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Development of a kilometre-based rewards system to encourage safer driving practices

By

Stephen Greaves and Simon Fifer

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ABSTRACT: There is growing interest in using kilometre-based financial mechanisms to encourage safer driving practices and reduce accident claims. The rationale behind such an approach is that in addition to driver characteristics such as age and gender, crash risk is intrinsically a function of both the kilometres driven and the circumstances under which those kilometres are driven (time-of-day, day-of-week, road type, speeding etc). In this paper, we explore options for designing a kilometre-based rewards scheme that incentivises drivers to reduce their kilometres, night-time driving and speeding using recent accident data and travel survey data collected in the Sydney Greater Metropolitan Area (GMA). Results show that young drivers (17-30 year-olds) would be hardest hit by the proposed scheme with middle-aged drivers (31-65) faring the best. The impacts of the reward system are then assessed hypothetically using evidence from 125 motorists who have completed five weeks of driving in which their kilometres, night-time driving and speeds are monitored using the latest GPS technology. Various charging scenarios and hypothesised behavioural changes are implemented to assess both their incentive for change and the overall financial impact for the project. These results are used in conjunction with the theoretical and empirical justification outlined in this paper, to set the final charging regime rates based on the overall study budget.

KEY WORDS: ***Road safety; driving behaviour; financial rewards***

AUTHORS: Stephen Greaves and Simon Fifer

CONTACT: Institute of Transport and Logistics Studies **(C37)**
The Australian Key Centre in Transport Management
The University of Sydney NSW 2006 Australia

Telephone: +61 9351 0071

Facsimile: +61 9351 0088

E-mail: itls@sydney.edu.au

Internet: http://www.sydney.edu.au/business/itls

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1. Introduction

Recent estimates suggest motor vehicle accidents cost the Australian economy around $17 billion per year (Connelly and Supangen, 2006). While both the number of crashes and crash rates (crashes/kilometre) has reduced dramatically in the last thirty years, latest statistics show that 1463 persons were killed on Australian roads in 2008, with 395 killed in the state of New South Wales alone (Australian Government, 2009). More worryingly, it appears reductions may have stagnated in recent years, leaving policy-makers searching for other options that might lead to significant drops in crash rates. While engineering-based methods for both roadway infrastructure and vehicles, and regulation and enforcement will continue to play a critical role in future road-safety initiatives, an area of growing interest is the use of kilometre-based financial mechanisms to encourage safer driving practices (Litman, 2009). The notion here is that by linking what motorists are charged to the kilometres they drive and the circumstances under which those kilometres are driven (e.g., night-time driving, route choice, speeding), motorists will be directly incentivised to change behaviour, reducing the overall risk and societal costs of accidents (Zantema et al. 2008).

Within this context, the current paper details the development of a kilometre-based rewards scheme designed to encourage safer driving practices and reduce the risk of crash involvement. The emphasis on *rewarding desirable behaviour* versus the traditional approach of punishing undesirable behaviour is deliberate and rooted in psychological theory showing this to be generally a more effective means of influencing behaviour (Mazureck and Van Hatten, 2006). Responses to the scheme will be tested both hypothetically through a willingness-to-pay study and empirically through a 10-week field study of 140 motorists in Sydney. In the field study, motorists are monitored using Global Positioning System (GPS) technology for a five week 'before' period to build up a detailed profile of their regular driving routines and patterns (Greaves et al. 2009).This information is used to set a 'budget' for each motorist based on their kilometres driven, night-time driving and speeding. Motorists are then informed they can make money based on the reduction in these measures relative to the before period and monitored for a further five weeks. At the end of the trial, they will receive a financial reward based on the observed changes - intuition and evidence shows this receipt of a tangible 'reward' is crucial for motorists to take the study seriously (Mazureck and van Hatten, 2006; Nielsen, 2004).

This paper is focused on the development of the rewards scheme and is structured as follows. The literature review focuses on 1) applications that have designed charging regimes focused on crash-risk reduction, and 2) the main factors impacting crash-risk that could be included in a charging scheme of the type being considered here. Then the rationale for and structure of the rewards system is detailed culminating in the proposed rates that will be charged. The impacts of the reward system are then assessed hypothetically using evidence from 125 motorists who have completed the 'before' study (note that 15 did not qualify for various reasons). Various charging scenarios and hypothesised behavioural changes are implemented to assess both the incentive for change and the overall financial impact for the project. These results are used in conjunction with the theoretical and empirical justification outlined in this paper, to set the final charging regime rates based on the overall study budget.

