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A Simple Way to Reduce Driving Related Harms and Increase Fairness

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Abstract

Motor vehicles are both a blessing and curse to modern society. They enable individuals the freedom to travel to where they want. But motor vehicles are also responsible for air pollution, traffic congestion, injuries in motor accidents and economic dependence upon oil. Motorists who drive more contribute more to these problems, but they pay the same vehicle registration fee, CTP and domestic motor insurance premiums as everyone else. Removing this economic distortion can help the environment, prevent injuries and reduce our dependence on oil.

Keywords: motor, environment, greenhouse, insurance, accident compensation, public policy.

Table of Contents

Introduction

Australia has approximately one motor vehicle for every two people (source: ABS). Motor vehicles are a familiar part of our daily lives. A vehicle user bears a substantial number of costs in choosing to drive. These include:

1. petrol
2. insurance
3. wear and tear
4. depreciation

There are also additional social costs are those borne by the rest of society as a result of an individual usage. These additional social costs are important because, as they are costs not borne by the individual, they are unlikely to be factored into the individual's decision to drive. The result is the classic problem of social cost – individuals drive more than is socially optimal. These social costs include:

1. Pollution: Motor vehicles emit particles and gases into the air that we breathe. Some of these emissions have been linked to health problems. Other emissions are greenhouse gases, which have been linked to climate change.
2. Congestion: As more and more people use the same transport infrastructure, traffic congestion becomes worse in cities. This in turn results in loss of productivity, more pollution and a requirement for large investments in infrastructure upgrades.
3. Cost of Accidents: The cost of car accidents for society is very large. The costs include loss of life, injury, loss in productivity, congestion, emergency services, and loss of income.
4. Oil Dependency: The world is heavily dependent on oil, and Australia is a net importer of oil. A large component of oil use is for motor vehicles.

The problem of excess vehicle usage is accentuated by the problem of fixed insurance costs. The standard motor insurance policy is a fixed price that is independent of vehicle usage. This paper considers a solution to this problem, known as pay as you drive (PAYD).

The first section of this paper estimates the social and economic costs of motor vehicle use in Australia.

The second section of this paper describes how pay as you drive insurance works and estimates how the introduction of pay as you drive insurance would affect the driving habits of Australians.

The third section of this paper links the first two sections together. It estimates the reduction in vehicle related social and economic costs associated with the reduction in driving that one would expect from the introduction of pay as you drive insurance.

Finally this paper recommends actions that governments can take in order to enhance and assist the take-up of pay as you drive insurance.

The Social Costs of Private Vehicle Use

This section of the paper estimates a number of social costs from the use of vehicles. A social cost is the sum of the direct costs to the user, and consequential external costs (or benefits) borne by people other than the user. For example, the cost of petrol is a director cost borne by the owner of the vehicle. However the extra traffic congestion caused by the use of a vehicle is an external cost because it affects people other than the person who made the choice whether to drive.

Table 1 gives this paper's estimate of the order of magnitude of the social costs of motor vehicle use in Australia.

Table 1: Summary of Social Costs of Motor Vehicle Use in Australia

Type of Social Cost	Cost (in $billion)	Cost per Vehicle	Cost per km
Accidents			
private motor	5.6	$ 539	$ 0.04
CTP	3.7	$ 350	$ 0.02
claim excess	0.5	$ 45	$ -
other	2.9	$ 273	$ 0.02
Petrol	10.7	$ 1,024	$ 0.07
Congestion	10.2	$ 971	$ 0.07
Pollution	2.3	$ 217	$ 0.01
Carbon	1.6	$ 152	$ 0.01
Oil Dependence	0.5	$ 43	$ -
Road Infrastructure	7.6	$ 723	$ 0.05
TOTAL	45	$ 4,337	$ 0.29

Vehicle use has an estimated social cost to Australians of 45 billion dollars per annum, and this cost is growing every year. These costs include direct economic costs to the vehicle user, such as petrol and insurance claim excesses, and external costs, such as time traffic congestion, pollution, carbon (greenhouse gases), oil dependence and road infrastructure.

While insurance costs can be thought of as direct costs, because the vehicle owner pays the premiums, they can also be thought of as a proxy measure of external costs because the insurances are being used to cover the such costs as medical treatment of pedestrians injured by motor vehicles. It is also important to note that while the choice to drive more often increases the social costs of motor vehicle accidents, the direct cost to the owner of the vehicle does not directly reflect this increased social cost.

The Cost of Accidents

Each year more than 10% (source: Insurance Statistics Australia) of Australian motor vehicles are involved in a motor vehicle accident. In 2000 the Bureau of Transport Economics wrote "When the human cost is considered in combination with associated property damage and the costs of the infrastructure required to deal with road crashes, it is clear that society bears a huge overall cost." (BTE 2000).

We have based our estimates of the cost of accidents upon the estimates within the BTE paper, from the general insurance statistics produced by APRA, and the published reports of

the various state authorities responsible for compulsory third party insurance. The insurance cost comes in two forms, private motor vehicle insurance and compulsory third party insurance. The other costs come from areas that are not directly covered by insurance, such as workplace disruption and police. It could be argued that our approach significantly underestimates the social cost of traffic accident – for example it does not include the pain and suffering of the relatives and friends of someone who is injured in a traffic accident.

For private motor insurance we have used the gross premium revenue value of $5,646,000 for "Domestic Motor Vehicle" shown in table 7 of APRA's half yearly statistical bulletin. The reason that we have used the premium amount rather than the claim amount is because the premium includes the costs associated with providing those claim payments, such as administrative costs and the cost of capital required to provide that insurance cover. We have not included the premium revenue for commercial motor vehicle because our paper has restricted itself to the costs of vehicles used primarily for personal use. However the use of domestic motor vehicles on the road does affect the cost of accidents for commercial vehicles because the damage to domestic motor vehicles is included in the commercial motor vehicle statistics in those cases where the commercial motor vehicle was the one at fault in the accident. By excluding commercial motor vehicles from our estimates, we may be underestimating the cost of accidents. Private motor insurance typically applies an excess to each claim, and this cost should be counted as part of the total cost of accidents.

In table 2 we estimate the cost of insurance claim excesses by relating these costs to the claims incurred by insurers.

Table 2: Estimation the Cost of Private Motor Insurance Excess

Gross Incurred Claims ($b)	5.52
Non-reinsurance Recoveries ($m)	0.84
Standard Excess	$500
Average Claim Size	$3,000
Proportion at fault	60%
Cost of Claim Excess ($b)	0.47

We have estimated the cost of insurance claims excesses by considering the annual claims cost for private motor, and doing a pro-rata calculation allowing for a typical policy excess and average claim size. This calculation uses APRA statistics for industry claims costs, combined with some assumptions for claim excess, average claim size and proportion at fault (based upon internal insurer data).

