Estimating Uninsured Vehicle & Unregistered Vehicle Rates: Sensitivity to Data and Assumptions

Lyn Hunstad

California Department of Insurance

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ABSTRACT

This paper contains a detailed review of a model that is believed to be one of the most accurate methods for estimating the uninsured vehicle (UV) rate: comparing the number of insured vehicles to the total number of vehicles. The difficulty in obtaining accurate data is discussed. A detailed model is presented that shows the assumptions and different inputs that are necessary to produce an estimated UV rate. An analysis of the sensitivity of the UV rate to the model inputs found that the estimate for the percent of unregistered vehicles and the percent of vehicles used for business purposes had the most effect on the variability of the estimated UV rate. Five different methods were used to estimate the unregistered vehicle rate. The UV rate for 1996 in California was estimated to be 28.1%. The 95% confidence interval was estimated to range from 25.5% to 30.9%.

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Any errors or inaccuracies are the responsibility of the author. As can be seen in this paper, there are many ways to improve the methods and data used to estimate the rate of uninsured vehicles. Any suggestions for improvement or criticism of the material presented would be most appreciated.

Lyn Hunstad
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e-mail: HunstadL@insurance.ca.gov

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EXECUTIVE SUMMARY

In order to intelligently select and develop a policy response to the uninsured vehicle (UV) problem, it is necessary to accurately assess the magnitude of the problem. However, the illegal nature of operating a vehicle without insurance makes obtaining a direct, accurate measure of the UV rate almost impossible. The most promising approach to accurately estimating the UV rate involves estimating the total number of vehicles on-the-road and the total number of vehicles with insurance. While this approach is straight forward, obtaining and processing the required data is not.

Insurance is generally linked to a specific vehicle. An individual can fluctuate between being insured and being uninsured depending on the vehicle he or she is operating. Because of this, the UV rate as it is used in this paper refers to the rate of uninsured *vehicles*, not the rate of uninsured individuals or uninsured *motorists*. To emphasize the fact that we are dealing with vehicles, not individuals, throughout this paper we have used the abbreviation UV rather than the more commonly used UM abbreviation. The definition of the UV rate is further restricted to only apply to vehicles that are not used for business[1].

In determining the total number of vehicles, the first problem that one encounters is picking the correct report from the Department of Motor Vehicles (DMV). A difference of up to 1.5 million vehicles can occur between the different reports. The “official” report released by DMV and cited by most other reports as the number of vehicles, counts *registrations*, not vehicles. Using this report results in an inflated estimate for the number of registered vehicles. Fortunately, a more accurate (though not perfect) report is available to estimate the number of registered vehicles. In 1996, the total number of vehicles registered in California as auto or commercial on 7-1-96 was estimated to be 21.6 million.

[1] This is due to insurer's practice of dividing insurance into personal and commercial lines. Insurance data on vehicles covered by commercial policies is very limited and of poor quality.

The next issue encountered in estimating the total number of vehicles, is estimating the number of vehicles that lack a current registration but are still being operated. Estimating the number of unregistered vehicles is a problem that is just about as difficult as estimating the UV rate. One approach to estimating the unregistered rate involves analyzing violation data from law enforcement agencies. Another approach examines the number of vehicles with recently expired registrations. Still another approach analyzes the not at fault vehicles involved in fatal accidents. There are problems with each of these and the other approaches used in this paper, but each perspective adds a unique insight. Combining the findings from five different approaches, it was estimated that the total number of registered vehicles should be increased by about 8½% in 1996 to reflect unregistered but currently operated vehicles.

In order to make the estimated total vehicle count comparable with the insurance data (that only reflects personal use vehicles that are not motorcycles) it is necessary to remove the motorcycles from the count and adjust the remaining balance. The need for this adjustment is created by California's requirement that virtually all small trucks be registered as commercial vehicles, regardless of their actual use. About 6% of all commercially registered vehicles are not trucks and these vehicles are assumed to be used for business. There are two approaches for the estimated business use of trucks. The first is a survey conducted by the U.S. Census Bureau. This survey estimated the percent to be 32%. The second approach is an analysis of the owner's name and the number of vehicles owned. This approach was used by the California Energy Commission (CEC). Their analysis estimated the percent to be 33%. The CEC analysis is the only source of data for the estimated business use of vehicles registered as *autos*. The estimated business use of autos was 7%.

Compared to the data on the total vehicle count, the data on the count of insured vehicles needs little adjusting. The only adjustment to the data on the number of insured vehicles is an adjustment for the estimated amount of under reporting. In 1996, the unadjusted insurance vehicle count was 14.6 million vehicles. Using data collected as part of a separate system by the National Association of Insurance Commissioners, it was possible to estimate that the number of insured vehicles needs to be increased by about ½% in 1996 to adjust for under reporting.

Once the total vehicle count and the number of insured vehicles count have been adjusted to be as accurate as possible, an estimated UV rate can be calculated. In 1996, the estimated UV rate was 28%. This was down one percentage point from the estimated UV rate in 1995.

In order to estimate the effects of the different adjustments on the final estimated UV rate two approaches were explored. The first approach analyzed each adjustment factor separately. Using a minimum and maximum value for the adjustment, two different estimated UV rates were calculated. The second approach analyzed all the adjustment factors simultaneously. This approach used a technique called Monte Carlo simulation to randomly vary the adjustment factors. The results of these simulations indicated that 95% of the time the estimated 1996 UV rate was between 26% and 31%.

Two approaches were used to evaluate the sensitivity of the estimated UV rate to the different factors. Both approaches ranked the estimates for unregistered vehicles and the percent of vehicles used for business purposes to be the most influential. Both of these factors are difficult to accurately measure. It is hoped that future research will help to increase the overall precision of these factors and the resulting estimated UV rate.

Given the variety of reasonable values that could be used for the several factors that are necessary to prepare an estimate of the UV rate, it is not surprising that estimates of the UV rate, prepared by different analysts, should result in different values. Analysts developing estimates of the UV rate need to clearly document the data and assumptions they used. Users of these estimates need to be aware of the impact that the data and assumptions have on the resulting estimated UV rate.

INTRODUCTION

The general public does not have a very favorable attitude toward uninsured drivers. In order to promote personal responsibility and crack down on uninsured drivers, there is broad support for a variety of measures to penalize uninsured drivers and limit their ability to collect damages. (Insurance Research Council, 1996 and Parker, 1997) Determining the most appropriate policy to deal with the uninsured motorists (UM) problem is closely related to the magnitude of the problem. However, estimating the number of vehicles that do not have insurance, but should, is a difficult task. Operating a vehicle on public roads without insurance is illegal. Individuals involved in illegal behavior often prefer to keep their identity hidden. This frustrates efforts to obtain accurate counts. Marowitz (1991a) reviewed nine different approaches to estimating the UM rate and then (in Marowitz, 1991b) evaluated the two most promising methods. The first method involved using the ratio of insured vehicles to total vehicles. The second method used California Highway Patrol (CHP) data on violations for driving without proof on insurance and court dismissal data. The first method covers all private passenger vehicles while the second method was believed to be more representative of the active drivers. Concerns about the representativeness of drivers on CHP patrolled roads, varying levels of enforcement activity, and inconsistent criteria for court dismissals led to the opinion that the first method is less subject ". . . to potential biases, and may therefore give a more valid estimate . . ." than the second method. This first approach is discussed in detail in this paper.

This approach to estimating the UM rate involves comparing the total number of vehicles to the number of vehicles with insurance. Subtracting the number of vehicles with insurance from the total number of vehicles gives the number of vehicles without insurance. The UM rate is calculated by dividing the number of vehicles without insurance by the total number of vehicles. While this process is theoretically simple, there are many difficulties in obtaining and accurately processing the data needed to perform these calculations. This paper discusses the different data that are available, and the consequences of different assumptions and different ways of processing this data. The methodology that is discussed is applicable to other states. All data are from California.

Khazzoom (1997) also discusses different methods for estimating the UM rate and concluded that "... the available estimates are very much intertwined with the methods used in generating them ... ."[2] The methods he reviews include matching databases (which is the method discussed in detail in this paper), use of the ratio of UM claim frequency to BI claim frequency, and surveys. Surveys encounter the problems of reaching a representative sample of uninsured motorists and obtaining truthful, accurate responses. Because of these problems, surveys of uninsured motorists tend to produce biased estimates of the UM rate, but are able to provide much richer information on the characteristics of people who drive without insurance. Surveys of uninsured motorists in general, as well as the results of a recently completed survey of uninsured motorists are discussed in a separate paper (see Hunstad, 1999b).

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[2] Khazzoom (1997) states that "Even when the methods are documented and appear to be the same, the results often diverge. In the case of California, for example, DMV and California's Department of Insurance (CDI) report apparently the same method of estimating the percent of uninsured motorists. But the picture the estimates of these two agencies project is quite different. DMV reports a pronounced downward trend in the proportion of uninsured motorists in 1988-1990; CDI reports an upward trend for the same period." His point is well taken and one of the purposes of this paper is to show how seemingly minor variations in the method or data influence the resulting UV estimate. However, there are a couple of problems with the data cited by Khazzoom. These are:

- The reference incorrectly refers to a 1990 report by Marowitz. The correct reference year is 1991 (referred to as Marowitz 1991b in this paper).

- The cited data from Marowitz's Table 3 is the wrong data to compare with the CDI data. Table 3 shows the estimated UV rate based on the method using the CHP violation data. The correct data to use is the data for "Approach 1" in Table 2. This table only has UV estimates for 1988 and 1989, and the estimated UV rates were 24.4% and 23.9%. The CDI estimates that were cited were 25.6% and 26.2%.

DMV's estimates show a 0.5 point decrease from 1988 to 1989. CDI's estimates show a 0.6 increase for the same time period. Considering the variability that will be illustrated latter in this paper, the DMV and CDI estimates are surprisingly close. It should also be noted that while the DMV and CDI both describe the method used in roughly the same terms, it is likely that there were some minor differences in how each agency parameterized their model. Also, there appears to be some differences in the source of insurance data. Also, the CDI estimates were prepared in 1997 six years after DMV's estimates were prepared. It is likely that there were data revisions during this six year time period.

The approach to estimating the UM rate that involves comparing the frequency of UM claims to the frequency of bodily injury claims is interesting because it uses summary insurance data that is easier to obtain than most data on uninsured motorists. However, this approach is believed to be biased and less accurate than the one reviewed in this paper. Hunstad (1999a) describes this approach in detail and discusses the problems and limitations associated with it.

At the outset it is important to mention the difference between uninsured motorists and uninsured vehicles. Generally, auto insurance is linked to the vehicle not the driver. An individual who owns two vehicles, one that is insured and one that is not, is an uninsured motorist when driving the uninsured vehicle and is an insured motorist when driving the insured vehicle. Hunstad (1999b) estimated that a large portion (possibly up to half) of the individuals who own one uninsured vehicle also owns a vehicle that has insurance. This temporal state of an individual's uninsured motorist status makes measuring the number of uninsured drivers difficult and somewhat confusing. As a result of the uncertainty about the status of a driver at any point in time, the measurement of the UM rate as it is used in this paper refers to vehicles not people. To emphasize the fact that we are dealing with vehicles, not individuals, throughout this paper we have used the abbreviation UV rather than the more commonly used UM abbreviation. We define the UV rate as the number of vehicles that should have insurance, but do not, divided by the total number of vehicles that should have insurance. This approach to measuring the UV rate produces an estimate of the percent of vehicles that are in violation of the financial responsibility laws. A more accurate portrayal of the problems created by uninsured vehicles on-the-road would combine the UV rate with a measurement of the on-the-road exposure of insured versus uninsured vehicles. This refinement would take into account the number of hours (or miles) a vehicle was on the road. Uninsured vehicles that are rarely used would not be considered as much of a problem as uninsured vehicles that are used frequently. Unfortunately, at this point in time such refined data are not available.