2. Literature review

2.1 Charging regimes focused on crash-risk reduction

Efforts to financially incentivise safer on-road driving behaviour are most visible through the commercial offering of pay-as-you-drive (PAYD) insurance options, in which premiums are differentiated to kilometres driven and in some cases time, location and speed (Litman et al. 2008). Although not widely available in Australia as yet, PAYD schemes are available in several states in the U.S. and have been trialled in the UK (through Norwich Union) and the Netherlands (Zantema et al. 2008). Commercial sensitivities (presumably) preclude details of how rates are set and while some aggregate indicators of the outcomes of the programs are provided, rarely is information provided on the before and after changes in driving. One exception to this was a recent government-sponsored trial of PAYD insurance in Dallas-Fort Worth (Reese and Pash-Brimmer, 2009). Here, motorists were monitored for 12 months (divided into two six month periods) before and after the imposition of a distance-based scheme that rewarded them at $US25 for each 5% percent reduction in miles driven up to a cap of $350 ($175 per period). The effects of the scheme were to reduce average miles driven by 560 miles (5%). Arguably the most ambitious PAYD scheme was the Norwich Union PAYD offering in which charges were differentiated by driver demographics, time-of-day, and road type with the heaviest charges levied on young drivers (23 and under) at night (Norwich Union, 2006). Despite the touted success of the scheme, it was shelved in 2008 because of a lack of uptake with only 10,000 people taking up the scheme of a projected 100,000 according to the company website.

Various academic studies have focused on exploring how variable-rate pricing regimes might affect motorist behaviour, largely from the perspective of congestion-mitigation with few focusing on risk-reduction per se (Nielsen, 2004; Xu, 2009). The closest parallel to what is proposed here is provided by Zantema et al. (2008) through a hypothetical investigation of the effects of various PAYD insurance schemes being proposed for young drivers in the Netherlands. The approach used is to set a base rate, which in this case is taken as the average insurance premium divided by the annual kilometres driven. The base rate is then adjusted upwards by factors (derived from various sources) reflective of higher accident risk, including driving at night versus driving during the day and driving on urban roads versus motorways. They conclude that the most ‘aggressive’ scheme, comprising obligatory time and road type differentiation could reduce crashes by over five percent. No published evidence is currently available on how this changed behaviour in reality.

Other studies have looked at specific methods of using financial mechanisms to change behaviour, primarily speeding. Mazureck and van Hatten (2006) detail a study in the Netherlands, in which motorists were paid to stay within the speed limit and maintain a safe following distance. Results indicated that speeding was reduced by around 20 percent based on a reward of 0.04 Euros for every 15 seconds spent not speeding – notably, once the rewards were removed, drivers largely reverted back to their original behaviour. In a similar study, the Swedish Intelligent Economic Speed Adaptation study involved directly linking incentives to actual speeding behaviour. In this study participants were paid a lump sum bonus and this bonus was reduced by a certain charge for every minute participants drove above the speed limit within the study period (Gunnar et al. 2005).

2.2 Factors impacting crash-risk

The risk of a crash is influenced by a number of interrelating factors pertaining to the driver, trip characteristics, passengers, vehicle, roadway conditions and weather (Drummond et al. 1992). Acknowledging this, the intent here is to focus on specific elements of relevance to a GPS-based charging regime of the type we are proposing here, namely the kilometres driven, time of day, road type, speeding and driver demographics.

2.3 Vehicle kilometres

Logic tells us that each additional kilometre driven increases the chance (all things being equal) of an accident, however safe the driver. However, the relationship between the actual number of number of kilometres driven and risk is problematic to directly determine because it is not information that is directly recorded from involved drivers in the event of an accident. Empirical evidence summarised by Litman (2009) in Figure 1 suggests that there is a near linear relationship between annual kilometres and crash related claims. However Litman also concludes that higher mileage drivers have a lower crash-related claim frequency than lower mileage drivers. Janke (1991) proposes that the relationship between miles driven and traffic accidents is nonlinear (i.e., smaller proportional increases in accident rate at higher levels of mileage). A recent report from the Californian Department of Motor Vehicles also supports these findings, calculating that the accident risk curve dips for drivers reporting higher mileage (Gebers 2003). Regardless of the exact slope of the curve, both studies conclude that a driver's current level of driving exposure can influence their risk of accident involvement.