Similarly for compulsory third party (CTP) insurance we have estimated the cost using the gross premium revenue in each state of Australia. The reason that we have used CTP premiums as a proxy for the social cost is because there is a cost to motor vehicle related injuries beyond just the medical costs and loss of income suffered by the injured person – there is also the administrative, legal and management work required and the cost of the capital required to support the provision of these services and costs.

In all states except ACT and NT there is a government authority that publishes statistics that show the premium revenue for the state's CTP scheme. For ACT there are no publically available statistics, so we have multiplied the standard published CTP premium in that state by the number of cars in that state.

Table 3: Estimation of CTP Premiums

State	Number of Vehicles	Average Premium	Premium Pool $m
NSW			1,221.00
ACT	208,011	$386.25	80.34
VIC			1,134.19
TAS			123.22
SA			397.16
WA			356.87
NT	103,795	$436.55	45.31
QLD			993.80
TOTAL			4,351.89

Compulsory third party schemes insure all vehicles, including trucks and buses. This paper is only concerned with private passenger vehicles, so we should only include a portion of the total CTP premium pool. The published statistics do not usually provide this level of detail. So we have done a pro-rata allocation of the premium pool using the vehicles counts from the 2002 vehicle census.

Table 4: Estimation of the Proportion of CTP That Relates to Private Motor Vehicles

Passenger Vehicles	10,101,441
Total Excluding Motor Cycles	12,450,979
Motor Cycles	370,982
Total CTP Premium Pool ($m)	4,351.89
Proportion relating to private vehicles	84.1%
Premium pool for private vehicles ($m)	3,660.34

Private motor insurance and CTP do not cover all of the costs of accidents. While CTP will usually cover the cost of lost wages, it does not cover the cost to the employer of workplace disruption. While private motor insurance covers the cost of repairs to vehicles, it does not cover the costs related to the unavailability of vehicles. Some accident related costs are born by the government e.g. correctional services and police. Accidents also cause traffic delays, both to the people involved in the accident, and to other motorists when the accident causes extra traffic congestion. In 2000 the Bureau of Transport Economics published a paper estimating the total economic costs of accidents. We have used that paper as the basis for estimating the non-insurance cost of accidents. Since the values in the paper are outdated, we have brought them up to the current values by assuming that the ratio of non-insurance to insurance costs has remained a constant proportion of 31%. That gives us an annual non-insurance cost of accidents of $2.86 billion.

The Cost of Petrol

We have estimated that private vehicles use approximately $16.27 billion of petrol per annum. This estimate is calculated based upon the average fuel efficiency of vehicles, and the average usage of vehicles.

Table 5: Estimation of the Total Cost of Petrol

km per annum per vehicle		14,600
litres per 100km		9.5
litres per annum		1,387
fuel price per litre	$	1.12
excise duty per litre	$	0.38
fuel cost per annum	$	1,553
number of private vehicles		10,472,423
total petrol cost per annum ($b)		16.27
net of excise duty		10.73

Australian vehicles drive an average of 14,600 km per annum (source: ABS). Private vehicles have an average fuel consumption of 9.5 litres per 100 km (source: BTRE), which means that each vehicle uses an average of 1,387 litres per annum. Fuel prices have been volatile over the past 12 months. We have used $1.120 per litre (source: ExplorOz.com), the average unleaded petrol price across Australia as at 12th February 2009, to estimate the total cost of petrol.

Petrol costs have varied across a wide range of prices per litre over the past twelve months. If one allows for a range of possible petrol prices from $0.95 per litre to $1.60 per litre, a similar range to that experienced over the past twelve months, the estimate of the cost of petrol can vary in the range $13 billion to $23 billion.

The Government collects $0.38143 per litre of excise duty (source: Australian Government Treasury). This excise duty goes into the government's general revenue and is then available for use to benefit Australians. The final value in table 10 shows the cost of petrol net of the excise duty – we have used this value as the contribution to social cost. Note that the social cost of pollution and carbon from the use of petrol is dealt with later in this paper.

The Cost of Congestion

Vehicle use leads to traffic congestion. Traffic congestion is an unavoidable component of modern urban life. Cosgrove (2000) estimates that half of the kilometres that we drive are in congested conditions.

Congestion is the first of the external costs of driving that are considered in this paper. Cosgrove (2000) said "Congestion, as an economic externality, imposes significant costs on society. Road users incur higher private costs when joining a congested traffic stream, through increased vehicle operating costs and trip travel times. Furthermore, road users do not typically take account of the fact that their decisions to travel serve to increase congestion, and therefore impose additional delays and (public) costs on other road users."
Traffic congestion is not a linear function. Having half the vehicles on the road would reduce the traffic congestion by more than half. In its review of the relationship between fuel prices and traffic congestion, Inrix (2008) noted that "modest drops in traffic volumes can lead to substantial drops in congestion".

This paper uses the estimate of congestion cost made by the Bureau of Transport and Regional Economics. The BTRE provides "estimates of the 'avoidable' cost of congestion (i.e. where the benefits to road users of some travel in congested conditions are less than the costs imposed on other road users and the wider community) for the Australian capitals (using an aggregate modelling approach) total approximately $9.4 billion for 2005. This total is comprised of $3.5 billion in private time costs, $3.6 billion in business time costs, $1.2 billion in extra vehicle operating costs, and $1.1 billion in extra air pollution costs." (BTRE 2007).

Furthermore they project the cost beyond their base year of 2005. The estimate for 2009 is $12.09 billion.

The BTRE's methodology considers only metropolitan areas (it ignores congestion in large regional centres such as Newcastle and Geelong). They begin by forecasting the number of kilometres driven by vehicles. For passenger vehicle use they note that in recent times the total number of kilometres driven has been trending upwards with population growth. For freight vehicle use they note that the total number of kilometres driven has been trending upwards in with GDP. They measure congestion as the actual travel speeds achieved versus the estimated free flow speed. The free flow speed can be thought of as the speed that a vehicle would achieve travelling across the city in the middle of the night. Then BTRE consider the cost of these kilometres. In particular they consider:

- extra travel time(e.g. above that for a vehicle travelling under less congested conditions),
- extra travel time variability (where congestion can result in trip times becoming more uncertain—leading to travellers having to allow for an even greater amount of travel time than the average journey time, in order to avoid being late at their destination),
- increased vehicle operating costs (primarily higher rates of fuel consumption), and
- poorer air quality (with vehicles under congested conditions emitting higher rates of noxious pollutants than under more freely flowing conditions, leading to even higher health costs).