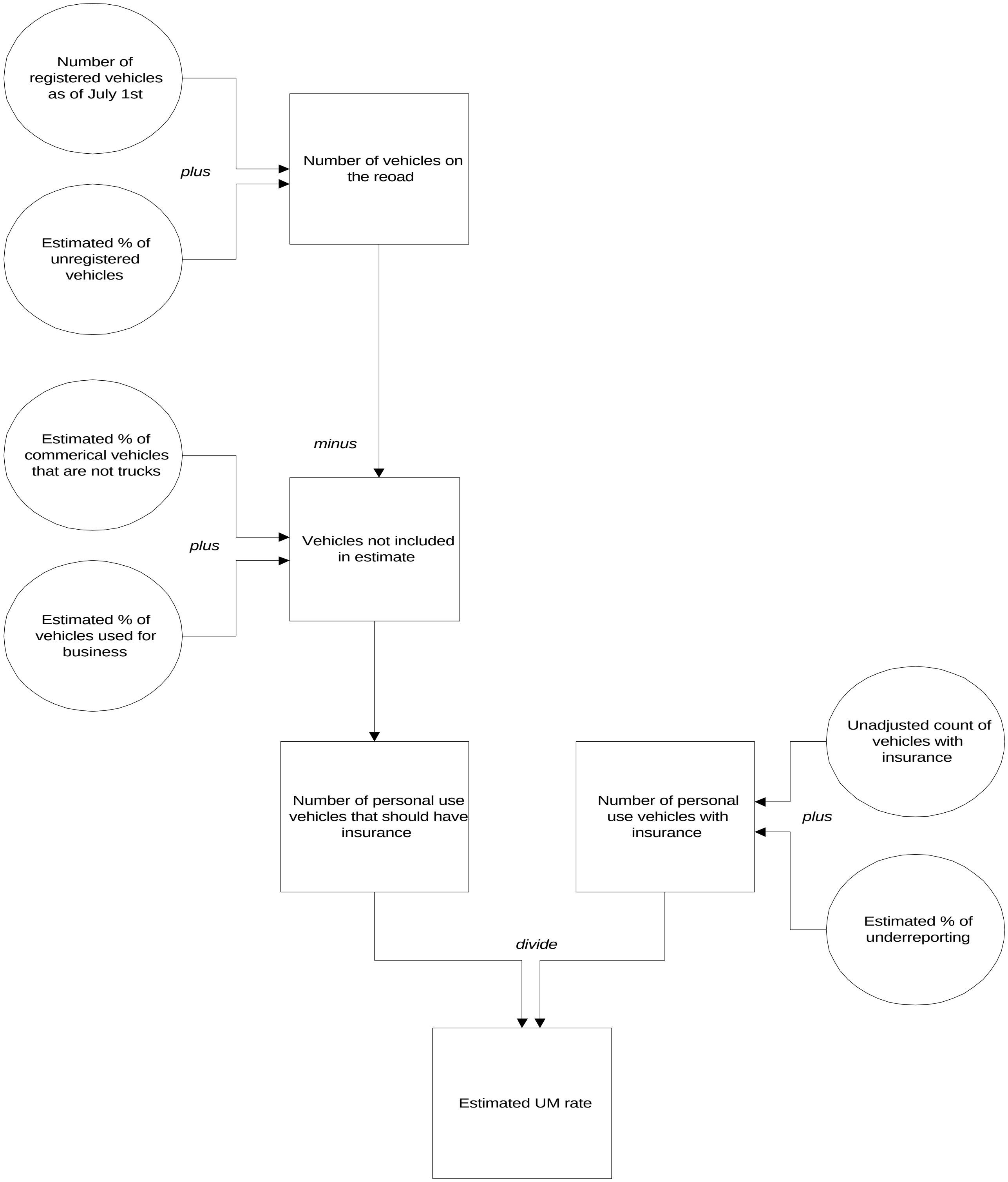
At this point it is also important to note that in this paper the estimate of the UV rate is limited to vehicles used for *personal* purposes. Vehicles that are used mainly for business purposes are specifically excluded. The reason for this is due to the way insurance companies divide insurance into personal and commercial lines. The data for commercially insured vehicles tend to be very limited and little information besides total premiums is available. As a result of this lack of data it is extremely difficult to obtain an accurate and reliable estimate of the number of vehicles that are insured by commercial insurers.

The two major tasks in estimating the UV rate are determining: 1) the total number of vehicles that should have insurance, and 2) the number of vehicles that actually do have insurance. The first two sections of this paper discuss these issues. Following this a detailed model for measuring the UV rate is described and the different data are combined to examine the sensitivity of the estimated UV rate to the different types of data.

An overview of the estimation method is shown in Figure 1. Inputs to the model are shown as circles and the calculated quantities are shown as squares. In the first part of the model, the number of vehicles on-the-road is estimated using an estimate of the number of vehicles registered as of July 1, plus an estimate for the number of unregistered vehicles. In order to arrive at an estimate for the number of personal use vehicles that should have insurance, the number of vehicles used for business is removed from the total number of on-the-road vehicles. Because the vehicle counts are broken down by auto and commercial registrations, the non trucks that are commercially registered must be removed before the estimated percent of trucks used for personal purposes is applied.

To determine the number of personal use vehicles with insurance, an unadjusted count is corrected for the estimated extent of underreporting. The final calculation of the model, the estimated UV rate, involves subtracting the number of vehicles with insurance from the total number of vehicles to arrive at the estimated the number of uninsured vehicles and dividing by the total number of vehicles.

Figure 1
Estimated UV Rate Model



TOTAL NUMBER OF VEHICLES

The primary source for data on the total number of vehicles is the Department of Motor Vehicles (DMV). The DMV maintains a Vehicle Registration (VR) database. The VR database contains registration information on vehicles that are currently registered in California. It also has information on vehicles that were once registered but whose registration has expired, and information on those who are in the process of registering or re-registering. Periodically reports are produced that contain various types of counts. Three different reports have been identified that provide information related to the total number of vehicles. These are:

- Report #1: Currently Registered Vehicles by Zip Codes [as of xx-xx-xx]
- Report #2: Fee Paid Vehicles Currently Registered [by County] as of Dec. 31, 199x
- Report #3: Estimated Fee-Paid Vehicle Registrations by County

Documentation on exactly what is and is not included in these reports is not readily available. However, after numerous discussions with programmers, analysts, forecasters, researchers, and user liaisons at DMV it has been possible to learn something related to what is actually being counted. Because the vehicle count is such an important input to determining the UV rate, it is worthwhile reviewing these reports in some detail.

> Report #1: Currently Registered Vehicles by Zip Codes [as of xx-xx-xx (this report is <u>not</u> run at on the same day each year), it is run periodically at the request of the Department of Insurance's Statistical Analysis Bureau]:
>
> - Does not perform any data validation checks. The only criterion for being counted is if the vehicle's registration is current as of the date the program is run.
> - Includes vehicles with not yet expired registrations that have re-registered out-of-state.
> - Includes vehicles with not yet expired registrations that have been junked.
> - Includes vehicles where a license plate with a different number has been issued and the original plate is still valid (not expired). Possible examples include plate lost and new plate issued, and new vanity plate issued. These inclusions would involve double counting.

- Excludes a vehicle if its registration has expired, even if it's current status is "transaction in process" (e.g., sent in check for registration but forgot to include other required paperwork such as a smog certificate).

Report #2: Fee Paid Vehicles Currently Registered [by County] as of Dec. 31, 199x:

- Excludes International Registration Program (IRP) vehicles. These are commercial vehicles based in other states that operate a certain percent of the time in California.
- Includes "prorated" vehicles. These are commercial vehicles based in California, but they are only licensed for a limited number of months at a time (presumably because of some type of cyclic or seasonal workloads).
- Excludes a vehicle if its registration has expired, even if it's current status is "transaction in process" (e.g., sent in check for registration but forgot to include other required paperwork such as a smog certificate).
- Excludes vehicles that have paid Planned Non-Operations (PNO) fees. Individuals registering a vehicle as PNO certify that it will not be operated on public roads.
- Perform validation checks on several variables and if one of these variables is missing or coded out of the acceptable range, the vehicle is excluded. It is estimated that approximately 60,000 vehicles are excluded based on these validation checks.

Report #3: Estimated Fee-Paid Vehicle Registrations by County:

- This report uses Report #2 to determine the distribution of vehicles in the 58 counties, but the actual counts in the report are based on data from DMV's Statement of Transactions (SOT) database. Although this is the "official" DMV report on the number of vehicles, the purpose of this report is to count *registrations* not vehicles. As such, it could count a single vehicle multiple times. A transaction is counted when a fee is paid and some type of sticker or permit is issued. Some examples of the possible double counting include vehicles being sold (one count for the original registration by the seller and one count for the new registration by the buyer), when a one day moving permit is issued multiple times for vehicles not currently registered, and multiple prorated registrations for less than a full year at a time.

- The SOT report used in producing Report #3 provides separate tallies for renewals and new registrations.

Reports #1 and #2 are counts as of one point in time. Report #3 covers the registrations in a one year time period. The computer program that produces Report #2 also produces several other reports. One of these reports identifies the number of vehicles with 90 to 120 days past due fees. A file containing this information is sent to the Franchise Tax Board (FTB) for collection. Currently, there is no record of what the FTB does with these referrals or what percentage of the fees they are able to collect.

In general, records are purged from the VR database four years after the last action to the record. However, if a vehicle has *ever* been registered out of state, it is never purged. In addition to the other differences between Reports #1 and #2, the daily variation in the VR database contributes to the differences in the counts reported by each report.

Differences Between the Reports

As report #3, “Estimated Fee-Paid Vehicle Registrations by County,” does not attempt to count vehicles (despite its “official” status), it is clearly not suitable as an estimate of the number of vehicles. The primary difference between Report #1 and Report #2 is that Report #1 is more inclusive. Vehicles *included* in Report #1 but *excluded* from Report #2 include:

- Vehicles with one or more invalid data field (approximately 60,000 vehicles).
- Vehicles whose California registration has not expired but have been re-registered in another state. In a 8-17-96 run against the VR database a total of 778,767 vehicles were marked as re-registered in another state. It is not known how many of these are the type marked for permanent retention in the VR database. The balance of the vehicles would generally have been re-registered out of state within the last four years. Assuming a uniform distribution across these four years, about one-quarter of these vehicles would have had the “re-registered” status less than one year and potentially could have a current California registration. Assuming a uniform distribution of

the date moved out of state, about one-half of the less than one year vehicles might be included in Report #1 because they had a current California registration but not in Report #2. If only 20% of the total count were being kept due to permanent retention, then we might expect the reports to differ by about 78,000 ((80% * 778,767) * 1/4 * ½).

- Vehicles that have been junked that still have a current registration. According to the 8-17-96 run against the VR database almost 4,000,000 vehicles in the database are classified as junks, nonrevivable junks, or a salvage certificate issued. These vehicles are purged from the VR database according to the four-year retention rule. Following similar logic as with the vehicles re-registered out of state, we estimate that approximately 500,000 (4,000,000 * 1/4 * ½) of these vehicles might be counted in Report #1 but not in Report #2.
- The double counting of vehicles in Report #1 for vehicles with two different license plate numbers, both of which have valid current registrations. We are not aware of any data that could be used to estimate this effect. DMV staff seems to believe it is probably a very small number. For analysis purposes, we assume a maximum of 10,000 vehicles.

Based on the above differences we estimate that the counts from Report #1 should exceed the counts from Report #2 by about 648,000 (60,000 invalid data item + 78,000 re-registered out of state + 500,000 junks still registered + 10,000 two current license plates). Table 1 summarizes the counts for autos and commercial vehicles from the three reports from 1992 to 1997. The observed differences also include the effect of the reports being run on different dates and range from 612,000 to 810,000. These differences seem to be consistent with our rough estimate of the differences between the two reports.

At the extreme, the number of auto and commercial registrations could differ by about 1.5 million vehicles between different DMV reports. Thus selecting an inappropriate DMV report could have a substantial effect on the estimated UV rate.

Table 1
Vehicle Counts From Different Sources

		Report #3	Report #2	Report #1*		Report #1**	
Auto	1991	16,926,944				16,400,861	
	1992	16,859,365		15,982,178		16,501,484	
	1993	16,994,947		16,041,490		16,601,831	16,551,520
	1994	16,837,449		16,130,460		16,732,297	16,686,783
	1995	17,157,152		16,243,073		16,871,492	16,747,739
	1996	17,449,209		16,418,676		17,272,948	16,950,179
	1997	16,670,867		16,057,930		16,734,899	17,334,849
	1998					16,660,128	
Commercial	1991	4,760,347			4,462,127		
	1992	4,692,863	4,300,780	4,480,085			
	1993	4,704,890	4,308,797	4,497,994	4,489,015		
	1994	4,672,873	4,317,734	4,510,583	4,513,155		
	1995	4,700,618	4,329,106	4,528,051	4,509,711		
	1996	4,807,511	4,346,437	4,607,202	4,539,713		
	1997	4,522,907	4,217,614	4,385,146	4,620,145		
	1998					4,355,858	
Motorcycle	1991	636,631				563,773	
	1992	580,660		551,619		547,400	
	1993	555,141		523,045		531,071	539,258
	1994	524,366		501,102		518,151	517,248
	1995	514,599		484,750		503,194	518,457
	1996	508,176		478,408		500,256	493,490
	1997	388,787		376,478		403,320	501,554
	1998					391,077	
Auto &	1991	21,687,291				20,862,989	
Commercial	1992	21,552,228		20,282,958		20,981,569	
Subtotal	1993	21,699,837		20,350,287		21,099,825	21,040,535
	1994	21,510,322		20,448,194		21,242,880	21,199,938
	1995	21,857,770		20,572,179		21,399,544	21,257,450
	1996	22,256,720		20,765,113		21,880,150	21,489,892
	1997	21,193,774		20,275,544		21,120,045	21,954,994
	1998					21,015,986	
Total	1991	22,323,922				21,426,762	
	1992	22,132,888		20,834,577		21,528,969	
	1993	22,254,978		20,873,332		21,630,896	21,579,793
	1994	22,034,688		20,949,296		21,761,031	21,717,186
	1995	22,372,369		21,056,929		21,902,738	21,775,907
	1996	22,764,896		21,243,521		22,380,406	21,983,382
	1997	21,582,561		20,652,022		21,523,365	22,456,548
	1998					21,407,063	