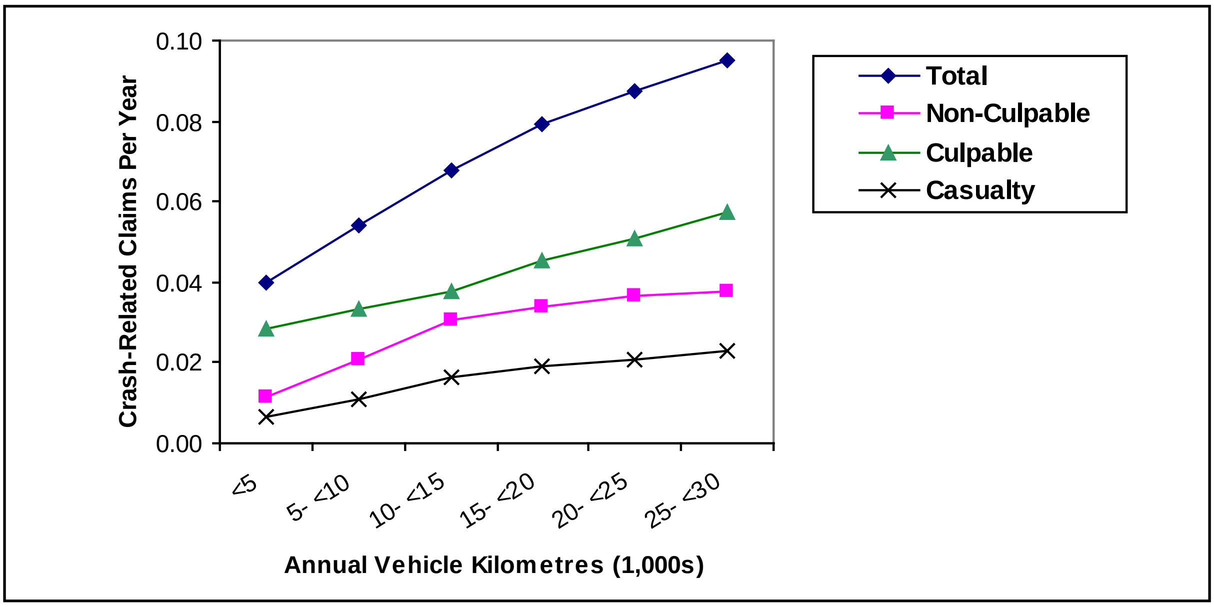

Figure 1: Crash rates by annual vehicle mileage (Litman, 2009)

2.4 Time of day

Numerous studies have shown the risk of having an accident while driving at night is greater than driving within daylight hours, with published studies suggesting the crash risk is 2-3 times greater all else being equal (e.g., Doherty et al. 1998; Zantema et al. 2008). OECD figures report that although the volume of travel at night is far less than compared to day travel volumes, 35% of road accidents occur during night hours (OECD, 1980). This increase in risk is partly due to reduced visibility and driver fatigue and the fact that night time driving is more heavily associated with risky driving behaviour, such as intoxication and passenger distractions (Zantema et al., 2008).

2.5 Road type

The safety of certain roads is linked to the road design characteristics such as the speed limit, number of lanes, oncoming traffic, intersections, roundabouts and crossings etc. Based on accident rates per million kilometres travelled/road type, the consensus appears to be that motorways are the safest roads, followed by dual carriageways and single lane roadways (Lynam and Lawson, 2005; Zantema et al. 2008). For instance, the Automobile Association (AA) Trust Report of British roads (part of the European Road Assessment Program 2006) found that motorways are five times safer than single carriageways and twice as safe as dual carriageways (AA Trust Report, 2006).

2.6 Speeding

Over the past 50 years considerable research has been undertaken to investigate the relationship between speed and crash rates. While the precise nature of this relationship is heavily debated and subject to many confounders, the overwhelming consensus is that (all else being equal) a linear increase in speed leads to an exponential increase in both the chance of and severity of a crash (Elvik et al. 2004; Aarts and Van Schagen, 2005). In their meta-analysis of almost 100 studies of speeds and accidents, Elvik et al. (2004) conclude that the relationship between speed and crash/severity can be described by a Power function as shown (in this case for fatal accidents):

$$\frac{\text{Fatal Accidents After}}{\text{Fatal Accidents Before}} = \left(\frac{\text{Speed After}}{\text{Speed Before}}\right)^4$$

The implication is (for instance) that lowering speeds from 100 km/h to 90 km/h would result in around a 34 percent decrease in fatal accidents. In an Australian context, research conducted by Kloeden et al. (2002) in Adelaide suggests the risk of a casualty crash involvement doubles every 5km/h for speeds above 60km/h (Figure 2). Despite the differences in the magnitude of the risk that is attributed to excess speeds within the literature, it is clear that speed does have an influence on risk of being involved in a crash.