BTRE takes the approach of estimating deadweight losses (DWLs) associated with a particular congestion level i.e. an estimate of how much total costs (for time lost and other wasted resources) could be reduced if traffic volumes were reduced to the economically optimal level. The economically optimal level of congestion is the one at which drivers' marginal costs (upon which they base their decision to make a trip) are equal to the marginal costs of that trip to the general economy. This means that the estimates of the cost of congestion are only for the amount of congestion caused by the fact that motorists do not directly pay for the congestion costs that their choice to drive imposes upon others.
Since the BTRE estimates of congestion cost are only the deadweight losses, our estimates of the cost of congestion per kilometre driven understate the total cost of congestion. Similarly, since congestion is not a linear function of traffic volumes, we believe that we have understated the benefits of reduced traffic volumes towards congestion costs.

The BTRE estimates are for all vehicles on the road. We have estimated the cost of congestion caused by private motor vehicles using a pro-rata of the number of vehicles on the road.

Table 6: Estimate of Proportion of Congestion Cost for Private Motor Vehicles

Total Congestion Cost	12.09
Proportion relating to private vehicles	84.1%
Congestion Cost for private vehicles ($b)	10.17

Since congestion is a non-linear function of traffic volumes, we believe that this pro-rata approach underestimates the marginal costs of congestion relating to the use of private motor vehicles.

The Cost of Pollution

For the purposes of this paper, the cost of pollution is simply the health cost of air pollution generated by vehicle use. Even though it is a pollutant, the environmental cost of carbon is considered separately to the health costs. We have not considered the health costs of noise

pollution from vehicle use, as this is considered to be a lower order of magnitude to the health costs of air pollution.

Air pollution from motor vehicle use includes airborne particles, toxic materials, and waste gases. The Bureau of Transport and Regional Economics names the following as pollutants:

- Lead
- Sulphur dioxide
- Carbon monoxide
- Nitrogen dioxide
- Ozone
- Volatile organic compounds
- Particulate matter
- Acetaldehyde
- Formaldehyde
- Carbonyl
- Benzene
- Toluene
- Xylene
- Polycyclic aromatic hydrocarbon
- Butadiene
- Dust
- Nitrates
- Sulphides
- Acrolein
- Metals
- Diesel particles

There is “mounting epidemiological evidence that exposure to air pollutants can be harmful to humans” (BTRE 2007). The harmful effects can include asthma and even premature mortality. A BTRE study published in 2005 estimated “that in 2000 motor vehicle pollution accounted for between 900 and 4500 morbidity cases—cardio-vascular disease, respiratory disease, and bronchitis—and for between 900 and 2000 early deaths.” (BTRE 2005).
We have used the estimates of economic cost provided by BTRE in 2005. Their approach was to use levels of particulate matter (PM10) in the air as a proxy measure for all air pollutants. The assumption underlying this approach is that the mix of air pollutants is relatively consistent across different geographic areas and across time. They related the levels of air pollution to the health results projected by epidemiological studies. This involved the use of a population model that adjusted for factors such as the population’s age, health status and weather conditions.

Table 7: Estimation of Proportion of Pollution Cost Relating to Private Motor Vehicles

Total cost ($b)	2.7
Proportion relating to private vehicles	84%
Cost relating to private vehicles ($b)	2.27

We have used the BTRE central estimate of $2.7 billion, and then used a pro-rata calculation to apportion the cost that relates to private vehicles. This gives us a social cost of $2.27 billion per annum from air pollution. We have not adjusted for the increase in the number of vehicles since the BTRE study, so our estimates will slightly underestimate the cost.

The Cost of Carbon

"Warming of the climate system is unequivocal" (IPCC 2007). The bulk of this warming is generally accepted as being attributable to the increase in the concentration of greenhouse gases in the atmosphere. Since the use of motor vehicles produces greenhouse gases, we have included an estimate of social cost of greenhouse gases.

We have chosen to estimate the cost of greenhouse emissions from private motor vehicles by combining the BTRE's estimates of greenhouse gas emissions from vehicles with the CSIRO's estimates of the cost of carbon dioxide.

The BTRE's estimates of greenhouse gases are in units of carbon dioxide equivalent (CO2) for carbon dioxide, methane and nitrous oxide. They do not include the indirect effects of other gases such as carbon monoxide, and they do not include the greenhouse gases used in the production and delivery of the fuel before it was purchased by the consumer. For this reason the estimates probably understate the true cost.

Table 8: BTRE Estimate of Carbon Dioxide Equivalent Arising From Cars

2004 CO2 emissions from cars	45,556	gigagrams
2010 CO2 emissions from cars	49,553	gigagrams
growth	109%	
2009 CO2 emissions from cars	48,863	gigagrams
	48,863,273	tonnes

The table above summarises the BTRE's estimates of the carbon dioxide equivalent arising only from cars. We have interpolated the BTRE's 2004 and 2010 values to obtain an estimate of CO2 emissions for 2009.

These emissions need to be priced. The pricing of carbon is uncertain because the cost of mitigation is uncertain, and much of the costs of climate change are decades in the future. There are already some carbon trading schemes in place, and they give us some indication of the current direct cost of carbon – we then need to consider whether the social costs are similar to the current direct cost of carbon.

Figure 1: Carbon Futures Trading Prices (source: www.ecx.au)