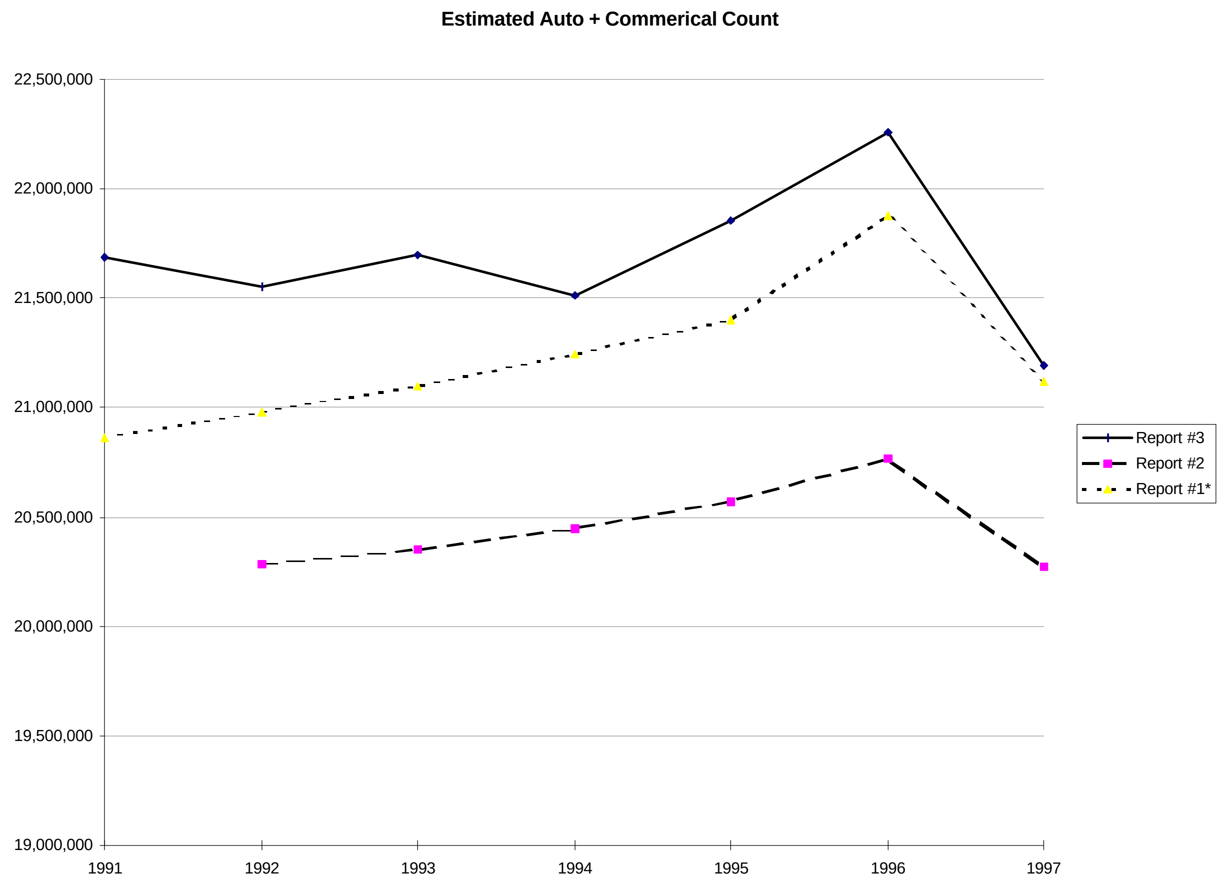
Run dates for Report #3 and Report #2 are Dec. 31st.
Run dates for Report #1 change every year and are:
1993 = unk.,11-5-94, 1-19-95, 8-7-96, 1-28-97, and 2-11-98

Report 1 is interpolated to estimated the count as of 12-31-9x
Report 1 is the raw counts as of the run date.

Trends in Vehicle Counts:

Figure 2 shows the trend of the auto plus commercial counts over the past seven years. Prior to 1997 there was a steady increase each year. Then there is a relatively sharp drop in 1997.

Figure 2
Number of Autos and Commercially Registered Vehicles



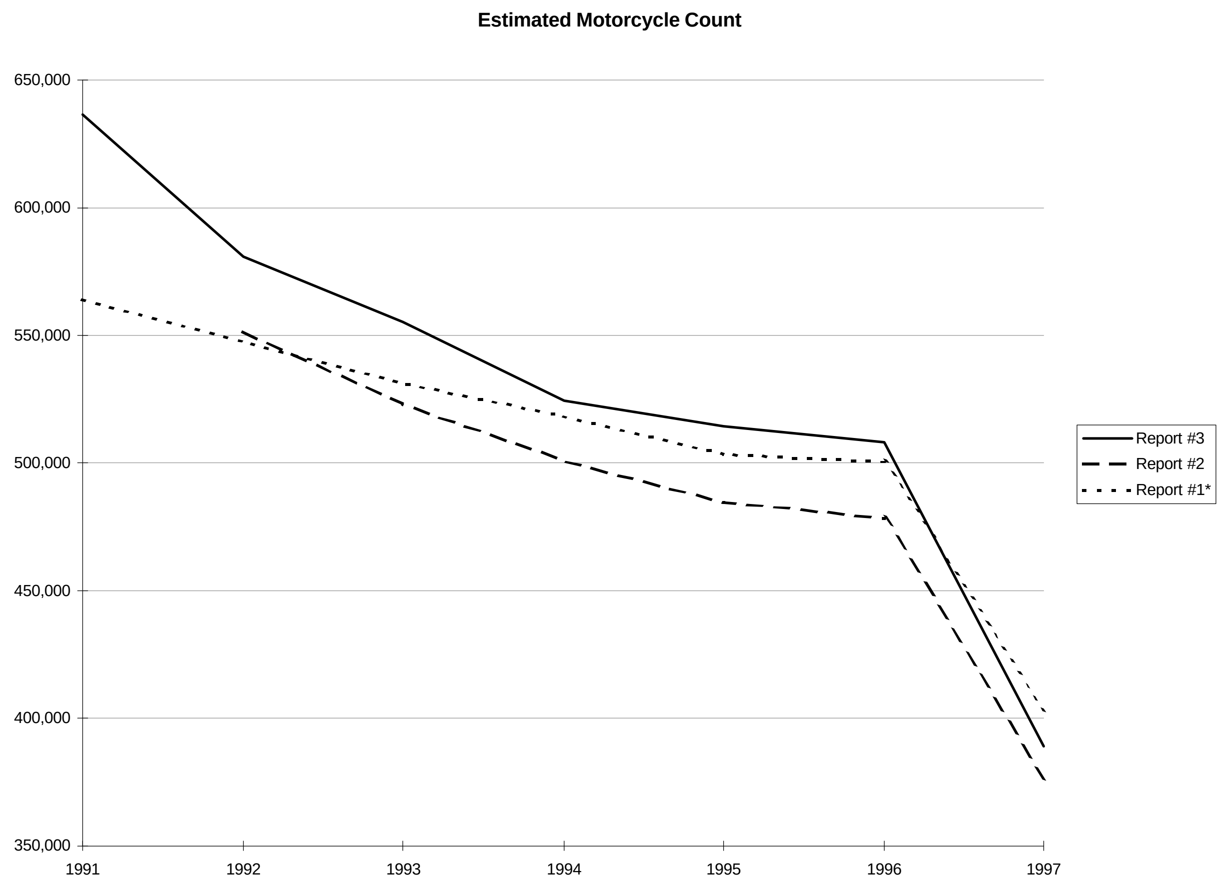
The large drop in 1997 occurred for both autos and commercially registered vehicles. The 1997 drop is even more of a deviation from previous trends given the continuing strong economy in 1997.

We are not aware of any other factors influencing the 1997 drop in the number of registered vehicles besides the new proof of insurance requirement for vehicle registration. This new law became effective January 1, 1997. It requires the vehicle owner to submit to DMV proof that the vehicle is insured before DMV can issue or renew the registration for the vehicle. Proposition 213 that denies pain and suffering damages to individuals without insurance on their vehicle, and its passage may have caused increased awareness of the insurance requirement for vehicle registration.

In order to estimate what the 1997 count might have been if the pre-1997 trend had continued, a linear regression was fitted to the pre-1997 data (from Report 1*). That trend line projected a 1997 count of 21.9 million vehicles. The estimated count of 21.1 million autos and commercially registered vehicles represent a 3.7% reduction from the projected count.

The number of registered motorcycles has seemingly been affected by different forces than the auto and commercially registered vehicles. Figure 3 shows the motorcycle counts for the past seven years.

Figure 3
Number of Registered Motorcycles



While the auto and commercially registered vehicles were on an upward trend prior to 1997, the number of registered motorcycles were steadily declining. However, in 1997 the number of motorcycles also experienced a sharp drop from their previous trend. The pre-1997 trend for the motorcycle count would have projected a 1997 count of approximately 481,000. The estimated count of 403,320 represents a 19.3 % reduction from the projected count. This suggests that the new proof of insurance requirement seems to be having a proportionately greater effect on motorcycles.

For estimating the total number of vehicles for use in an analysis to estimate the percent of vehicles not insured, the ideal measurement for the total number of vehicles in California would be the number of vehicle-years. This would be comparable to the insurance data that measures the number of vehicle years of earned premium. Vehicles that are registered the entire year will appear in both Report #1 and Report #2. Additionally, Report #1 counts some vehicles that are likely to not have been operated in California for the entire year (most likely due to the vehicle being junked or being moved out of state). However, only about half of these partial year vehicles appear to be counted in Report #1. If the event that caused the vehicle to cease being operated in California was uniformly distributed across the months of the year, counting half of these vehicles would tend to reflect a vehicle-year type of measurement. Since Report #1 seems the closest to the ideal type of measurement for estimating the percent of vehicles uninsured, it appears to be the best source for a vehicle count for an analysis of uninsured vehicles.

Other Factors to Consider:

The above discussion has focused only on determining the total number of registered vehicles at one point in time. Other factors that need to be addressed in the analysis include:

- What is the most appropriate point in time to use for an estimated count?
- How many vehicles are operated without being registered (if a vehicle is being operated on the public highways, it is required to have insurance and thus should be included in the analysis)?
- How many of the vehicles are not used for business use and should have purchased private passenger auto insurance?

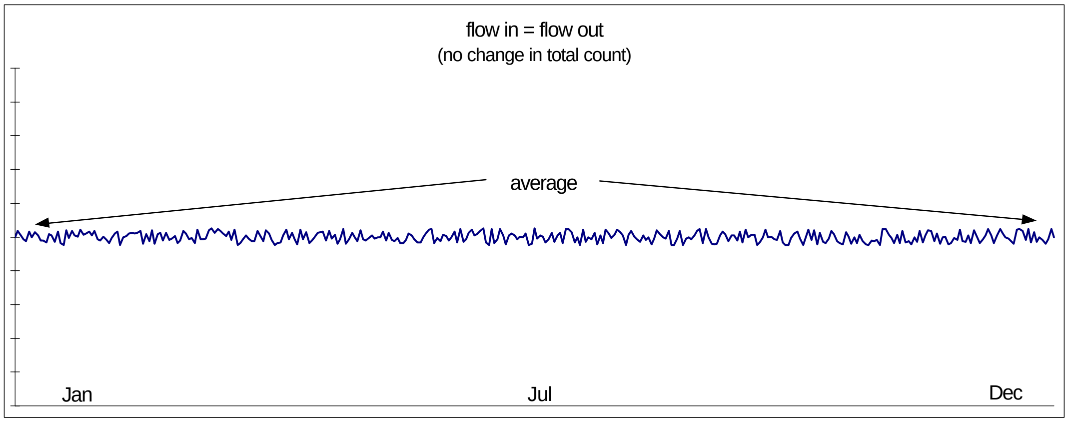
As stated previously, the ideal type of measurement for the number of vehicles would reflect the number of vehicle years that occurred in a given year. Vehicles that only existed for part of the year would be counted on a prorated basis in such a measurement. Unfortunately, this type of information is not available. The next best alternative is to estimate what this count might be.