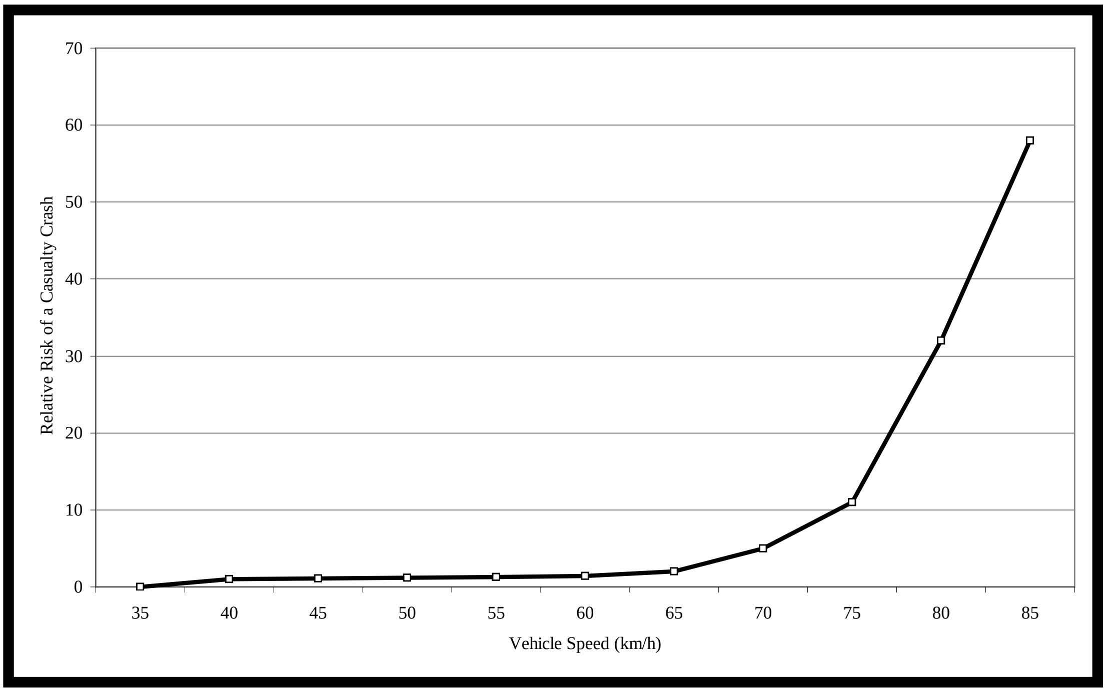

Figure 2: Vehicle speed and the risk of involvement in a casualty crash in a 60 km/h zone relative to travelling at 60 km/h.

Note: Interpretation is that at a speed of 70 km/h, the risk is over 10 times that of a casualty crash relative to a speed of 60 km/h

Source: Kloeden et al. 2002

2.7 Driver demographics

The differences in crash-risk by driver demographics are well documented with in particular young drivers having a substantially higher crash rate when compared to most other drivers (Doherty et al. 1998; Zantema et al. 2008). In the state of New South Wales young drivers (under 26 years of age) hold only 15% of all licences but are annually involved in 36% of all road fatalities according to the New South Wales Roads and Traffic Authority, the statutory road safety authority (RTA, 2009). Similar figures around the world support the over representation of young drivers in motor vehicle accidents. This is particularly pronounced for young, male drivers (Ferguson et al. 2007; Gray et al. 2008). Despite the strong focus on young male drivers, some studies report that once exposure is taken into account young male and female drivers typically have similar crash risks (Ryan et al. 1998; Cavallo and Triggs, 1996). This increased risk of young drivers is clearly reflected in driving insurance premiums, which in many countries is almost double the premiums for older drivers.

3. The rewards system: Rationale and structure

The concept behind the proposed rewards system is that motorists receive a financial payment based on the relative reduction in correlates of crash-risk (i.e., kilometres driven, night-time driving, speeding etc) equated to a per kilometre rate between a 5-week charging period (Period 2) and a 5-week base period (Period 1). In selecting the correlates (crash-risk groupings) and setting the rates, various scientific and pragmatic factors were considered, specifically:

1. The crash-risk groupings should capture major factors impacting crash-risk while resulting in a scheme that is easy for participants to understand: To accurately facilitate behavioural change it is important that the charging regime is transparent and participants fully understand how the charges are levied for their trips.
2. The rates must to be relevant: One of the insightful outcomes of interviews conducted with pilot participants is that incentives must be large enough to warrant a change in behaviour for a particular circumstance (i.e., relevant for that trip purpose). For example, if a participant were to travel 10 km to work and their assigned per km rate was $0.10, the total cost for this car trip would be $1.00. This equates to essentially a $1.00 incentive to forgo that car trip given the incentive mechanism used in this study (i.e., the difference between the budgets for the two study periods). According to pilot feedback this $1.00 incentive would not cover the costs of an alternative mode of transport or the inconvenience of having to reschedule the work commute.
3. Payment of the rates must be within the project budget: The hypothetical scenarios presented in this paper serve the purpose of providing an estimate of the incentive liability required for this study. Unfortunately due to limited resources the charging regime chosen will be heavily influenced by the expected incentives that will be required to be paid to participants.