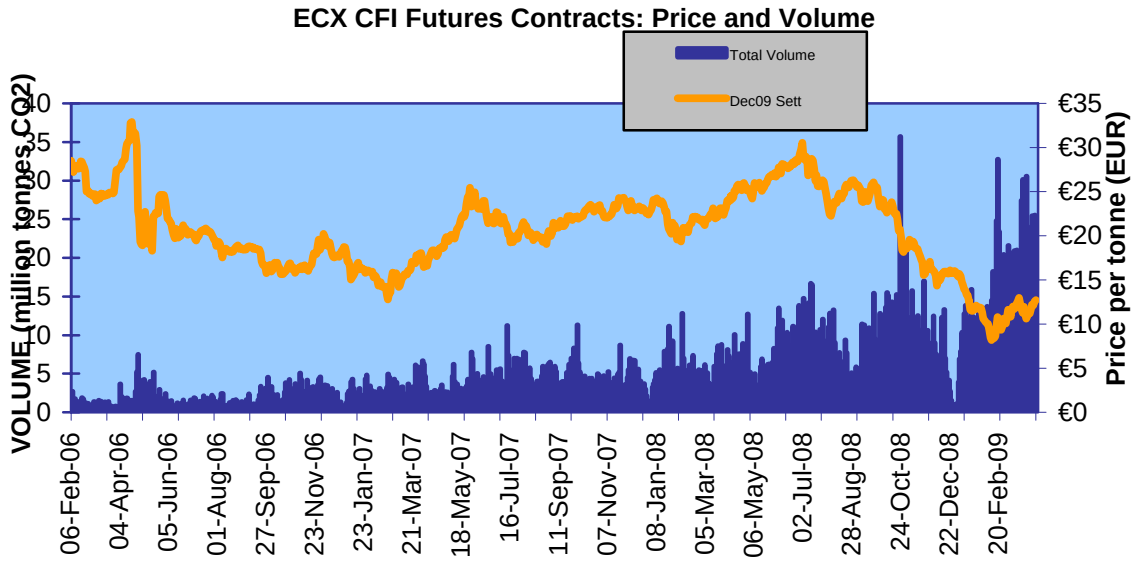

Figure 1 shows the historical price per tonne of carbon from the European Climate Exchange. The price has varied between a high of 32.90 euros and a low of 8.20 euros. On the current exchange rate of 0.5331 (source: Reserve Bank of Australia) this equates to a price range of $15.38 to $61.71 and a current spot price of $23.84 per tonne. It should be noted that carbon

trading schemes do not set caps at a level at which there is no climate impact from greenhouse gases. This means that the traded price for carbon is less than the social cost.

In order to allow for some of the external costs, we have used the work of the CSIRO, which has considered the likely cost of carbon under different capping scenarios. “Modelling conducted for the Future Fuels Forum projects that the price of emission permits can be expected to begin at around A$25-40/tCO2e, increasing to A$70-100/tCO2e for a 60 per cent emission cut by 2050 target and A$200-300/tCO2e by 2050 if Australia chooses to pursue near-zero emission targets within the emission trading scheme.” (CSIRO 2008). We have used a price of $32.50 per tonne of CO2, the midpoint of the $25 to $40 lower price range given by the CSIRO. After noting that the CSIRO had considered a higher price range possible, depending upon emission targets, we feel comfortable that this value is not overstating the social cost.

Table 9: Calculation of the Cost of Carbon

2009 CO2 emissions from cars		48,863,273
cost of CO2 per tonne $AUS	$	32.50
total cost $AUS	$	1,588,056,386
total cost $AUS b		1.59

In table 9, by multiplying the emissions by the price, we obtain an estimate of $1.59 billion for the cost of greenhouse gas emissions from driving private motor vehicles. Given the volatility of the traded price of carbon, we believe that the cost of carbon could vary between $0.75 billion and $3 billion.

The Cost of Oil Dependence

Australia’s oil supplies are running out. “Based on official production and demand forecasts Australia will need to import approximately two thirds of its oil by 2015, in a setting of rapidly declining availability and increasing prices in international markets” (Birol 2008). The costs of oil dependence to Australia are:

- Increasing costs of fuel: this stands to reason if supply is reducing, and demand is unchanged or even increasing
- Inflation: “From a market perspective, increased costs of oil based fuels will filter through the economy, increasing the cost of all goods and services.” (CSIRO 2008)
- Volatile fuel prices: this increases uncertainty in economic decision making
- Depreciation in the $AUS: “One way to gauge the effect of higher oil prices on the Australian economy is through the trade balance in oil-related products. For economies that are net importers of oil, an increase in the price of oil could be expected to reduce the purchasing power of national income.” (Reserve Bank 2004)
- Oil shock: The rapid increase in oil prices in the 1970s led to a period of stagflation (low economic growth accompanied by high inflation)
- Geopolitical risk: the money in oil rich countries has been used to fund both authoritarian governments (Iraq) and terrorism (Al-Quaida’s heritage is in Saudi Arabia), and these types of risks have led to Australia’s military actions in Iraq and Afghanistan

The more people drive, the greater these risks to the Australian economy.
We were not able to find any published estimates of the cost of oil dependence to the Australian economy. However Konstantinidis gave the following estimate of the effect of fuel prices upon Australia’s GDP: “a sustained rise of 10% in the price of petrol would cut real consumer spending by 0.3%, leading to a 0.2% cut in GDP growth as a first round effect…Finally, the effect on the trade balance is estimated as a deterioration of the current

account deficit of around 0.1% of GDP, leading to a combined effect on GDP growth of -0.3%." (Konstantinidis 2006).

Table 10: Petrol Prices in Australia (source: Australian Institute of Petroleum)

Calendar Year	Average Petrol Price	Increase
2002	87.3	
2003	90.4	4%
2004	98.2	9%
2005	111.7	14%
2006	125.2	12%
2007	125.4	0%
2008	142.4	14%

Table 10 shows that over the past several years, petrol prices have increased by an average of 10% pa. Prices over the past nine months have been quite volatile, probably as a response to the global financial crisis. For the first three months of 2009, petrol prices have been an average of 20% lower than the average price for 2008, but they have been trending up from the low of $0.98 per litre seen in December 2008. Given the long term trend of an increase in the worldwide demand for petrol, and the non-renewable nature of its supply, we believe that petrol prices will increase in the long run. We have therefore estimated the cost of oil dependence as the effect upon GDP growth of a 5% increase in fuel. However annual petrol prices increases are likely to vary across quite a wide range of values.

Table 11: Estimation of the Cost of Oil Dependence

Petrol price increase	5%
GDP reduction %	-0.2%
GDP $b	301.331
GDP reduction $b	-0.45

Our estimate of a cost of $0.45 billion represents a one year reduction in GDP caused by oil dependence. By using a 1 year GDP reduction we are understating the cost, because the reduction in GDP could continue for some time. One could argue that a sustained increase in oil prices would lead to structural and technological changes in which the economy adapts by finding more efficient processes, and replacing oil with alternative fuels that increasingly become cost competitive. For example, the oil shock in the 1970s caused people to switch to more fuel efficient vehicles. For this reason we do not see the reduction GDP as occurring in perpetuity.

Given the volatility of petrol prices and the uncertainty about the amount of time it takes for the economy to adapt to higher petrol prices via structural and technological changes, it may be useful to express this estimate as varying across a range of $0 to $5 billion (based upon a 10% pa petrol price increase and a 5 year duration of the effect).

The Cost of Infrastructure

The use of motor vehicles requires roads. The BTRE states that "The total amount of funding for road-related expenditure by the Australian, state, territory and local governments in 2004–05 was $9.0 billion" (BTRE 2007).