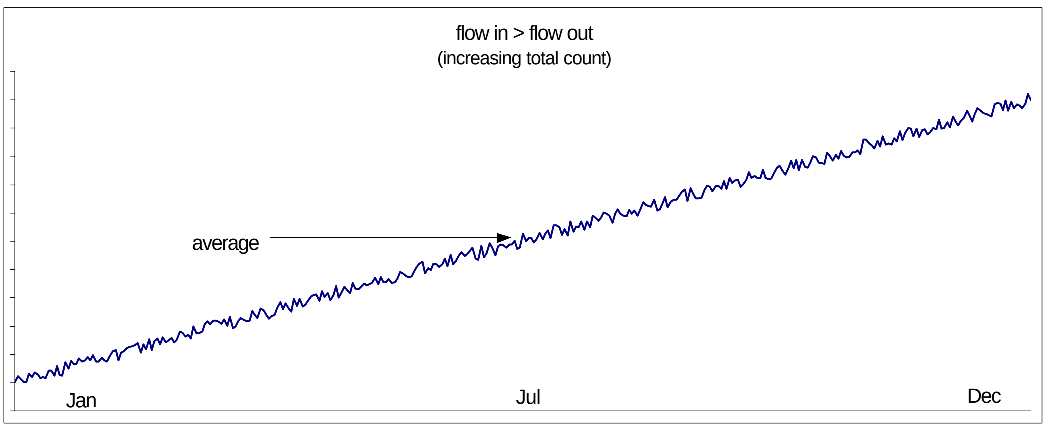
If the flow of new vehicles into the state and the flow of old vehicles out of the state are uniform throughout the year, it is possible to estimate the number of vehicle years. While it is unlikely that the number of vehicles per day that are added or retired is the same for every day of the year (as would be the case if perfect uniformity existed), if the number per day is more or less the same, we can estimate how the count of the total number of vehicles changes throughout the year. If the flow of new vehicles in equals the flow of old vehicles out, then there is no change in the total number of vehicles for the year. (See top box of Figure 4.) In this situation (assuming the flows to be approximately uniform) the vehicle count would be about the same every day and this count would be the average for the year.

If the flow of new vehicles in did not equal the flow of old vehicles out, then only at the mid point in the year would the daily count equal the average for the year. (This assumes approximately uniform flow in and out throughout the year.) In general, if there is a trend to increasing numbers of vehicles, the flow of new vehicles in will be greater than the flow of old vehicles out. (See bottom box of Figure 4.) In such a case the daily counts for the first half of the year will always be less than the daily counts for the last half of the year. The midyear count would be the only daily count that equaled the yearly average.

Unless there is evidence of a distinct seasonality in the net change to the number of vehicles in the state, the best date to use for estimating the average number of vehicle years is July 1st. To the extent that the flows (either in or out) tend to be random in nature as opposed to approximately uniform throughout the year, a confidence interval would need to be placed around any specific day count to reflect the random nature of the daily count fluctuations.

Figure 4
Variations in Vehicle Counts under Steady or Increasing States





Unregistered Vehicles Estimates:

CEC Estimates:

The California Energy Commission (CEC) has attempted to estimate the rate of unregistered vehicles. The models developed by the CEC produce detailed estimates of the composition of the fleet of vehicles operated in California now and estimates of what the fleet mixture will be in the future given different scenarios. An important input to these models is the total number of vehicles currently being operated. In order to estimate the percent of unregistered vehicles, the CEC periodically obtains a copy of the DMV's VR database and examines the percent of vehicles with expired registrations. One approach to modeling unregistered vehicles assume that vehicles with registrations that have expired less than 12 months in the past are still being operated, and any vehicle with an expired registration greater than 12 months is not being operated. It is clear that on an individual vehicle basis sometimes these assumptions will not be correct. However, it is not clear on an overall count basis, how accurate these assumptions are. The CEC is currently involved in an analysis to attempt to trace the vehicles with expired registrations over time and estimate how many of them have some sort of registration activity that might indicate that they are being operated. An estimate that CEC has used in their models is based on the percent of vehicles with expired registrations within the last 12 months. For 1995 the percent of vehicles with an expired registration less than 12 months old was 9.0%. Applying the 9.0% rate to the number of autos and commercial registrations would yield an estimated 1.9 million vehicles being operated without registration.

In the CEC's first trace analysis, all vehicles with expired registrations and without a transaction in process in August 1996 were identified. (See Table 2).

Table 2
Summary of Tracing Vehicles with Expired Registrations 8/96 to 10/97
(all numbers are in millions of vehicles)

Initial cohort of vehicles with expired registrations as of August 1996			5.19
Results of trace conducted October 1997:			
Could not locate			1.00
Registration expired 0 to 12 months		0.36	
Registration expired 1 to 2 years	0.12		
Registration expired 3 or more years		0.52	
Located vehicle		4.18	
Vehicle still unregistered & no registration activity	3.38		
Vehicle currently registered or some reg. activity	0.80		

The analysis started with a total of 5.19 million vehicles, with 1.65 million (32%) having registrations that expired *within* the last 12 months. The remaining 3.54 million vehicles had registrations that expired more than one year ago. An attempt was then made to locate all 5.19 million of these vehicles 14 months later in the October 1997 VR database. Searching only a subset of the October 1997 database using the vehicle's license number and vehicle identification number (VIN) produced 4.18 million (81%) matched or found records. A majority (52%) of the one million August 1996 records that did not match, had registrations that had expired for three or more years in August 1996. These were probably not located because they had been purged from the VR database due to four years having elapsed since the last registration activity. Of the balance not matched, 36% had registrations that had expired with the past 12 months, and 12% had registrations that had expired 1 to 3 years prior to August 1996. The most likely reason for these records not matching was due to the owner moving out-of-state or junking the vehicle. Table 2 summarizes the results of the matching trace.

The vehicles with expired registrations that were located in the VR database 14 months latter were evaluated to determine if they had a transaction in process or had a change to their registration expiration date (indicating that they were currently registered or some sort of registration activity had taken place). The majority approximately 3.38 million (81%) of these matched records had no evidence of a current registration or any registration activity. Approximately 0.80 million records (19%) either were currently registered or had evidence of registration activity. The more recent the expiration of the registration, the more likely the vehicle to convert to currently registered. The percent of vehicles with 1 year or less, 1 to 2 years, 2 to 3 years, 3 to 4 years, and 4 or more years expired registration to convert to currently registered status were 33%, 6%, 4%, 2%, and 1%.

Additional research is needed to determine how may of the 3.38 million still unregistered vehicles convert to being currently registered at some point in the future. If only 10% convert then the total number of vehicles with some indication of activity would increase to 1.14 million (0.80 + 0.34). An estimate of 1.14 million vehicles being operated in 1996 without registration is substantially lower than the 1.65 million estimated using the assumption that vehicles with expired registration within the last 12 months are still being operated. However, the 1.14 million estimate should be increased by an amount to reflect those vehicles not in the August 1996 VR database that were being operated. Currently there is no data available to estimate an appropriate size for this increase adjustment.

It is important to note that this analysis is distinctly limited due to unique data considerations. The “in process” records were not included in the August 1996 VR database that were used as input data for the analysis. Analysis of the October 1997 VR database showed that including the “in process” records with expired registration increases the total number of unregistered vehicles by 26%. If this 26% had similar experiences to the other August 1996 vehicles with expired registrations, the 0.80 million vehicles would increase to slightly more than 1 million vehicles. Since these 26% had a transaction in process in August 1996 it is likely that they would have an even higher match rate and a higher rate of conversion to currently registered status. If this were the case, the estimate of one million vehicles would likely be increased. Also, if registration activity was suppressed in 1997 due to the new proof of insurance requirement, a 1996 to 1997 match would tend to lead to an understatement of the unregistered but currently operated vehicles. These circumstances confound drawing a clear conclusion from the first trace analysis. Subsequent analysis with better data will hopefully shed more light on this, including the likelihood of conversion from expired registration status to currently registered.

In a second trace analysis the CEC started with those vehicles that had expired registrations in October 1997 and followed up 6 months later, in April 1998. This cohort totaled 5.36 million vehicles, with 2.40 million (45%) having registrations that expired within the last 12 months. The remaining 2.96 million vehicles had registrations that expired more than one year ago. Due to the short time between creation of the cohort and the follow up trace, virtually all of the records were located in the file 6 months later. Table 3 summarizes the results of the second matching trace.

Table 3

Summary of Tracing Vehicles with Expired Registrations: 10/97 to 4/98

(all numbers are in millions of vehicles)

Length of time registration expired	Initial cohort	Follow-up Status: Registered/ Activity	Follow-up Status: Not Registered
0 to 12 months:	2.40	1.27	1.13
1 or 2 years:	1.56	0.45	1.12
3 or more years:	1.39	0.29	1.11
Total:	5.36	2.01	3.35

An important difference between the first and second trace analysis was that "in process" vehicles were included in the initial cohort of the second trace. This inclusion more accurately reflects the vehicles in the state. The majority, 3.35 million (63%) of the vehicles had neither evidence of a current registration nor any registration activity. However, in this more realistic second trace analysis, 2.0 million (37%) were either currently registered or had registration activity "in process." As in the first trace analysis, the more recent the expiration of the registration, the more likely the vehicle was to convert to current registration.

The fact that the second trace analysis identified over 2 million vehicles that converted to currently registered or "in process" status tends to support the practice of estimating the number of on-the-road unregistered vehicles using the expired registrations within the previous 12 months. Using this method, in October 1997 the number of unregistered vehicles would have been estimated at 2.40 million. In just 6 months it appears that 2.01 million came back into the system[3]. If subsequent traces add only 0.4 million, the 12 month method would seem to be an accurate estimate.

[3] It should be noted that approximately 46% of the 2.01 million were "in process" in April 1998. Some of these vehicles could have been "in process" at the time the initial cohort was formed and remained "in process" at the time of the 6 month trace. If there was not some type of registration activity on these records (i.e., a change in expiration date or something else) they may have been not operational and probably some should not be considered on-the-road. Unfortunately, the second trace analysis did not include evaluating "in process" vehicles for registration activity. The implication of this is the estimated 2.0 million vehicles may be too high.

Also, Bernstein (1999) found some support for estimating that vehicles with registrations that had expired within the last 12 months are still being operated. He compared DMV's records with insurance company records and found that 17% of the vehicles with expired registrations of less than 12 months still had active insurance coverage. Only 1% of those vehicles with expired registrations of more than 12 months had active insurance coverage.[4]

It should also be noted that there is some limitation to the approach of tracing of vehicles with expired registrations over varying time periods to see if they convert to a registered status. Even if this process could be executed perfectly, it would still miss two groups of unregistered vehicles. The first group is vehicles that were never registered. The second group is those vehicles that were last registered four or more years ago and have been purged out of the DMV database. Additional research is needed to estimate the size of these two groups of long term unregistered vehicles and the extent to which they are still on-the-road.

Estimating of the number of unregistered vehicles currently being operated has been made more difficult by a recent law change that provides increased incentive to not register a vehicle. Effective January 1, 1997 in order to renew a vehicle's registration the owner had to submit proof that the vehicle was insured. For many without insurance, not registering their vehicle becomes a tempting alternative. The impact of this new law could be behind the observed drop in registrations for 1997 that was discussed earlier. This change in the registration environment also limits the applicability of historical estimates of the number of unregistered to post 1997 time

[4]Bernstein's analysis also uncovered another group of vehicles that traditionally have been excluded from estimates of on-the-road vehicles and may be currently operated. These are vehicles that are registered as PNO (Planned Non-Operative) and as junked. Many of these vehicles carry current liability coverage and may actually be on-the-road. The analysis found that 47% of the PNO/junked vehicles with a current registration had current insurance coverage. This relatively high level of insurance coverage may be due to a number of these vehicles being recently involved in an accident and being considered “totaled.” Of the vehicles with a less than 12 month expired registration, 8% had current insurance coverage. Only 2% of the PNO/junked vehicles with a registration that had expired over 12 months were currently insured.

periods. Prior to 1997 the total number of vehicles registered were on an upward trend. In 1997 the total vehicle count dropped by 0.6 to 1.2 million vehicles (depending on the report used). Vehicles that were unregistered in 1996 were probably much more likely to remain unregistered than in any previous year.

Early DMV Estimates:

In a 1990 DMV study Marowitz reported that 13.7% of vehicles cited for violations by the CHP in 1988 were unregistered. Due to some of the vehicles being stopped specifically because they did not have a current registration, Marowitz reasoned that the 13.7% was not a random sample of vehicles on-the-road and could not be used as an estimate of the unregistered vehicles. He apparently made a judgment to reduce the 13.7% by half and used 7% as an estimate of the percentage of registered vehicles that are operated unregistered. To the best of our knowledge, this analysis was the first time that a published report estimated the rate of unregistered vehicles. At the time of Marowitz's report very little information was available on unregistered vehicles.

In a 1991 study, Marowitz reported on the percent of public contacts by the CHP that resulted in a citation for an unregistered vehicle (i.e., California Vehicle Code 4000a). He reasoned that public contacts were a better sample of the on road vehicles because in addition to stops for citations, stops for various types of assistance are also included. This created a broader base that the number of citations were compared to, and as a consequence the percent that was estimated was lowered. Marowitz felt that these estimates were an *upper bound* for the actual percent of unregistered because CHP officers would have observed a greater number of vehicles than the number of public contacts they made. It is not clear whether using a broader base like public contacts improves or diminishes the accuracy of the estimated percent of unregistered vehicles. The key issue in effectively using violation data is in determining how well it represents the general on-the-road population. This is discussed in more detail below. The percent of public contacts that resulted in a citation for operating an unregistered vehicle in 1988, 1989, and 1990 were 6.8%, 5.9%, and 5.2% respectively. Considering these percents as upper bounds, Marowitz revised his previous 7% estimated unregistered rate in 1988 to 5% and used 4% as the estimated rate in 1989.