3.1 Development of crash risk groupings

The decision on crash risk groupings was based on evidence from the literature review, computation of crash risks and pragmatism mainly in terms of comprehension of the charging regime. Crash risk is simply the number of accidents occurring per some measure of exposure (e.g., number of licensed drivers, million kilometres driven) and is computed as follows:

$$R_{ij} = \frac{A_{ij}}{D_{ij}} \tag{1}$$

Where:

A = annual number of accidents

D = annual vehicle kilometres travelled

i = demographic/situational grouping, where situational refers to time-of-day, day-of-week, road type, speeding etc

j = accident type: fatality, injury, property damage only

Crash data were sourced from the Traffic Accident Database System (TADS) year 2002 – 2006, an accident database produced by the New South Wales Roads and Traffic Authority (RTA), the statutory road authority for the state. The TADS provides comprehensive details of all accidents reported to the police involving one moving road vehicle on a public road in which a person was killed or injured or at least one motor vehicle was towed away. Accidents are defined according to severity. A *fatal accident* is an accident in which at least one person dies within 30 days of an accident as a result of injuries received in the accident. An *injury accident* is a non-fatal accident in which one person is injured as a result of the accident and who does not die within 30 days of the accident. Injury accidents are not differentiated by the severity of the injury, but at the per person level they are defined in terms of *serious injuries*, which are those requiring hospitalisation and *other injuries*, which do not require hospitalisation. A *Property Damage Only (PDO)* accident is one in which there is neither a fatality nor injury but which involves at least one vehicle being towed away. The implication of these definitions is that the accident class takes on the highest order. For instance, an accident with one fatality and 3 injuries would be classified as a fatal accident but not appear as an injury accident.

The exposure data were sourced from the Sydney Household Travel Survey (SHTS). The SHTS is a continuous (covers all days of the year) survey of approximately 5,000 households/annum from across the Sydney Greater Metropolitan Area that has been running since 1997 (Transport Data Centre, 2007). The data can be manipulated to provide weighted VKT estimates by driver age and the time-period for passenger vehicles. For this analysis, data from 2001/2002 to 2005/2006 were pooled (around 25,000 households) and weighted to the 2005 population.

Based on the computation of crash-risk using the SHTS and TADS data, six demographic segments (17-30 male, 17-30 female, 31-65 male, 31-65 female, 66+ male, 66+ female) and two time-periods (day = 05:00 – 17:59, night = 20:00 – 04:59) were defined resulting in a total of 24 demographic/situational categories. Further differentiation by night-time week-end driving was also considered, particularly for young drivers, where the crash rates were notably higher, but this was not pursued through to the final scheme. The decision not to include road type was based on i) practical difficulties with computing the required exposure measures from the SHTS because road type was not recorded, and ii) the concern this would result in a scheme that was overly complex for participants to comprehend.

3.2 Derivation of per kilometre rates

Per kilometre rates were based on the notion that the external costs of accidents be internalised across the 24 demographic/situational categories according to their crash risk. Accident costing is an inexact science and is an ongoing area of research and development (Risbey et al. 2007). It is mainly dependent on the particular costing approach used, crash cost components, and quality and quantity of available data. The current approach for estimating the cost of crashes in New South Wales (as with the rest of Australia) is based on the *human capital (HC)* approach stipulated by Austroads, which is the association of Australian and New Zealand road transport and traffic authorities (Austroads, 2003). Under this approach, dollar costs are assigned to the various components of crashes, specifically the human (e.g., medical costs, ambulance costs, loss of earnings), vehicle (e.g., repairs, towing) and general costs (e.g., travel delays, police costs). The approach has come under heavy criticism, primarily because evidence from the UK, USA, New Zealand, and Sweden suggests it undervalues the price individuals place on reducing their crash risk while driving (Hensher et al. 2009). Recent evidence from Sydney, in which motorists were asked to trade-off crash-risk against travel time and out-of-pocket costs using innovative Stated Choice (SC) methods, strengthens this claim (Hensher et al. 2009). Table 1 provides a comparison of this (so-called) *value of risk reduction (VRR)* approach versus the HC approach, suggesting that fatalities in particular may be under-valued by around four times using the HC approach. The story with injuries is not as clear, which even allowing for some definitional issues suggest that serious injuries in particular may be over-valued using the HC approach (or under-valued using the value of crash risk approach).

Table 1: Casualty costs per person using the human capital and value of crash risk reduction approach in New South Wales (2007)

Human Capital Approach [1]		Value of Risk Reduction Approach [2]	
Fatal Injury	$1,605,737	Fatal Injury	**$6,369,655**
Serious Injury – S (requires hospitalisation)	$ 400,094	Serious Injury – S (requires hospitalisation, results in permanent disability)	$310,292
		Hospital Injury - H (requires hospitalisation but full recovery)	$75,476
Minor Injury – M	$16,264	Minor Injury - M	$16,552
Total Injuries (S+M)	**$108,395**	Total Injuries (S+H+M)	$44,793

(1) Modified from RTA Economic Analysis Manual, Version 2, (1999), table 11, page B-9 to 2007 using the inflation rate provided by the Reserve Bank of Australia (RBA, 2009) at http://www.rba.gov.au/calculator/calc.go#divFrmCalcQ
(2) Adapted from Hensher et al. (2009)