Table 12: Estimation of the Proportion of Road Infrastructure Relating to Private Vehicles

Total cost ($b)	9
Proportion relating to private vehicles	84%
Cost relating to private vehicles ($b)	7.57

We have obtained an estimate of the cost relating to private vehicle use by applying a pro-rata calculation to the road infrastructure costs, apportioning by the number of vehicles. One may question the validity of a pro-rata apportionment, given that heavy vehicles do more damage to roads, but on the other hand there are many roads that are used primarily for private use e.g. the roads in residential areas. We do not have sufficient information to determine a more accurate apportionment.

Not all of the cost of road infrastructure relates to the amount of use that a road gets. For example some road maintenance is to repair weather related damage. Similarly some road construction is new development and needs to be done regardless of the actual level of road usage. We do not have any data upon which to estimate the proportion of road infrastructure that relates to the level of road usage, and we have no reason to believe that non-usage of roads is significant, so we have not been able to allow for road usage in our estimates.

Our estimate of the cost of road infrastructure is therefore $7.57 billion.

Pay As You Drive Insurance

Pay as you drive insurance is a mechanism by which the cost of insurance is directly related to the distance driven. When people drive less, they pay less. Those who drive more will pay more. The analogy eloquently used by Jason Bordoff and Pascal Noel in their Brookings Institute paper (Bordoff & Pascal 2008) is that of an All-You-Can-Eat-Buffet. Traditional motor insurance is like All-You-Can-Drive insurance. You pay for your insurance once, and then you can drive us much as you like without it costing any more. Given that you can only be involved in an accident if you are actually driving your car, this is about as absurd as paying a flat rate for petrol and filling up whenever you need to.

There are a number of ways of reducing driving, such as increasing petrol taxes, increasing toll costs, increasing registration costs or introducing road use taxes in other formats. All of these have the effect of forcing people to drive less because driving becomes more expensive. So people drive less but driving costs the same or more.

Negative Externality

A negative externality is an economic concept. It occurs when someone makes a decision but does not have to bear the full cost of the decision. The cost to society is greater than the cost the decision maker is paying. This causes inefficient decision making, and sometimes brings harm to members of society without them having any control over it. Negative externalities exist when the social cost is greater than the direct cost.

The pricing of traditional motor insurance has a negative externality. A simple way of describing this: Your neighbour is exactly the same insurance profile as you are. That means the same age, same gender, same car, and the same insurance history. Your neighbour will pay exactly the same as you would for traditional motor insurance. This is regardless whether you take the train to work and your neighbour does 50,000km per annum with their car. In fact, every time your neighbour gets in their car and incurs the risk of an accident, there is upward pressure on your insurance premium. This is a classic negative externality.

Rating Factors

Insurance pricing relies on a crude set of rating factors to approximate actual underlying risk. By analysing groupings of risk by rating factor, insurance companies have determined that

young people cause more accidents than older people, that cars located in one suburb cause more accidents than cars in another suburb, etc. The rating factors serve as proxies for the true underlying risk.

To use a rating factor, it has to have the following characteristics:

1. Have a logical relationship to the risk, and be able to translate it mathematically into a charge for the risk.
2. Be measureable.
3. Be verifiable.

Pay as you drive insurance uses the distance driven as a rating factor.

Contributors to Accident Risk

Looking at motor accident risk, the contributors to risk are:

1. The ability of the combination of vehicle and driver to drive safely and avoid accidents.
2. The environment in which they are driving and the likelihood of risks outside the driver's control causing an accident. This can be defined by accident density, time of day and road conditions.
3. The extent of the exposure to risk. If the car is in a garage, not being driven, there is no accident risk.

Neither of the first two contributors to risk above can be accurately measured or verified. Traditional motor insurance uses rating factors to approximate the risks (age, gender, make and model of car, year of manufacture, type of use, location where the vehicle is kept, how the vehicle is kept overnight, previous accident history and others).

Traditional motor insurance uses time as its measure of exposure to risk. It inherently assumes that for any combination of risk factors, the extent of exposure to risk is exactly the same. Unless the other rating factors are good proxies for the differentials in kilometres exposed to risk, the pricing structure will allow cross subsidies between those people who drive more or less kilometres.

The reason that traditional insurance has used actual vehicle usage is that it has not historically been verifiable. It satisfies the first two conditions for a rating factor very well, but mechanisms for verifying the risk has not historically been available in the way traditional motor insurance was transacted. Pay as you drive insurance measures the actual number of kilometres driven. Variants of pay as you drive also measure other contributors to risk, and are discussed below.

Extensions to Pay As You Drive Insurance

The term "Pay As You Drive" is the widely used term for usage based insurance world-wide. For purposes of this paper, and in order to differentiate three different types of usage based insurance, Pay As You Drive refers to pricing using distance only. The insurance premium charged to the policyholder is directly and explicitly linked to the kilometres driven (but not policies where discounts are given for declared annual mileage driven, with no verification and typically one or two levels of discounts only, e.g. less than 10,000km pa). Current providers selling Pay As You Drive include Real Insurance in Australia and Milemeter in Texas.

Pay How You Drive

Pay How You Drive combines mileage with telemetric data on driving behaviour. The telemetry device feeds data back to the insurance company that includes data such as time of day, speed, acceleration and deceleration. From this data the driving behaviour is correlated with accident statistics. That gives the insurance company the ability to link premium not only to distance driven, but also the way in which the distance was driven.

A benefit that Pay How You Drive has over pure mileage based Pay As You Drive is that observing driving behaviour is likely to change driving behaviour. That means the presence of the telemetric device improves accident experience. This in turn increases the savings above the reduced mileage savings estimated in this paper.

Pay How and Where You Drive

Finally, Pay How and Where You Drive adds location to the equation. The telemetry device has a positioning system (either a GPS based device, or a device using mobile phone triangulation). Combined with time of day and actual driving behaviour, a much more accurate driving profile can be formed in order to more accurately determine premiums.
As with Pay How You Drive, the location based device has the potential to change behaviour, both in terms of how the policyholder drives, as well as avoiding high risk roads or areas.

The disadvantages of Pay How You Drive and Pay How and Where You Drive are:

1. Both have privacy concerns: Consumers do not want a big brother watching them. For example, one overseas insurer told me that it found that some of its claimants were not telling the truth about where a claim incident occurred because they didn't want their wives to know where they were at the time. Privacy is a greater concern for location tracking devices.
2. Product complexity: It is difficult to communicate how the products work. The pricing and monitoring of these products is also more complex and requires additional investment from the insurer.
3. Cost: Both rely on telemetry devices which were initially expensive compared to the price of motor insurance. The cost of these devices has however declined significantly, and is likely to continue to do so. The cost includes the cost of the device, cost of installation and ongoing cost of tracking and data.