Also, it is not clear why the 1990 CHP rate for unregistered as a percent of public contacts should have declined by nearly one-quarter from the rate in 1988. This much variation in the rate causes one to suspect that factors other than the number of unregistered vehicles are affecting the rate. The actual counts are not reported in Marowitz's report, making it not possible to determine if the CHP used a different strategy for reporting their public contacts in the years reflected by the data or other changes in the data reporting process occurred. A decision by CHP to target particular locations or types of vehicles (e.g., older cars) or particular types of enforcement activities could result in a different ratio when there was no change in the actual percentage of on-road unregistered vehicles. A new CHP administrative rule about when a “public contact” should be reported could cause a similar distortion in the rate. In order to more fully explore the violation data, ten years of the source data were obtained from the CHP. A detailed analysis of this data is described in the next section.

Estimates Based on CHP Violations:

In order to provide another perspective on estimating the rate of unregistered vehicles, more recent CHP data were analyzed. Data files containing individual citation records covering the ten year period from 1988 to 1997 were obtained from the CHP. The data files contained records for all citations that involved an uninsured (CVC 16020a or 16028a), unregistered (CVC 4000a), or a hit-and-run (CVC 20001a or 20002a) violation. These data only reflect citations issued by the CHP. The percentage of all types of citations issued for any reason that involved an unregistered vehicle are shown in Table 4.

Table 4
CHP Citations for Unregistered Vehicle

Year	Percent of Citations Involving Unregistered Vehicle
1988[5]	13.2%
1989	6.3%
1990	10.0%
1991	9.8%
1992	9.1%
1993	8.6%
1994	11.3%
1995	10.5%
1996	11.9%
1997	12.2%

Detailed data tables showing the actual counts are included in Attachment A. The percentage of CHP citations that involved an unregistered vehicle violation is not the perfect method to use in estimating the number of unregistered vehicles on-the-road. The violation data provides an alternate perspective on the phenomena of unregistered vehicles. It is subject to a number of factors that may bias its use for estimating the number of on-the-road unregistered vehicles.

A most basic question concerning the use of citation data involves the issue of representativeness. This can be broken down into two sub-issues. The first sub-issue is: does the percent of individuals receiving a citation for a specific offense represents the percent of individuals in the population of violators who are committing the offense? This may either be the case or it may not. If one assumes that:

1) all violations are equally observable by an officer,

2) a patrolling officer observes a representative sample of the area and vehicles being patrolled, and

3) once a violation is observed, the officer stops the offending individual and issues a citation,

[5]The 13.2% of citations for unregistered vehicle for 1988 is 0.5% less than the 13.7% reported for 1988 by Marowitz in 1990. The difference is most likely due to data cleaning and refinements during the succeeding eight years.

then the percentage of citations for a specific offense will be an unbiased estimate of the percentage of the population that are committing a violation of that specific type of offense in areas covered by the CHP. These three assumptions will be discussed below.

The second sub-issue focuses on the relationship between the percentage of the *violating* population that are committing a specific type of violation and the percentage of the *total* population that are committing a specific type of violation. If 100% of the total population can be considered a member of the violating population, then the percentage of the specific type of violation would match the percentage of these occurrences in the total population. If only 10% of the total population can be considered a member of the violation population, the percentage associated with the specific type of violation would need to be reduced (to 10% of its initial value) to reflect the occurrence rate in the *total* population.

Evaluating these sub-issues is complicated by the fact that violations generally occur for a distinct period of time. Most individuals commit some type of violation at some point in time. Some individuals spend a longer amount of time in a state of violating some law than others. Also, some individuals appear to be more adept at avoiding detection than others.

If close to 100% of the total population were also a member of the violating population, and each individual spent roughly the same amount of time exposed to detection in a state of violating some law, then the percentage of violations for a specific violation would correspond to the percentage of the total population committing a specific violation. However, this is clearly not the case. Numerous analyses have shown that younger individuals commit more violations (i.e., spend more time in a state of violating some law). This is even more true for younger males. However, it is also true that this segment is a relatively small part of the total population. Other analyses (Hunstad, 1995) have shown that over 90% of the population can be classified as “good drivers.” To the extent that these 90% are equally “good” (i.e., spend roughly the same amount of time in a state of violating some law), they can be considered to have equal exposure to the risk of being cited for a violation. If this is the case then the violation data provides a rough approximation of the percentage of different violation types for most of the violating population.

This still leaves the issue of what percent of the total population is also a member of the violating population. Speeding is one of the most common violations and a 1995 survey by the Insurance Research Council found that a majority (51%) of the respondents agreed that it is acceptable to speed on the highway (Insurance Research Council, 1995). Drivers license data analyzed in the next section estimates that about 13% of those with a drivers license receive a *conviction* each year. If about one out of eight violators are caught and convicted, this estimate would support estimating most of the driving population committing a violation at some point in the year. An alternate way of looking at this issue is to attempt to estimate the percentage of the population that has not committed any violation in the year being estimated. In order to be counted in this category, an individual would have to have not made any driving mistakes during the entire year. While this is clearly not impossible, the percentage of the driving population that meets this high standard is likely to be small. Hence, the bias due to the violation population being smaller than the total population is likely to be not large. However, because of this, it is likely that the percent of violations for unregistered vehicle will be *greater* that the percent of the vehicles on-the-road that are unregistered.

Some factors that might influence the ability of the violation data to produce an accurate estimate of unregistered vehicles on-the-road include:

- While the CHP's jurisdiction is spread throughout the entire state, the specific areas covered by the CHP may not be representative of the state as a whole. (Currently, there does not appear to be any data that shows a potential for bias in this area).
- Citations are not the same as convictions. If a citation is found to be not true or the charge is dismissed prior to conviction, the vehicle should probably not be counted as unregistered. If citations for unregistered vehicles have a higher or lower conviction rate than the average of all other types of citations, then a bias could be introduced. (At this

time there is no evidence of a differential conviction rate for citation for unregistered vehicles).

- Due to limitations in CHP's data system, at most four violations can be captured in the citation record. The data system is structured so that the last two of these four violations can only be for correctable or "fix-it" types of violations. As uninsured and unregistered are considered to be correctable offenses, these citations can appear in any of the four possible violation locations in the data record. (A speeding violation, on the other hand, could only appear in the first two violation locations in the citation record.) To the extent that an unregistered citation is excluded due to this limitation in the CHP's data system, it would tend to under estimate the actual number of unregistered vehicles. An analysis of over four million citation records for the 1988 to 1997 time period that involved citations for uninsured, unregistered, or hit-and-run found 1.3 million that did not include a citation for unregistered vehicle. None of these 1.3 million records had all four citation locations in the data record filled. This indicates that the negative bias due to the data system limitations is likely to be extremely small or non-existent.
- Issuing a citation for an unregistered vehicle has a lower enforcement priority that most other types of violations. Anecdotal reports from CHP officers indicate that if an officer observes a potential drunk driver or a speeding vehicle at the same time as a potentially unregistered vehicle he or she will pursue the vehicle committing the more serious offense. To the extent that unregistered vehicles are observed but not cited, the percentage of citations for unregistered vehicles will be an under estimate. Anecdotal reports indicate that the observation of multiple vehicles each committing an offense does occur but not frequently. Thus this is probably the source of a small bias towards underestimating the percentage of unregistered vehicles.
- Most violations occur as the result of some behavior or lack of behavior by an individual. To the extent that this behavior can be observed, there is the chance that a citation will be issued for the violation. Some violating behaviors are more observable that other. A large vehicle exceeding the speed limit or running a red light is easy to observe and can be

observed at a great distance. Observing whether or not the stickers on a license plate are current requires the officer to be fairly near the vehicle and have good lighting[6]. Anecdotal reports by CHP officers indicate that more citations for unregistered vehicles are written during the daylight hours when it is easier to observe a vehicle's license plate. On the other hand, vehicles committing various types of moving violations commit them only for a specific time period. Vehicles can not be continually running red lights. Even a person speeding, generally does not speed 100% of the time they are driving. However, an unregistered vehicle is potentially observable as being unregistered 100% of the time it is on-the-road. It is not clear whether these delectability and temporal differences give the unregistered driver a greater or lesser probability of citation than a driver committing some other type of moving violation.

- A person with an unregistered vehicle may reduce the time he or she uses the vehicle compared to if the vehicle was registered. This tendency has been confirmed by anecdotal reports in focus groups. There is also some support for the idea of reduced exposure by

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[6]Some individuals driving unregistered vehicles take deliberate steps to conceal their lack of registration. It is not known how many unregistered vehicles appear to be registered due to their owners use of stolen license plates or registration stickers. Due to limitations in their data systems, DMV is not able to determine how many license plates or registration stickers are reissued each year due to theft. It is possible to determine the number of vehicles that have had substitute plates issued. These reissued plates could have been reissued because the original plates were stolen, the owner was replacing the old regular plates with new custom vanity plates, or for some other reason. Also, there is no count of the number of current year registration stickers that were stolen. As of August 1998, there were a total of 4.54 million vehicles (3.44 personal, 1.02 commercial, and 0.09 motorcycle) in the VR database that have had plates reissued at some time during the vehicle's life. According to a October 3, 1997 DMV press release about 1 million vehicles have current custom vanity plates. If all of these vehicles first had a regular plate before obtaining the custom vanity plate, it would still leave at least 3.54 million vehicles with reissued plates where the reissue was not for a custom vanity plate.

An analysis of the June 1997 VR database found it to contain approximately 30 million motor vehicle records. The average vehicle age of those considered to be on the road was approximately 11 years old. If the 3.54 million vehicles with a reissued (non-vanity) plate were spread over an 11 year period, about 1% of the vehicles would be obtaining a reissued (non-vanity) plate each year. Thus, an estimated upper bound for the number of license plates stolen in a one year time period would seem to be about 1% of the registered vehicles. However, this limit does not include the theft of registration stickers. Theft of a current registration sticker would seem to be a preferred way to disguise an unregistered vehicle, as a stolen license plate would seem much more likely to be reported to the police.

unregistered drivers to the extent they also have lower incomes. In an analysis of travel survey data Bernstein (1994) found that lower income drivers tended to driver fewer miles than higher income drivers. To the extent that an individual minimizes the unregistered vehicle's on-the-road exposure compared to their likely behavior if the vehicle was registered, the chance of that vehicle receiving a citation for being unregistered is reduced, and the percentage of citations would tend to underestimate the percentage in the total population.

The percent of violations for unregistered vehicle is clearly not the perfect measurement of the percent of vehicles on-the-road that are not registered. Some of the factors affecting the percent of violations for unregistered vehicle tend to bias it downwards, and some factors tend to bias it upwards. Because the affect of these factors can not be precisely estimated, the accuracy of any estimate based on the violation data can not be established. However, in a general sense, the violation data can be seen as providing a rough estimate of the percent of unregistered vehicles on-the-road.

DMV Drivers License Records:

Another way of generating an estimate of unregistered vehicles involves using DMV drivers license records. One advantage of this approach is that only convictions appear on an individuals' record. If an individual received an unjustified citation and it was so ruled by a court, it would not appear on the individual's drivers license record.

However, there are some distinct disadvantages to using drivers license records to estimate the prevalence of unregistered vehicles. The drivers licensing system is focused on individuals not vehicles making it further removed from the actual vehicles that may lack registration. Because the records in the drivers license database focus on the individual and what he or she does, there are layers and procedures in the system that may affect the ability of these records to accurately estimate the number of unregistered vehicles on the road. Some factors that work to the disadvantage of using drivers license records to estimate unregistered vehicles include

- Among local law enforcement, enforcement of traffic and vehicle laws have a relatively low priority. Unless some particular traffic issue becomes a major problem, local law enforcement generally places higher priority on more serious crimes such as theft, burglaries, alcohol and drug problems, assaults, etc.[7]

- The conviction information reported by the courts to the DMV may be incomplete or not represent the primary reason for the citation. For example, if an individual is cited for a violation and fails to appear or pay the fine, he is charged with a failure to appear by the court. When the individual is subsequently caught or for some other reason desires to clear the failure to appear off his record, he may plead guilty to the failure to appear in exchange for dismissal of the initial violation. The courts have some incentive to emphasize collection of failure to appear fines over vehicle code violation fines. All funds collected from failure to appear fines are kept locally, whereas most of the funds collected for vehicle code violations goes to the state. Also, as of mid 1999, DMV was just finishing automation of the court reporting process. Previously, a variety of tapes and paper copies were used to report violations.

-Some licensed drivers do not own any vehicles. Also, many drivers own more than one vehicle. Ideally, each driver license record should be weighted by the number of vehicles owned. Unfortunately, this data was not available.

- Perhaps the most serious problem is the ability of an officer to issue an unregistered citation as a "fix-it" ticket. When (of if) the owner corrects the situation by obtaining the required registration it does not make it onto his or her drivers license record.