Given the dual desires of basing the rates on risk, but also developing rates that encourage behavioural change, it was decided to use the higher (highlighted) figures from the two approaches for fatalities and injuries. This also required conversion of the per person casualty costs to a per crash casualty cost – this was computed from the TADS data as being 1.19 fatalities/fatality accident and 1.30 injuries/injury accident. A further issue here was PDO accidents, for which cost estimates are derived separately based on insurance claims data by the Bureau of Transport Economics (Bureau of Transport Economics, 2000). Final details of the estimated crash costs together with the annual accidents and total annual accident costs are shown in Table 2. A further issue with PDO accidents is that they only appear in the TADS database if at least one vehicle requires towing. Given that (according to the BTE report), only 21 percent of vehicles involved in a crash require towing, PDO accidents from the TADS database were factored by 1.79 to account for this under-reporting. It should be noted this will still tend to under-estimate the number of PDO crashes, because the BTE only considers those crashes that involve an insurance claim.

Table 2: Crash costs for the study period

Accident Type	Annual Accidents(1)		Cost/Accident (AUD$)	Annual Accident Costs
	Total Accidents	Total Vehicles Involved		
Fatal Injury	228	250	$7,553,194	$1,722,128,165
Injury	14,961	21,221	$140,870	$2,107,556,070
Property Damage Only	100,899(2)	154,783	$7,954(3)	$802,554,766
TOTAL	116,088	176,254		$4,632,239,001

(1) Computed as the average number of accidents/year over the five-year TADS data used.
(2) Adjusted to account for non-towaway accidents.
(3) Based on BTE (2000) rates factored to 2007.

Having established the total cost of accidents for each accident type L_j the next step was how to internalise/assign this cost across the 24 categories. The approach taken was to establish a base charging rate χ_B , representing the per kilometre charge for the lowest risk category, with rates for other categories set dependent on the *relative crash risk* (β) to this base category. Given the requirements for costs to be based on a per kilometre basis, β needed to be weighted by the relevant VKT for that category such that:

$$(VKT_1 \times \beta_{1j} \times \chi_{Bj}) + (VKT_2 \times \beta_{2j} \times \chi_{Bj}) + \ldots + (VKT_{28} \times \beta_{28j} \times \chi_{Bj}) = L_j$$

$$\chi_{Bj}((VKT_1 \times \beta_{1j}) + (VKT_2 \times \beta_{2j}) + \ldots (VKT_{28} \times \beta_{28j})) = L_j$$

$$\chi_{Bj} \sum_{ij} (VKT_i \times \beta_{ij}) = L_j \qquad (2)$$

$$\sum_{j} L_j = L \qquad (3)$$

Where:

i = demographic/situational category

j = accident type: fatality, injury, property damage only

VKT_i is the vehicle kilometre travel of category i

β_{ij} is the relative risk for category i and accident type j

χ_{Bj} is the base charging price of accident type j

L_j is the total accident cost of accident type j

L is the total accident cost

The initial per kilometre charges are shown in Table 3, together with an indication of how these were derived. The group with the lowest crash rates/risk were 31-65 year-old males driving during the day with a base charging rate of 7.7 cents/kilometre (highlighted in grey). Charges for other groups were then set based on the relative risk of each particular category to this base category, such that the total accident costs shown in Table 2 were maintained. Per kilometre charges ranged from 7.7 cents to 69.7 cents for the highest risk group, 17-30 year-old males driving at night, largely due to around a 16 times greater relative fatality risk. It should be noted that the (perhaps surprisingly) high figure of 66.2 cents for elderly (66+) female drivers at night is misleading, because of the very low sample representation in the exposure database for this particular group – in this case, it was decided to simply use the figure for elderly males.

Table 3: Derivation of per kilometre rates for the 12 charging groups

			Crash Involvements per Year				Crash Rates			Relative Risk			Cents/km			
Gender	Age	Time of Day	Fatal	Injury	PDO	Total VKT	Fatal	Injury	PDO	Fatal	Injury	PDO	Fatal	Injury	PDO	**All Crashes**
Male	17-30	5-20	43	3,793	33,540	3,832	0.011	0.990	8.753	3.03	2.63	3.18	7.8	9.8	4.5	**22.2**
		20-5	36	1,140	10,126	598	0.061	1.904	16.920	16.30	5.05	6.15	42.0	18.9	8.8	**69.7**
	31-65	5-20	55	5,516	40,240	14,629	0.004	0.377	2.751	1.00	1.00	1.00	2.6	3.7	1.4	**7.7**
		20-5	22	780	5,975	1,426	0.015	0.547	4.189	4.06	1.45	1.52	10.4	5.4	2.2	**18.0**
	65+	5-20	19	876	5,950	1,477	0.013	0.593	4.030	3.48	1.57	1.47	9.0	5.9	2.1	**17.0**
		20-5	1	52	325	71	0.020	0.729	4.569	5.28	1.93	1.66	13.6	7.2	2.4	**23.2**
Female	17-30	5-20	16	3,143	21,061	2,685	0.006	1.171	7.843	1.64	3.10	2.85	4.2	11.6	4.1	**19.9**
		20-5	10	528	3,624	360	0.028	1.466	10.063	7.44	3.89	3.66	19.2	14.6	5.2	**38.9**
	31-65	5-20	33	4,600	28,707	9,702	0.003	0.474	2.959	0.92	1.26	1.08	2.4	4.7	1.5	**8.6**
		20-5	6	340	2,250	674	0.009	0.504	3.340	2.47	1.34	1.21	6.3	5.0	1.7	**13.1**
	65+	5-20	7	432	2,881	625	0.011	0.692	4.610	2.92	1.83	1.68	7.5	6.9	2.4	**16.8**
		20-5	1	22	104	10	0.058	2.134	9.981	15.46	5.66	3.63	39.8	21.2	5.2	**66.2**