Estimating the Reduction in Driving Through PAYD

It is the contention of this paper that the introduction of PAYD insurance will reduce the distance that people drive each year. There are two ways to estimate the reduction in distance:

1. Price elasticity – estimating the reduction in kilometres driven on the marginal cost per kilometre
2. Overseas experience – what reductions in distance have been observed overseas

There are however some other factors to consider. For example,

- Not all people are attracted to PAYD, whereas petrol price increase will affect all drivers
- Overseas there are different insurance arrangements

These factors are considered below. We estimate an average reduction in distance driven of 7% per annum.

Price Elasticity

The purpose of this section is to estimate the price elasticity of PAYD insurance per kilometre i.e. the change in kilometres driven when insurance is priced per kilometre. Since there is no direct data that measures this price elasticity in Australia, we need to link the price elasticity of PAYD to the price elasticity of another product: petrol.

But before we get into estimating the price elasticity, we need to stop and think about what the price elasticity is that we are estimating and why.

In traditional motor insurance the premium is not directly affected by the number of kilometres that a policyholder drives. When a policyholder makes a decision about whether to drive their car for a particular trip, they will take into account the running costs of the car for that trip e.g. how much petrol will be required to make the trip. But their insurance costs will not directly vary whether they make the trip or not. If they have an accident during that trip, then maybe (not always) their premium next year will be higher, so there is an indirect cost of insurance. But since a vehicle is involved in an accident on average only once in every 8 years, or once every 115,000 km, the probability of an accident during a particular trip is so low that there is little incentive to drive less. So the marginal insurance cost per kilometre is effectively zero.

With PAYD motor insurance the insurance has a direct cost per kilometre. This cost is known to the policyholder. So when a policyholder makes a decision about whether to drive their car for a particular trip, they will take into account the running costs of the car for that trip, plus the extra cost of PAYD insurance for that trip. This means that the marginal cost for the trip is higher than if the person had traditional motor insurance. Since the marginal cost for a trip is higher, some trips will be cancelled or combined with other trips, because the cost is no longer justified by the benefits.

When estimating the price elasticity, we can simplify the problem by considering only the largest cost. Since the largest running cost for a car is petrol, we can consider the problem from the perspective of two scenarios:

1. Traditional Insurance: The marginal cost of a trip is the cost of petrol
2. PAYD Insurance : The marginal cost of a trip is the cost of petrol, plus the cost of PAYD insurance

If the car owner is economically rational, then the decision about whether to make a trip should have the same outcome as if the following two scenarios, with identical marginal costs, are considered:

1. Current petrol price: the marginal cost of a trip is the current cost of petrol
2. A higher petrol price: the marginal cost of a trip is a higher cost of petrol, and that increase in the price of petrol is equal to the marginal cost of PAYD insurance

When expressed in this manner, it can be seen that the effect of PAYD upon distance driven should be identical to the effect of the price elasticity of petrol.

There is data available to estimate the price elasticity of petrol. Data is published that shows the average daily price of petrol, and quarterly data is published that shows the amount of petrol that was purchased. In the past two years petrol prices increased dramatically and this has led to reduction in the amount of petrol purchased. Australian petrol sales fell by 55.7 million litres (1.2%) in the three months to 31 March 2008, compared with the same period in the previous year. “There is no denying that record prices for petrol are causing Australian motorists to rapidly change their buying habits” (Energy Quest 2008).

Gargett and Hossain (2008) have estimated the price elasticity of petrol in Australia using published data. They consider the price increases in petrol up to 2008, and the concurrent reduction in petrol usage, and conclude that "In the short run, car fuel use declines about 1.5 per cent with a 10 per cent increase in the petrol price. This rises to about a 4 per cent decline when long-run demand and technology adjustments are made." Another way of wording this conclusion is to say that in Australia a 10% increase in petrol price causes people to drive 1.5% less, and to switch to more fuel efficient vehicles that reduce petrol usage by a further 2.5%. For our purposes the reduction in driving of 1.5% per 10% price increase is the appropriate result to use because we are interested in the distance driven rather than the amount of petrol consumed.

We can therefore estimate the reduction in distance driven by estimating the running cost per kilometre for petrol, and then considering the effects of a price increase in petrol by the amount of the PAYD cost per kilometre.

Table 13: Calculation of the Average Cost of Petrol per Kilometre

litres per 100km	9.5
fuel price per litre	$ 1.12
fuel cost per km	$ 0.11

In table 13 we obtained the petrol running cost per kilometre using the average fuel efficiency of cars in Australia and the average petrol price on 12th February 2009.

Earlier in this paper we estimated the social costs of driving. Our summary results included a cost per kilometre for private motor insurance and CTP insurance. If both private motor and CTP insurance were provided in a PAYD form, the marginal cost of a trip would increase from $0.11 to $0.17 per kilometre.

Table 14: Price Elasticity Estimation of Change in Km Driven

Fuel cost per km	$ 0.11
Insurance cost per km	$ 0.06
Increase in per km cost	56%
elasticity per 10% price rise	-1.50%
Change in km driven	-7.0%

A PAYD premium of $0.06 per kilometre changes the marginal price of driving by an amount equivalent to a 56% increase in the price of petrol. We calculate that this would result in a 7% reduction in the distance that people drive per annum.

Similar work by Bordoff and Noel (2008), but applied to USA, estimated a reduction of 8% in distance driven from the introduction of PAYD.

Overseas Experience

There have been a couple of test programs in the USA that have measured the reduction in distance driven by policyholders who switch to PAYD. They have been on a small scale, and while they have their shortcomings, they can be used as a sensibility check on the estimates obtained via price elasticity modelling.

The Federal Highway Administration and the Minnesota Department of Transportation cosponsored a demonstration project to test how consumers would change their driving behaviour under PAYD pricing. They monitored the distance driven by participants and gave each a per-mile insurance price of between 5 cents and 25 cents per mile based on their mileage levels. Cambridge Systematics (2006) reported an 8% reduction in distance driven.

Similarly, in a 2006 PAYD pilot program by Progressive Insurance in Texas, drivers who opted for PAYD drove 10 percent fewer miles (Progressive 2007). In that pilot, participants received $25 for every 5 percent fewer miles driven than expected, an average of 4 cents per mile, up to $350 a year.

NCTNOG (2008) reported that in 2006 Progressive Insurance began a PAYD insurance pricing test with 3,014 volunteer participants who can receive $50 annual savings for every 5% mileage reduction compared to their expected mileage. The 93 participants with odometer reading data available from previous years' emission inspection drove an average of 1,237 fewer miles during the test's first year compared with previous years, a 10% reduction.