The drivers license data used to estimate the percent of unregistered vehicles was a 1% systematic

[7] Just considering the serious traffic offense of driving under the influence (DUI) shows how much local law enforcement tends to emphasize non-traffic enforcement. In 1997, the primary state law enforcement agency (CHP) accounted for only 10% of the full time sworn law enforcement personnel, yet they made 46% of all arrests for DUI (California Department of Justice, 1999a and 1999b). This difference is likely to be even more exaggerated for the low priority vehicle laws.

random sample of DMV's drivers license database. This sample was drawn in May 1998. Each sampled record consisted of one or more sub-records. The sub-records could be of four types: the first type was the basic licensing information that contained information on birth date, sex, county of residence, and dates license issued and expires; the other three types of records were abstracts of convictions. The conviction abstracts were divided based on the number of points associated with the most serious offense. The three types were 0, 1, and 2 point citations. Each citation record contained a listing of the sections violated. The record contained room for up to eight violations. The citation record also contained information on the data of violation, the date of conviction, fine, suspension, and jail indicators.

The file was structured so that the basic license record appeared first followed by any citation records associated with the driver. The initial sample contained 1,046,139 records, representing 376,861 driver licenses. This analysis only included drivers who had a valid license in 1998. When the expired licenses, ID card only, and special EDP records were removed a total of 209,033 licensed drivers were available for analysis. Because some citation data are only kept for three years, only the three prior years, 1995 to 1997 were analyzed.

For each year the number of drivers convicted of any violation, an unregistered vehicle violation, and a uninsured vehicle violation were counted. It should be noted that while this data did not include any identifying information such as drivers license number, name, or street address, it did contain citations that are not normally a part of the public record. These included citations that are considered dismissed as a result of the violator attending traffic school, and a small number of cases where the judge suppressed the information for other reasons. The basic results are shown in Table 5.

Table 5
Drivers Cited for Unregistered Vehicle

	1995		1996		1997	
Total drivers	209,033	100%	209,033	100%	209,033	100%
Cited for any reason	27,100	13.0%	26,288	12.6%	26,563	12.7%
Cited for unregistered vehicle	1,156	4.3%	1,025	3.9%	863	3.2%
Cited for uninsured vehicle	147	0.5%	161	0.6%	2,793	10.5%

It appears the percent of drivers being convicted of any violation during the year remained stable at about 13% from 1995 to 1997. However, the percent of drives with a unregistered vehicle citation appeared to be on a declining trend. In 1995, 4.3% of the cited drivers included a citation for an unregistered vehicle. This percent had decreased by more than 25% to 3.2% in 1997. For comparison purposes, the percent of cited drivers cited for uninsured vehicle was 10.5% in 1997. Prior to 1997 police did not routinely ask for proof of insurance.

The small percentage of citations for unregistered vehicle in the drivers license citation records is puzzling, particularly the declining percent in 1997. As has been previously discussed, in 1997 a new law required proof of insurance before a vehicle registration could be renewed. This seemed to result in fewer than expected registrations and more citations for unregistered vehicle from the other sources reviewed in this report. In particular, the CHP citation data shown in Attachment A shows an increased percent of unregistered vehicle citations (to 12.2%) in 1997 and uninsured vehicle citations at 13.9% in 1997. It is not clear why there should be such a discrepancy between the information in the drivers license records and the CHP citations. Perhaps the discrepancy is due to a combination of the factors cited previously on the problems in using drivers license records to estimate unregistered vehicles. If there was a dramatic difference between local law enforcement and CHP's inclination to issue citations for unregistered vehicles, some of the observed differences could be explained. The smaller difference on the percent of citations for uninsured vehicle could have been due to the novelty of a new law going into effect in 1997 and gaining more attention from local law enforcement agencies. Also, the decline in convictions for unregistered vehicles could have been the result of officers sympathizing with individuals having to comply with the new 1997 law on proof of insurance, and issuing most of the unregistered citations as “fix-it” citations.

The low percentages could also be due to some type of DMV data process error. An internal DMV report titled “DL Conviction Report” indicates the total number of times a vehicle code section was implicated in a citation. These numbers when compared to the total number of licensed drivers indicate an increase in unregistered vehicle violations in 1997.[8]

While the citation data in the drivers license records may under estimate the unregistered vehicles they do provide selected demographic and geographical information not usually available on the operators of unregistered vehicles. If there is a bias to the under count of unregistered vehicles than this additional information is of lessor value. However, we are not aware of any such biases with the exception of the unregistered vehicle citations being less likely to come from local law enforcement. Table 6 shows the characteristics of the drivers cited for any violation, unregistered vehicle, and uninsured vehicle during the time period from 1995 to 1997.

[8] The actual numbers off the “DL Conviction Report” are:

	Licensed Drivers	Unregistered Veh. Cites		% from Sample
1996	20,278,100	205,933	1.016%	0.490%
1997	20,487,400	214,060	1.045%	0.413%
1998	20,735,500	206,709	0.997%	n.a.

Table 6

Characteristics of Unregistered Vehicle Drivers, Cited Drivers, and All Drivers

	All Drivers	Drivers Cited in 1995 to 1997	Drivers Cited in 1995 to 1997 for unreg. veh.	Drivers Cited in 1995 to 1997 for unins. veh.
Age:				
under 21	5.9%	6.7%	5.2%	8.9%
21 to 25	8.7%	14.0%	16.7%	20.3%
26 to 30	11.1%	15.6%	20.4%	20.1%
31 to 40	24.1%	28.3%	32.0%	29.2%
41 to 50	21.2%	19.9%	18.1%	15.5%
51 to 60	13.2%	9.4%	6.0%	4.4%
over 60	15.7%	6.4%	1.7%	1.7%
Sex:				
male	52.4%	64.0%	69.5%	71.3%
female	47.6%	36.3%	30.5%	28.7%
Region:				
Los Angeles County	26.0%	30.5%	29.0%	34.2%
South coast	22.0%	21.6%	18.1%	20.7%
South inland	9.2%	9.1%	11.4%	9.3%
SF Bay area	20.7%	20.0%	19.9%	15.8%
Sacto. & Fresno County	5.7%	5.1%	7.4%	5.7%
Central Valley	8.3%	7.7%	8.1%	9.2%
Foothills & Sierra Counties	3.1%	2.2%	2.8%	1.4%
NW Calif.	4.5%	3.8%	3.0%	3.4%
Out of state / unknown	0.4%	0.0%	0.3%	0.2%
Average number of cites from 1995 to 1997 for:				
any violation	0.48	1.64	2.73	2.50
unregistered vehicle	0.02	0.06	1.25	0.21
uninsured vehicle	0.02	0.06	0.19	1.13
Total number:	209,033	61,556	2,854	3,068

Considering a citation for *any* violation, males and those aged from 21 to 40 are more likely to be cited. Females and those over 50 are less likely to receive a citation. Those in Los Angeles

County were more likely to be cited, while drivers in the foothills, sierra, and north western [9] counties were less likely to be cited.

Considering just the citations for unregistered vehicle, the findings are similar. Males and those aged 21 to 40 were most likely to be cited for an unregistered vehicle. Females and those over 40 are less likely to be cited for an unregistered vehicle. Those in Los Angeles, the south inland counties, and Sacramento and Fresno counties were more likely to receive a citation for an unregistered vehicle. Drivers in the south coast and north western counties were less likely to be cited. Also, it appears that those who receive a citation for an unregistered vehicle have a poorer driving record that other cited drivers. Drivers who were cited for any violation in the 1995 to 1997 period averaged 1.64 citations. Drivers who were cited for an unregistered vehicle violation in the 1995 to 1997 period averaged 2.73 citations. These drivers were over three times as likely to be cited for uninsured vehicle as drivers cited for any violation, and over nine time as likely to be cited for an uninsured vehicle as the general licensed driver.

Drivers cited for an uninsured vehicle shared similar characteristics to the drivers cited for an unregistered vehicle.

Estimates Based on Survey Research:

In 1999 Hunstad reported on efforts to estimate the rate of uninsured and unregistered vehicles using random telephone interviews. Assessments of the representativeness and accuracy of the sample and the respondent's responses indicated that the data are likely to under estimate. For example, only about 10% of vehicle owners reported owning an uninsured vehicle (Hunstad, 1999b). This is less than half the rate of 22.6% estimated from an analysis (that is believed to be more accurate) of DMV and insurance company records (Bernstein, 1999).

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[9] The regions used in this analysis used the same regional definitions used in Hunstad (1994).

During this same survey 7.1% of the vehicle owners reported owning an unregistered vehicle. An additional 8% refused to answer the question, raising the suspicion that they too may be unregistered. Thus, based on these survey data an estimated 15% may possible be unregistered. Given the tendency of the survey data to produce an substantially underestimated rate, 15% seems like a very high estimate. However, two additional factors need to be considered. The first is that some of the 7.1% who reported owning an unregistered vehicle actually had registered the vehicle as a planned non-operative (PNO) vehicle. If these vehicles were in fact actually not operated, then the percent reporting an unregistered vehicle would be reduced from 7.1% to 6.6%.

The second factor to consider is that just under half of those admitting an unregistered vehicle reported that the reason for the vehicle not being registered was that the vehicle was not used or did not run. If these respondent were providing truthful answers, the estimated unregistered rate based on these survey data would drop to the 3.3% to 7.0% range.

If the under estimation bias due to problems with the survey data apply equally to the reporting of uninsured vehicles and unregistered vehicles, then the unregistered estimates should be adjusted by a factor of 2.26 (22.6% / 10.0%). Applying this adjustment factor would put the estimate of the unregistered vehicle rate in the 7.5% to 15.8% range.

Given the problems in obtaining a representative sample of uninsured and unregistered individuals (i.e., low income, low education, highly mobile) and the problems inherent in obtaining honest, accurate responses to questions on what are essentially illegal behaviors, it seems advisable to regard these estimates with a certain amount of caution. Based on the best available information it seems reasonable to conclude that the survey data supports an estimated unregistered rate in the 7% to 16% range.

Fatal Accident Reporting System:

Another approach towards estimating the percentage of unregistered vehicles concentrates on only the data from fatal accidents. Studying fatal accidents can provide unique insights because a wealth of data is available about them. Also, involvement in a fatal accident can occur at any time or at any place. Individuals who cause or are responsible in a fatal accident are probably not a representative sample of the vehicles on-the-road. However, if one only considered those drivers who were *not responsible* for the accident, and involved in the accident only due to being in the wrong place at the wrong time, then these vehicles could be considered a type of pseudo-random sample.

Since 1975 the U.S. Department of Transportation, National Highway Traffic Safety Administration has been operating the Fatal Accident Reporting System (FARS). The FARS collects detailed data on every fatal motor vehicle accident in the United States. The data on each accident is contained in a series of hierarchical data records. The highest level record is the accident record. This record contains data on the date and time of the accident as well as the physical characteristics of the road and environmental conditions. The second level in the hierarchy is the vehicle record. One vehicle record is created for each vehicle involved in the accident. The vehicle record contains data on the type and characteristics of the vehicle, the number of occupants, and a description of the damage sustained. Of key interest in this analysis is the data on the vehicle's registration and the registered owner. FARS staff do not simply take the vehicle registration information off the accident record, but independently verify with the DMV the registration status of each vehicle involved in the accident.

The third level in the hierarchy is the driver record. One driver record is created for each vehicle record. The driver record contains data on the driver's license characteristics and status, as well as information on citations issued in the accident, and previous violations and accidents. The fourth and final level in the hierarchy is the person record. A person record is created for each vehicle occupant (including the driver) as well as any non-vehicle occupant involved in the accident (e.g., a pedestrian or bicyclist). The person record contains data on age, sex, position and behavior in the vehicle, injury sustained, and drug/alcohol use.

The basic methodology used in this analysis of the FARS data was similar to that used in the analysis reported by De Young (1997) to estimate the percentage of drivers with suspended or revoked driver's license on-the-road. The major difference is that this analysis focuses on the registration status of the vehicle. The criteria for selecting vehicles to include in this analysis were:

1) the accident must have occurred in the state of California,
2) at least two vehicles were involved in the accident,
3) the driver was not cited for a moving violation, and
4) the driver did not die in the accident.

Single vehicle fatal accidents were not included because they were believed to be not representative of the general driving population. Also, it was believed that if the driver died in the accident, examining the citation data would not show if the driver was considered to be at fault for the accident. Consequently, these vehicles were not included in the analysis.

In the vehicle registration data, three possible codes indicated the possibility of a vehicle being unregistered. One category clearly identified the vehicle as not registered. The other two categories were “not applicable” and “unknown”. The use of one versus the other of these two categories has seemed to vary over the last ten years. Frequently it appeared that the not applicable code was used when another variable (e.g., registered owner) in the record indicated that the vehicle was unregistered. The registration status of the vehicles in the unknown category is the most unclear. These are vehicles for which there is no identifying information, perhaps due to the vehicle leaving the accident scene, or for which no DMV records could be found. The latter would be likely if the vehicle was never registered with DMV or the registration that the vehicle once had had expired for four or more years and the DMV records had been purged. To the extent that these unknowns actually had a current registration, the estimated percent of unregistered vehicles using the FARS data would be biased upwards. Additional analysis of the vehicles with an unknown registration status indicated that slightly over half (57%) of these vehicles were involved in hit-and-run accidents. The CHP citation data shown in Attachment A shows that between 1988 and 1997 an average of 6.8% (range 4.3% to 8.8%) of those cited for a hit-and-run violation were also cited for an unregistered vehicle. However, it appears that the CHP may only catch and cite about one in seven of the hit-and-run vehicles (Hunstad, 1999a, endnote 2). Discussions with sergeants, traffic officers, and the FARS coding supervisor at the CHP indicate that those who are cited for hit-and-run are probably not representative of all hit-and-run vehicles. It is likely that factors other than operating an unregistered vehicle, such as alcohol use or having an outstanding arrest warrant, would provide greater motivation to flee an accident. However, it seems reasonable that an unregistered vehicle driver would be more oriented to avoiding detection than a registered vehicle driver, and thus might be more effective in fleeing the scene of a hit-and-run accident. CHP officers familiar with the investigation of hit-and-run accidents indicated that with a vehicle license number that is currently registered, they have approximately a 90% success rate in apprehending the hit-and-run driver. However, without a current registration for the license number, the success rate in apprehension drops to below 50%. Thus, it appears that the majority of those who avoid being cited for a hit-and-run accident have a much higher likelihood of being unregistered.