3.3 Speeding

Speeding was dealt with as a simple multiplier on the base rates, similar to the approach proposed by Zantema et al. (2008). The main issues were the tolerance given and speeding bands. In terms of tolerance, current New South Wales as of July 1st, 2009 law is zero tolerance and is based on radar and camera enforcement. As a result speeding was defined as anything over the speed limit irrespective of the time spent speeding, which is deliberately more stringent than similar studies (e.g. Mazureck and van Hattern, 2006; Agerholm, 2009). In terms of bands, initially speeding was differentiated into two categories, minor speeding (1-10 km/h over) and major speeding (>10 km/h). However, following considerable debate and some confusion by pilot participants, this was simply differentiated as speeding (>=1 km/h above the posted speed limit) and a multiplier of double the base rate was applied.

The initial per kilometre rates are shown in Table 4. Young males (the highest risk group) would be charged the highest per kilometre rates ranging from $0.25 per kilometre, for driving within the speed limit during the day, to as high as $1.40 per kilometre for driving above the speed limit during the night. Middle aged females would be charged the lowest per kilometre rates ranging from $0.20 per kilometre (day, non-speeding) to $0.40 cents per kilometre (night, speeding).

Table 4: Initial per kilometre rates

Demographic Group	**Day (0:500 – 20:00)**		**Night (20:00 – 05:00)**	
	Non Speeding	**Speeding**	**Non Speeding**	**Speeding**
17-30 Male	$0.25	$0.50	$0.70	$1.40
17-30 Female	$0.20	$0.40	$0.40	$0.80
31-65 Male	$0.10	$0.20	$0.20	$0.40
31-65 Female	$0.10	$0.20	$0.15	$0.30
66+ Male	$0.20	$0.40	$0.25	$0.50
66+ Female*	$0.20	$0.40	$0.25	$0.50

*Due to very small sample size in the SHTS data use the same figure for 66+ males.

4. Scenario testing

The purpose of the scenario testing was to assess and refine the rewards scheme to both maximise the motivation for behavioural change while staying within the confines of the project budget for incentives, which was approximately $AU10,000. This involved taking the 125 drivers who qualified for the rewards phase of the project and computing a 'budget' for them based on their VKT, night-time driving and speeding combined with the applicable rates over the five-week before period. This budget represents the maximum amount of money they could make by changing behaviour, which equates to not driving their vehicle at all for the five-week after period. Drivers were recruited from an online panel, which enabled targeted recruitment based on age and gender. They were told the study was about transport planning in Sydney and asked to take a GPS device for the duration of the study. Nothing was mentioned about the rewards phase because of the potential for affecting their driving in the before phase.

The original aim was to only recruit drivers under the age of 65 with roughly equal numbers in the four demographic categories. It became clear after several weeks of trying that this was not going to be possible and it proved particularly problematic to recruit young drivers, especially males, while comparatively easy to recruit older females. Table 5 shows the final breakdown of the sample along with their driving characteristics and starting budget. Average VKT was highest for the older male group while night-time driving peaked for the young male groups, both in line (arguably) with a priori expectations. Speeding was reasonably consistent across the groups, peaking for the young, female drivers. Contrary (perhaps) to current expectations, young male drivers did not exhibit higher speeding tendencies than the other demographic groups. This may be down to the self-selection bias introduced through the sampling process, which suggests that young males exhibiting more risky behaviour are less inclined to participate in a driving study of this nature, an observation that seems to hold true across similar studies (Agerholm, 2009).