These trials in USA have measured changes in distance driven similar to those estimated via price elasticity by Bordoff and Noel (2008), who estimated a reduction in distance driven of 8%. That 8% estimate for USA is slightly higher than our 7% estimate for Australia. This is not a reflection of lower price elasticity to petrol in Australia – in fact the opposite appears to be the case. Gargett and Hossain (2008) comment that "although the price increase in Australia was smaller, the Australian decline in fuel use is in fact greater than that in the US (8.2 percent below business-as-usual for Australia, versus 6.4 per cent for the US). This demonstrates that fuel use responsiveness to fuel price change is quite idiosyncratic across countries". Instead the difference in price elasticity of PAYD is due to the difference in taxation of fuel between Australia and USA. Since fuel taxes are higher in Australia than in USA, fuel prices are higher in Australia than in the USA. This means that the addition of PAYD to the marginal cost of travel is a greater percentage increase in USA than in Australia i.e. the introduction of PAYD would cause the marginal cost of travel to increase by a greater percentage in USA than it would in Australia.

Estimated Impact of Pay as You Drive

This section estimates the savings in social cost that could result from the introduction of pay as you drive insurance

Table 15: Estimation of Savings in Social Cost

Type of Social Cost	Change in social cost (in $billion)	Change in social cost per Vehicle
Accidents		
private motor	-0.40	-$ 38
CTP	-0.26	-$ 24
claim excess	-0.03	-$ 3
other	-0.20	-$ 19
Petrol	-0.75	-$ 72
Congestion	-0.71	-$ 68
Pollution	-0.16	-$ 15
Carbon	-0.11	-$ 11
Oil Dependence	-0.03	-$ 3
Road Infrastructure	-0.53	-$ 51
TOTAL	-3.2	-$ 304

As shown in table 15 above, we estimate that the introduction of PAYD will bring benefits of $3.2 billion per annum to Australia. This equates to more than $300 for every car in Australia. This is based upon a 7% reduction in distance driven.

Less than 20% of the savings come from insurance. Due to the way that PAYD insurance works (fewer kilometres driven results in lower premiums), insurers would automatically pass these savings directly through to policyholders.

Policyholders would directly benefit by only half of the savings in social cost, with the remainder of the savings accruing to other road users, the general population and to the government.

We have assumed that the savings are proportional to the reduction in distance driven. The assumption of proportionality is quite appropriate for costs such as petrol and oil dependence, where the costs are directly proportional to the distance driven. For other costs, such as congestion, the benefits could easily be greater than the estimates we have presented above. Alternatively one could argue that reduced congestion could lead to an increase in driving.

Public Policy Response

Pay as you drive is a potentially powerful intervention resulting in more responsible private vehicle use. It removes an existing negative externality caused by traditional motor insurance.

Obstacles to Widespread Adoption of PAYD

Pay as you drive insurance will not however be offered quickly and widely by insurance companies. This is due to a number of reasons, including:

1. Multiple Prisoner's Dilemma
2. Legacy Systems
3. Cost of Telemetry Devices

Multiple Prisoner's Dilemma

The concept of PAYD, or usage based pricing for car insurance has been around since 1920. The audited odometer mile exposure unit has been available for commercial fleets since at least the 1920s, was discussed by 1996 Nobel laureate economist William Vickrey in a 1968 paper, was the subject of a sex-discrimination lawsuit brought in 1986 by Pennsylvania National Organization for Women and documented in three Journal of Insurance Regulation (JIR) papers in 1988 and 1989, was described as the basis for an efficient pre-paid-miles personal car odometer system in a 1993 CAS Forum paper to support exposure unit legislation introduced in Pennsylvania 1990-1993, and was tested by Progressive in a pilot programme as early as 1998.

So why is it taking so long for insurers to adopt Pay As You Drive? Progressive in the US had a pilot called Autograph in 1998. That was 10 years ago. Either the concept is flawed, or there must be another reason.

The concept of PAYD will be flawed if there is no meaningful relationship between how far a person drives, or how they drive, or where they drive, and the amount of risk they bring to the risk pool. The possibility of there being no meaningful relationship is counter-intuitive, but nevertheless possible. Published results of Progressive's Autograph pilot in Texas indicate a clear relationship between distance driven and risk. Furthermore, traditional insurance pricing does its best to capture driving behaviour, by looking at factors like age, gender, vehicle modifications, etc as proxies for risk. So it is unlikely that PAYD is not taking off due the concept being flawed. There must be some other reason.

The concept of Prisoner's Dilemma is a classic game theory problem. Myerson (Myerson 1991) describes the prisoners' dilemma as follows:

> "The players are accused of conspiring in two crimes, one minor crime for which their guilt can be proved without any confession, and one major crime for which they can be convicted only if at least one of them confesses. The prosecutor promises that, if exactly one confesses, the confessor will go free now but the other will go to jail for 6 years. If both confess, then they both go to jail for 5 years. If neither confesses then they will both go to jail for only 1 year."

The best overall outcome for the prisoners is if neither confesses, because then they will each serve only 1 year. But there is an incentive for each individual prisoner to confess so that they reduce the 6 year sentence to 5 years, or even to zero years if the other prisoner doesn't confess at all.

What does the prisoners' dilemma have to do with PAYD? To answer this we need to look at the basic premise of the product: In traditional insurance, people who drive less, pay the same as people who drive more (all normal rating factors assumed to be the same). The reason for

this is that traditional rating factors (age, gender, suburb, car make and model, claims experience, etc.) are crude proxies for the true underlying risk. Insurance companies have not used mileage actively as a rating factor, because of the difficulty of verifying mileage (mileage as a rating factor is mandated by law in California, but is not checked by insurance companies and a consumer can frankly declare whatever they want). So PAYD introduces accurate pricing for mileage, and by doing so low mileage drivers can receive a more accurate and fair premium.

If you are an existing insurance company with a large book of existing car policies, you most likely have a finely balanced book that is profitable, albeit with thin margins. Your pricing is working, and the cross-subsidies between high mileage and low mileage drivers are balanced. If you introduce PAYD you will charge low mileage drivers less (and a fairer price) and high mileage drivers more. High mileage drivers will most likely leave you and take insurance from someone else who still provides traditional insurance. As an insurance company you face the prospect of losing a large part of your book before you can replace it with low mileage drivers (where you are in fact competitive). That is a daunting prospect. You have a large infrastructure in place which you've built up painstakingly and which is well matched to your current size and volume. If you lose material volume your expense ratios will blow out, which will in turn very quickly eat through your thin margins, leaving you unprofitable. That is not an appetising scenario for any insurance executive.