According to the FARS coding supervisor, the other primary reason for a vehicle being coded as unknown registration status is the vehicle did not have any license plates. While there is the possibility of the vehicle's license plates was stolen, it seems reasonable to estimate that the vast majority of the vehicles without license plates are not currently registered. The other situation that would likely result in a vehicle's status being coded as unknown involves the DMV search of the license plate number yielding a vehicle that does not match the description in the accident report. Because the FARS unit is able to identify and correct data entry errors (made by the reporting police officer) in the accident report by cross searching on the owners name, it was estimated that these types of situations only accounted for a few percent of the vehicles coded as unknown. Using the somewhat subjective impressions of the individuals involved with the FARS data is estimated that approximately two-thirds of the unknown status vehicles were unregistered. This estimate assumes that the hit-and-run vehicles (57% of the total "unknowns") are unregistered about 50% of the time, the vehicles with no license plates (40% of the total "unknowns") are unregistered about the 95% of the time, and the remaining vehicles (3% of the total "unknown") are unregistered about 10% of the time (67% = 57% * 50% + 40% * 95% + 3% * 10%).

Table 7 shows the number of vehicles included in the analysis and the category counts for the estimated unregistered vehicles. The "Estimated Total Not Registered" column is calculated by adding the Not Applicable and Not Registered colmums and then adding 67% of the Unknown column.

Table 7
Not At Fault Vehicles in Fatal Accidents

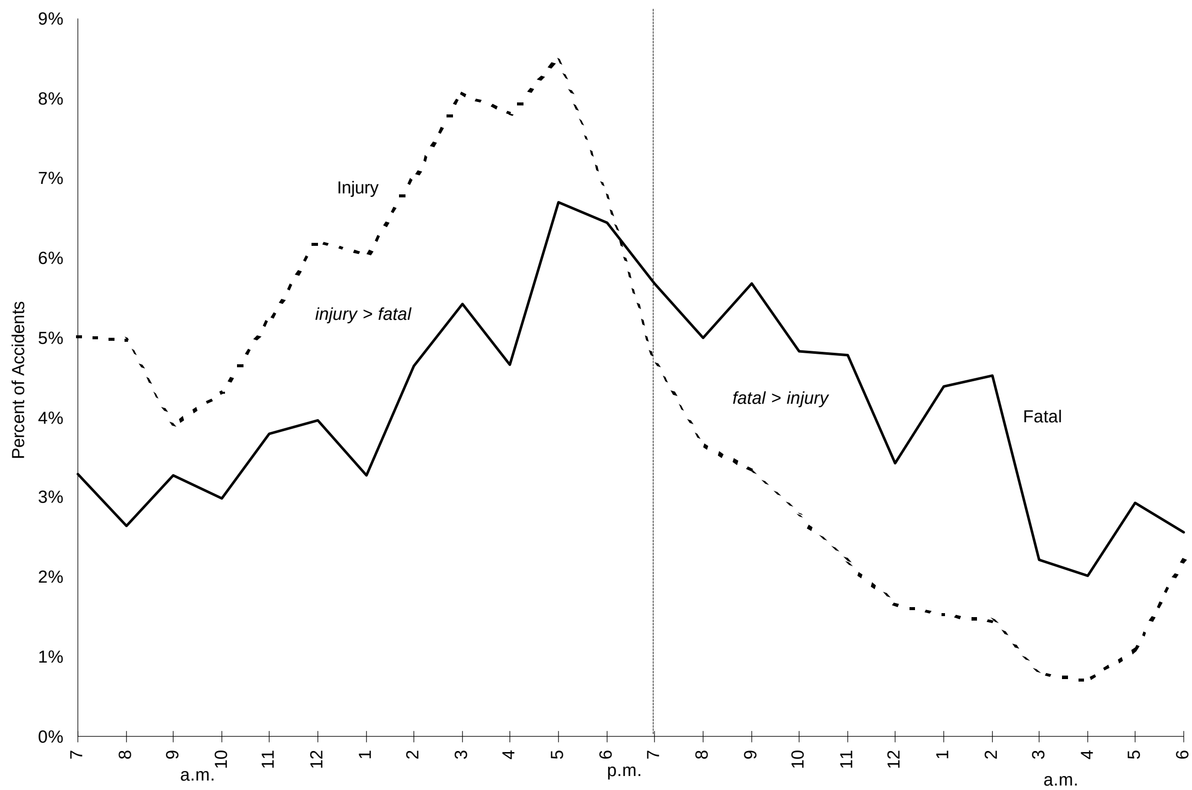
	Total Number	Registration Status:			Estimated Total	Estimated
Year	of Vehicles	Not Applicable	Not Registered	Unknown	Not Registered	Percent
1988	2343	9	154	138	255	10.9%
1989	2283	4	123	136	218	9.6%
1990	2107	4	110	101	182	8.6%
1991	2103	10	135	108	217	10.3%
1992	1861	40	91	71	179	9.6%
1993	1748	32	98	75	180	10.3%
1994	1908	24	86	74	160	8.4%
1995	1823	32	84	54	152	8.3%
1996	1827	33	72	58	144	7.9%
1997	1660	44	75	43	148	8.9%

A key question in assessing the accuracy of the FARS based estimate of unregistered vehicles is: are the not at-fault vehicles contained in the FARS data a representative sample of all vehicles on-the-road. De Young (1997) points out that it would be more accurate to say that these vehicles are a sample of the vehicles on-the-road during the times and in the places where fatal crashes occur.

We are not aware of any data describing the vehicles and drivers *using* the roadways where fatal crashes occur. It seems unlikely that the places where fatal crashes occur could result in a bias. If a particular spot or stretch of roadway had a well known reputation for producing a high frequency of fatal crashes, and if there were alternate roadways available to drivers, then a knowledgeable and risk adverse driver would tend to avoid that spot or stretch of roadway. To the extent that this knowledgeable, risk adverse driver tended to have a greater likelihood of driving a registered vehicle, the rate of unregistered vehicles would tend to be overstated. While there is no definitive data available, the conjunction of all these conditions would seem to effect a very small percent of the fatal accidents.

Data is available on the time of fatal accidents. This data can be compared to the time of all injury accidents which is likely to be more representative of all vehicles on-the-road. Figure 5 shows the distribution of fatal accidents versus injury accidents by the hour of the day.

Figure 5
Time of Accident: Fatal vs. Injury



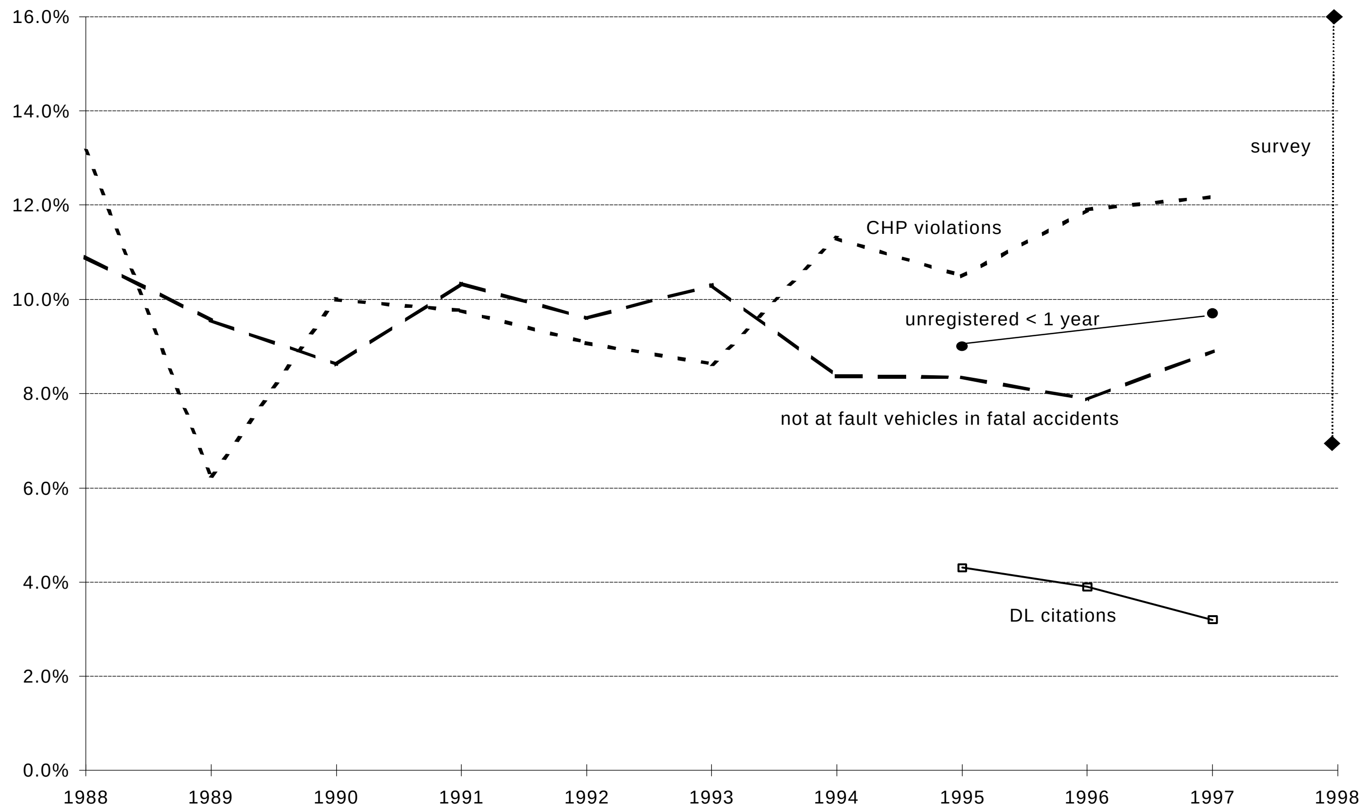
While fatal accidents occur during every hour of the day and every day of the week, the time period from 7 p.m. until 6 a.m. contains a higher percentage of fatal accidents compared to injury accidents. Other data show that fatal accidents are more likely to occur on the weekend. As there is no evidence to indicate that unregistered vehicles have a higher or lower tendency to use the roads at these times, it is difficult to conclude that those vehicles not at fault in fatal accidents are a biased sample due to the skewing of the likely time of occurrence for fatal accidents.

The estimate of unregistered vehicles based on the FARS data can be seen as another perspective on the on-the-road unregistered vehicles. There does not appear to be any systematic biases in this estimate, either upwards or downwards. However, simply due to the fact that this data represents a sample, there is likely to be some variation in the estimate. At the 95% confidence level, a variability of +/- 1% to 2% would be expected from the data.

Summary of Unregistered Estimates:

Figure 6 summarizes the different estimates of the percent of unregistered over the past 10 years. As expected most estimates show an increase for 1997. Overall, the estimate based on the CHP violation data tended to be more variable (and likely less accurate) than the estimate based on the not at fault vehicles in fatal accidents. The standard deviation of the CHP violation based estimate was 1.91% compared to 0.96% for the FARS based estimate. However, except for 1989, both of these estimates are within 2 to 3 percentage points of each other.

Figure 6
Estimates of Unregistered Vehicles from Five Methods



The estimate based on the vehicles with expired registrations of less that one year is in fairly close agreement with the FARS based estimate. The differences in 1995 and 1997 were 0.7 and 0.8 percentage points. Because of their stability and agreement, these two estimates are believed to be more accurate than the violation based estimate. However, because of the complexity of the issue and the difficulty obtaining a direct measurement, the perspective contained in the CHP violation data are believed to provide some additional information. While the estimates from the drivers license records were puzzling, it was thought that they should be included and given some consideration.

In order to utilize the contributions of the various different perspectives on the issue of unregistered vehicles, the different estimates were combined to form a weighted average. Because of the greater stability of the FARS based estimate, it was given greater credibility than the violation based estimate. In the weighted average it was assigned twice the weight of the CHP violation based estimate. For the two years that the estimate based on the vehicles with expired registration of less than one year were available, they were included in the calculation of a weighted average with a weight equal to the FARS based estimate. The estimate for the 1995 to 1997 time period based on drivers license records were given half the weight of the CHP data. Table 8 contains the standard deviations and the weighted average of the estimates.