Table 5: Driving characteristics and starting budget for motorists in the study

Age-Group	Sample	Average Daily VKT	% Night VKT	% Speeding (Day)		% Speeding (Night)		Starting Budget (based on 5 weeks)	
				Mean	Max	Mean	Max	Mean	Range
17-30 Male	9	24.7	26%	11%	17%	12%	44%	$343	$86-$635
17-30 Female	23	28.4	16%	14%	34%	16%	50%	$288	$88-$564
31-65 Male	47	32.2	12%	13%	44%	13%	45%	$160	$14-$440
31-65 Female	46	26.7	7%	12%	26%	12%	39%	$123	$15-$362
TOTAL	125	29.0	12%	13%	44%	13%	50%	$183	$14-$635

*Maximum budgetary impacts - $22,043

Projected incentives payable were then computed by conducting a sensitivity analysis according to assumed rates of change to VKT, night-time driving and speeding over the five-week 'after' period (shown in Table 6). The basis for these assumptions was evidence collected from a number of voluntary travel behaviour change interventions conducted in Australia and in-depth interviews conducted with pilot participants for this project. Under the most conservative scenario (Scenario 1), the projected incentives ranged from $8 for 31-65 year-old females to $32 for 17-30 year-old males, with a projected payout of $1,695. Under the most aggressive scenario (Scenario 4), the average incentives ranged from $22 to $87 across the four groups with a projected payout of $4,658.

Table 6: Projected incentives under various scenarios (initial per kilometre rates)

		Starting Budget	Scenario 1	Scenario 2	Scenario 3	Scenario 4
% reduction - VKT			5%	8%	12%	15%
% reduction – night driving			10%	15%	15%	20%
% reduction - speeding			15%	25%	35%	45%
17-30 Males	Average	$343	$32	$50	$69	$87
	Range	$86-$635	$8-$58	$12-$93	$17-$129	$21-$161
17-30 Females	Average	$288	$23	$36	$50	$62
	Range	$88-$564	$5-$47	$9-$74	$13-$102	$16-$127
31-65 Males	Average	$154	$12	$19	$27	$33
	Range	$14-$353	$1-$37	$2-$58	$3-$77	$3-$97
31-65 Females	Average	$130	$8	$13	$18	$22
	Range	$15-$440	$1-$25	$1-$39	$2-$53	$2-$66
Projected Incentive Payout		***$22,043***	**$1,695**	**$2,676**	**$3,727**	**$4,658**

The various scenarios in Table 6 suggested that the initial rates would be unlikely to motivate the majority of participants to change their driving behaviour. A number of other rate structures were tried and tested before establishing the final scheme shown in Table 7. The final rates were chosen to provide more encouragement to change behaviour while at the same time maintaining the relative risk cost framework outlined in this paper. Upon careful consideration it was decided that the rates would differentiate based on age and not gender. This was due to the small sample sizes of the four demographic groups and proposed analysis requirements.

Table 7: Final rates used for the rewards phase and budgetary implications

	Day - Non Speeding	**Day - Speeding**	**Night - Non Speeding**	**Night - Speeding**
17-30 Male	$0.20	$0.60	$0.80	$2.40
17-30 Female	$0.20	$0.60	$0.80	$2.40
31-65 Male	$0.15	$0.45	$0.60	$1.20
31-65 Female	$0.15	$0.45	$0.60	$1.20

Sensitivity analysis was also performed using the new rates (outlined in Table 7) according to the same rates of change to VKT, night-time driving and speeding as before (Table 8). The average incentive ranges from $21 for Females 26-65 years of age to $119 for Females 17-25 years of age, depending on the behavioural response scenario. Again, it must be emphasised this is based on hypothesised behavioural changes – in actuality payouts to individuals could be much larger as shown by the starting budgets.

Table 8: Projected incentives under various scenarios (final per kilometre rates)

		Starting Budget	Scenario 1	Scenario 2	Scenario 3	Scenario 4
% reduction - VKT			5%	8%	12%	15%
% reduction – night driving			10%	15%	15%	20%
% reduction - speeding			15%	25%	35%	45%
18-30 Males	Average	$352	$41	$64	$87	$108
	Range	$83-$627	$9-$84	$14-$131	$19-$171	$24-$210
18-30 Females	Average	$403	$45	$71	$96	$119
	Range	$105-$815	$6-$111	$9-$175	$13-$234	$17-$290
31-65 Males	Average	$315	$32	$50	$68	$85
	Range	$29-$911	$3-$116	$5-$182	$7-$241	$9-$301
31-65 Females	Average	$233	$21	$33	$45	$56
	Range	$23-$654	$1-$56	$2-$87	$3-$116	$4-$145
Projected Incentive Payout		***$36,335***	**$3,708**	**$5,831**	**$7,895**	**$9,855**

5. Conclusions

This paper details the development of a kilometre-based rewards regime designed to encourage safer driving practices. Clearly, while a number of scientific and pragmatic factors must be taken into account when designing such a scheme, the primary issue is whether it is sufficient to motivate behavioural change. Initially, a scheme developed based on crash risk and costs was developed and while this provided a substantial impetus for a small number of high-risk drivers, the majority had little incentive to change. Following a number of trials, a scheme was developed that presented the majority of participants with a budget deemed sufficient to motivate change (around $300) without putting the project budget at undue risk. Of course, it remains to be seen how participants respond to the regime and whether in fact they are able to make meaningful changes, something which will be known early in 2010 following completion of the field trial of the regime.

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