000
Tennessee	0.2000	0.2000	0.1700	0.1400
Texas	0.2000	0.2000	0.2000	0.1500
Utah	0.2450	0.2450	0.2450	0.2450
Vermont	0.2000	–	0.2900	–
Virginia	0.1750	0.1750	0.1750	0.1750
Washington	0.3750	0.3750	0.3750	0.3750
West Virginia	0.3220	0.3220	0.3220	0.3220
Wisconsin	0.3090	0.3090	0.3090	0.2260
Wyoming	0.1400	0.1400	0.1400	0.1400
US average ^c	0.2074	0.2627	0.2147	0.0985

^a The table includes only state-wide volumetric taxes, such as excise, environmental taxes, special taxes and inspection fees. ^b 'Gasohol' is a mixture of petrol and ethanol that comprises 10 per cent ethanol. ^c Average weighted by sales volumes, and as reported by FHWA (US) (2011b). – Nil or rounded to zero. .. Not applicable.

Source: FHWA (US) (2011b).