So this is where the multiple prisoners' dilemma comes in. If nobody acts (i.e. nobody offers PAYD), then status quo remains, books remain finely balanced and life goes on. The first large player to offer it faces the uncertainties listed above, and may take some short term strain. After the short term strain however, the first mover(s) will start benefiting from attracting more and more low mileage drivers and having a competitive offer for arguably 50% of the market.

What does that do to the other companies? As their low mileage drivers start abandoning them, their book becomes unbalanced. They have less low mileage drivers to cross-subsidise their high mileage drivers. Over time their margins will erode, and arguably in time they will be forced to switch to PAYD.

The Prisoner's Dilemma is not a trivial problem for existing insurers to overcome. Ultimately, however, new entrants who sell PAYD will gain enough market share so that existing insurers will have no choice but to switch to offering PAYD.

Legacy Systems

The systems typically used by insurance companies are large, cumbersome, fragmented and very expensive to change. PAYD further challenges traditional insurance systems by changing the very basis on which insurance premiums are charged. Traditional motor insurance premiums are charged against time, typically per annum. PAYD insurance premiums are linked to actual kilometres. Although this is a conceptually simple difference, the impact on systems is substantial.

Cost of Telemetry Devices

Not all PAYD products rely on telemetry devices (e.g. Real Insurance), but many do. The devices were initially very expensive (Norwich Union) but have since then reduced significantly in cost (e.g. Progressive's MyRate). The costs have three components:

1. Cost of the actual device
2. Cost of fitment
3. Cost of tracking and data

The cost of these devices will reduce as the technology improves and as the number of units being sold allow for economies of scale in production. So while the cost of these devices will be an initial obstacle, it will become less of an obstacle with time.

What Governments Can Do

There are a number of things the Government can do to stimulate widespread adoption of PAYD. There are also a number of things that can be done to further make the cost of car ownership variable and remove further negative externalities.

Remove Unnecessary Barriers to Pay as You Drive

The Government can make changes to regulatory barriers that are currently prevent or deter the introduction of pay as you drive. These interventions include:

1. Change CTP legislation to allow Pay As You Drive style Compulsory Third Party insurance. Some states have CTP schemes insured by the government, and those states could change their scheme design to price on a PAYD basis. Other states allow insurers to offer CTP, but restrict the way that insurers charge premiums – a change in CTP legislation is require in order to allow insurers to charge in a PAYD manner.
2. Provide insurers with access to information on vehicle use collected by governments. Governments collect annual odometer readings on many vehicles as part of the vehicle registration process. By providing access to this information the government would give insurers a basis for estimating vehicle usage and for checking for fraudulent alterations to odometer readings.

Actively Support Pay As You Drive

In addition to removing barriers to the introduction of pay as you drive, Governments can adopt strategies that would encourage insurers and policyholders to switch to pay as you drive products.

1. Waive stamp duty and or GST on Pay As You Drive insurance until it is adopted widely. The added consumer cost benefit will make the product more attractive and therefore accelerate adoption. The loss in revenue to the government would be offset by the saving to society and government, as estimated in this paper.
2. Pay incentives to insurance companies providing PAYD insurance. This may take the form of a nominal amount per policy written (say $200 per policy for the first 100,000 policies) to offset the development costs of systems and processes to enable the product to gain a foothold.

Further Reductions in Negative Externalities

Another tool that the government has to reduce negative externalities is vehicle registration costs. Vehicle registration costs at present are a flat annual fee that is not linked to car usage. The Government has the data for inspected vehicles to explicitly link registration fees to usage. For new vehicles still in the window (typically 3 years) where inspections are not required, the registration fees can be calculated on declared odometer readings. The system is self-regulating as the car cannot be sold without registration fees being fully paid up. A buyer will insist on an accurate reflection of the odometer on the purchase transfer document, otherwise the buyer will become liable for the driven kilometres.

Registration renewal fees in NSW according to the RTA website are:

Body type: Car, station wagon or small bus. Registration usage: Private	
Tare weight: Small (Up to 975 kg)	$223
Tare weight: Medium (976 to 1154 kg)	$245
Tare weight: Large (1155 to 1504 kg)	$275
Tare weight: Extra Large (1505 to 2504 kg)	$393

The second tool available to the Government is tax. There is a tax benefit in the fringe benefit tax system in Australia that benefits drivers who drive more than 15,000 kilometres pa. This tax benefit may sometimes negate some of the benefits of pay as you drive. By removing this incentive to drive further, the Government would be both supporting pay as you drive and also removing a negative externality.

Estimated Impact of Changes to Public Policy

In the same way that we estimated the changes in kilometres driven following the introduction of pay as you drive insurance, we have also estimated the change in kilometres driven if, in addition to the introduction of pay as you drive insurance, vehicle registration fees were linked to the kilometres driven.

Table 16: Price Elasticity Estimation of Change in Km Driven From Registration Fees

Fuel cost per km	$ 0.11
Insurance cost per km	$ 0.06
Registration cost per km	$ 0.02
Increase in per km cost	74%
elasticity per 10% price rise	-1.50%
Change in km driven	-8.7%

Table 16 shows the estimated reduction in kilometres driven if insurance were offered as pay as you drive and also vehicle registration fees were based upon kilometre usage. Comparing the results to table 14, we see that the reduction in kilometres driven changes from -7.0% to -8.7%.

Using $275 as the midpoint, the impact of making registration costs usage based, will be that the reduction in distance driven will improve from 7% to 8.7%. This will result in savings to social cost of several hundred million dollars per annum.

Table 17: Estimation of the Reduction in Social Cost From Making Registration Fees Km Based

Type of Social Cost	Change in social cost (in $billion)	Change in social cost per Vehicle
Accidents		
private motor	-0.10	-$ 9
CTP	-0.06	-$ 6
claim excess	-0.01	-$ 1
other	-0.05	-$ 5
Petrol	-0.18	-$ 17
Congestion	-0.17	-$ 16
Pollution	-0.04	-$ 4
Carbon	-0.03	-$ 3
Oil Dependence	-0.01	-$ 1
Road Infrastructure	-0.13	-$ 12
TOTAL	-0.77	-$ 73

Conclusion

Pay as you drive insurance has the potential to reduce negative externalities. We estimate that on average this will mean that drivers will reduce their annual kilometres driven, resulting in a reduction in social costs of $3.2 billion per annum. There is a significant level of uncertainty to this estimate, with greater potential for upside than downside. The potential savings in social cost could be augmented by appropriate government policies to reduce barriers to the introduction of pay as you drive, to encourage the use of pay as you drive, and to reduce other sources of negative externalities.

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