Table 8
Weighted Average of Estimated Percent Unregistered Vehicles

	Source of Estimate					
Year	FARS not at fault vehicles	CHP violations	DMV unreg. < 1 yr	DL citations	Survey	Weighted Average
1988	10.9%	13.2%				11.7%
1989	9.6%	6.3%				8.5%
1990	8.6%	10.0%				9.1%
1991	10.3%	9.8%				10.1%
1992	9.6%	9.1%				9.4%
1993	10.3%	8.6%				9.7%
1994	8.4%	11.3%				9.3%
1995	8.3%	10.5%	9.0%	4.3%		8.6%
1996	7.9%	11.9%		3.9%		8.5%
1997	8.9%	12.2%	9.7%	3.2%		9.3%
1998					7% - 16%	
standard deviation	0.96%	1.91%				0.91%

The weighted average is considered the best estimate of the percent of unregistered vehicles. It will be used as the input to the model described later.

Business vs. Personal Use of Vehicles:

The DMV regularly reports on the number of commercially registered vehicles. However, the numbers reported by DMV reflect commercial *registrations* not business use. The problem with the DMV's numbers mainly involves light pickup trucks. DMV requires that most of these vehicles be registered as a commercial vehicle even though they are used entirely for non-business use.

One estimate of the percent of trucks that are used for personal purposes comes from the Truck Inventory and Use Survey, a national survey conducted every five years by the Census Bureau for the U.S. Department of Transportation. In the survey conducted in 1987, 68.1% of the trucks in California were estimated to be used for personal transportation. In 1992, the survey estimated that 68.0% of the trucks in California were used for personal transportation. The 1992 survey in California had a total sample size of 3,950. A 95% confidence interval for the percent of trucks used for personal transportation is 62.4% to 73.6%. The results of the 1997 survey are not estimated to be available until early 1999. California appears to not be following the national trend toward increasing personal use of trucks. Nationally, the percent of personal use of trucks for 1977, 1982, 1987, and 1992 were 54%, 57%, 66%, and 68%.

It would not be correct to apply the estimated percent of trucks used for personal use to the DMV's number of commercially registered vehicles. While trucks make up almost all of the commercially registered vehicles, some other vehicles are also registered as commercial vehicles. Taxis, ambulances, and private buses are some examples. An analysis of DMV's VR database as of 6-1-97 found that 94% of the commercially registered vehicles were classified as a truck or in such a way they would be included in the Truck Inventory and Use Survey.

In order to accurately estimate the number of vehicles that should be purchasing private passenger auto insurance, it is also necessary to estimate the business use of vehicles that DMV reports as “autos.” Unfortunately the Census Bureau survey does not estimate the business use of autos and other non-truck vehicles. Estimating vehicles eligible for private passenger auto coverage is made more difficult due to the ability of some business use of a vehicle to be covered under a private passenger auto insurance policy. This situation usually occurs when a person uses their vehicle as part of their job or self-employed business. Generally there is a limit to how much business use an insurer will allow and still write the coverage under a private passenger auto insurance policy[10]. Practically, any use of more than at most a few vehicles predominately for business use would likely require a commercial auto insurance policy. The prevalence of predominantly business use of more that a few vehicles classifiable as autos is more difficult to estimate. Virtually all previous estimates of the UV rate have not made an allowance for the business use of autos. This tends to overstate the UV rate because an auto with commercial insurance would be counted as uninsured if only personal lines are considered.

The CEC also prepares estimates of the business use of vehicles for input into their models. As opposed to using surveys, the CEC conducts an analysis of each vehicle registered or recently registered in the state. One of the benefits of this approach is that it produces an estimated business use rate for both autos and trucks.

The CEC process involves two major steps. In the first step the vehicle type is determined. In the second step the type of use is estimated. There are three different approaches to estimating the vehicle type: the Guide File, VINA software, and VIN8 software. The Guide File maps vehicles into a category based on their make, series name, and model. Most post 1971 vehicles can be classified using the Guide File. If a vehicle cannot be classified using the Guide File an attempt to classify it using VINA software is made. The VINA software uses the vehicle's VIN to classify it. The VINA software can process vehicles back to 1966. However if the VIN contains typos or other data errors, the VINA software can fail to classify it. In such cases the VIN8 software is

[10]It is also possible that some vehicles used for personal purposes are covered under commercial policies (e.g., a small business or professional may have a single policy that covers both their business vehicles and their personal vehicles). At this time there is no data to indicate how many vehicles classifiable as business use are covered under a private passenger auto policy, or how many vehicles classifiable as personal use are covered under a commercial policy. This cross over between type of use and type of coverage creates less accuracy in the business vs. personal use estimation. This is an area where future research can improve the model for estimating the UV rate.

used. The first eight characters of the VIN uniquely identify a vehicle's type. Using these first eight characters the VIN8 software attempts to classify the vehicle. If all these attempts fail to classify the vehicle, the DMV data fields for make, model year, and body type are examined and a vehicle type is assigned if possible.

A vehicle's type of use is estimated by grouping all vehicles with the same owner and address into “fleets” and then classifying the fleet as personal or commercial. Most fleets contain one or two vehicles, a few contain thousands. The fleet identification process uses the four name and address fields in the DMV's VR database. After cleaning and standardizing these fields, a key is generated for each vehicle. The file is then sorted multiple times using the key, county, and zip code to group the fleets together. Once the fleets are grouped together, the first step is to examine the type of registration. Commercial license plates on a vehicle other than a pickup indicate a business use. Business use is also inferred based on name analysis and fleet size.

If a fleet contains ten or more vehicles it is assigned business use. Also if a fleet contains three or more trucks, it is assigned business use. The name analysis examines the content of the name searching for commercial words or word fragments (e.g., INC.), one word names, or names beginning with initials instead of the last name. The content analysis of the name analyzes various parts of the name and compares them with a large file of commercial terms. Vehicles with business owners are assumed to be used for business purposes.

The CEC's process for estimating type of use is extremely time and resource intensive, but it produces a type of use estimate for each of approximately 25 million vehicles. This is extremely useful for any analysis that examines smaller geographic units such as counties or zip codes. With these data the personal/business use proportions can be estimated down to the zip code level, providing a much more accurate estimate than a single statewide average. The process that the CEC uses to estimate type of use is continuing to be enhanced. The latest and most accurate data are for 1995. These data indicate that 92.9% of autos and 66.9% of tucks are used for personal purposes[11].

VEHICLES WITH INSURANCE

The primary source for data on the number of vehicles with insurance is the Department of Insurance's Statistical Analysis Bureau (SAB). Each year SAB collects data from each insurer licensed to issue auto insurance policies in California. This data covers the amount of premiums earned and written, the number of months of exposure earned and written, and the number and amount of any losses incurred. These data are collected separately for the following coverages: bodily injury (BI), property damage (PD), combined single limits (CSL) (for insurers that combine BI and PD together), medical payment (MP), uninsured motorist - bodily injury (UM-BI), uninsured motorist - property damage (UM-PD), collision (CL), and comprehensive (CM). Further these data are collected for each zip code in which the insurer does business[12]. The data collected by the SAB cover both private passenger auto policies, which are the major source of auto insurance coverage in California, and the California Assigned Risk Program the insurer of vehicles unable to find coverage in the voluntary market. However, these data do not include coverage for motorcycles. This limits estimating the UV rate to vehicles used for personal purposed that are not motorcycles. Motorcycles have been gradually declining as a percent of all

[11]It is interesting to note that the exact estimated rate of personal use is sensitive to the process used to determine vehicle type. If instead of CEC's process for determining vehicle type, the vehicle type is determined by only using the VINA software, the estimates for personal use become 90.5% for autos and 65.6% for trucks. The issue of properly classifying a vehicle's type has also impacted the U.S. Department of Transportation's National Center for Statistical Analysis's (NCSA) estimation of injury rates for different types of vehicles. Shelton (1995) provides an explanation of the process NCSA used to make their data more reflective of the industry data from R. L. Polk.

[12]A summary of six years of these data limited to the private passenger auto coverage can be seen in the Private Passenger Auto Frequency and Severity Bands Manual. This manual is available from the DOI and on the internet in the Policy Research Information section which can be found by clicking on “Insurers” at www.insurance.ca.gov.

vehicles. In 1991 they represented 2.9% of all vehicles, by 1997 the percent had dropped to 1.8%. Another analysis has found that the UV rate is very high among motorcycles[13].

To estimate UV rate, the data we are interested in is earned exposures. Earned exposures are the number of months in a calendar year the insurance company had a policy in force and assumed liability for losses caused by the policy holder. Written exposures on the other hand reflect the issuance of a policy to cover a vehicle for a specific time period in the future. For example, if a consumer purchases a six month auto policy on 11-1-97, the insurer immediately has six months of written exposure. However, as of 11-1-97, the insurer has accumulated zero months of earned exposure for this policy. Theoretically the consumer could cancel the policy on 11-2-97 and demand a refund of his entire premium less a charge for the one day of coverage. If the policy remains in force, at the end of 1997, the insurer would have earned two months of the six months of exposure that was written on 11-1-97.

In an environment where the overall amount of exposure is not increasing or decreasing, and consumers did not cancel a policy once it was issued, the amount of written exposures would be equal to the amount of earned exposures. In an environment where the amount of exposure is increasing, the amount written exposures will tend to be larger than the amount of earned exposures. This is due to the new vehicles coming into the system. For these new vehicles insurers are immediately given credit for the entire policy period in the written exposure count, but only accumulate the earned exposure as time progress. If some of the new consumers coming into the system have a higher likelihood of canceling the policy before the term has expired, then the difference between written and earned exposure increases. With the new requirement to provide proof of insurance at the time of vehicle registration, some have expressed concern that those who do not want or can not afford the insurance will just purchase the insurance long

[13] In 1997 it was estimated that about two-thirds (66%) of the motorcycles were uninsured. See *California's Uninsured (Preliminary Report)*, California Department of Insurance, Sacramento, California, 1998.

enough to complete the registration process and then promptly cancel the policy. At this point in time we do not have any convincing data to support the contention that this practice is widespread.

Ideally we would like to know the number of separate vehicles that were covered by insurance in a given year. Unfortunately the data only tell us the number of months of exposure the insurance company earned. Twelve months of earned exposure could have been accumulated by three vehicles each purchasing four months of insurance, or twelve vehicles with each purchasing only one month of coverage.

If each vehicle that purchased insurance was insured for the entire year without any lapses in coverage and there were no new partial year vehicles coming into the system, then we could divide the number of months of exposure by twelve and determine the number of vehicles insured during the year. Further, under such an assumption, the number of vehicles insured on any given day would be the number of vehicle years of exposure earned during the year. If we relaxed these assumptions allowing new vehicles to enter the system for partial years and old vehicles to exit the system after completing a partial year of exposure, we can still estimate the number of vehicles insured. If the rate of new vehicles into the system was approximately equal to the rate of old vehicles out of the system, then there is no net change to the number of vehicles with insurance. If the rates of flow in and out were approximately uniform or at least equal during the year, then the estimated number of vehicles with insurance on any given day would be the number of earned exposure years for the year. In a situation where the number of vehicles with insurance is changing each year, but there was still an approximately uniform flow of new vehicles in and old vehicles out, then the number of vehicle years of earned exposure would be the best estimate of the number of vehicles insured at mid year.

Due to a lack of data it is not clear if the uniform rate assumption is an accurate description, but lacking evidence to the contrary, it seems a reasonable assumption. Consequently, until more accurate data are available to evaluate the seasonality of the in and out flows, the best estimate of the number of vehicles with insurance at mid year is the number of years of earned exposure. This mid year estimate of the number of insured vehicles would also match the mid year estimate of the number of vehicles that should have insurance.

Other Issues:

Two other issues impact the estimate of the number of vehicles with insurance. These are incomplete reporting and selecting the coverage to count earned exposures. There are more than 200 companies that sell private passenger auto insurance in California. Most of these companies do a very good job of meeting the reporting requirements to report exposure data to the SAB. However, there are some companies who do not report accurately and a few who do not report at all. The most common problems are incomplete and erroneous reporting. The net result is that after the data have been cleaned, the number of vehicles with insurance is understated. In order to estimate the extent of under reporting the SAB compares the total liability premiums of the data reported to the CDI with the total liability premiums reported to the National Association of Insurance Commissioners (NAIC). The reports to the NAIC are part of a different reporting system that does not require the level of detail that the SAB reports do and have a better reporting level. Table 9 compares the liability premiums reported to the SAB and the NAIC and calculates an annual adjustment factor[14].

[14]The total amount of liability premiums reported by NAIC also includes a small amount for the coverage of motorcycles and policy fees. As the SAB figures do not include motorcycles or policy fees, the NAIC premiums have been adjusted downward to make them comparable to the SAB premiums. The 1996 data reported here are preliminary unedited data. Once it has been edited some company's data will likely be removed. After this editing, it is likely that the under reporting level will be more in line with the 1993 to 1995 levels. As the unadjusted count of vehicles reported to have insurance in 1996 (used in Table 9) is also unedited, it is appropriate to use this low under reporting level for 1996.

Table 9
Estimated Under Reporting Level

Year	Liability Premiums Reported to: NAIC	SAB	Estimated % Under Reported (NAIC/SAB - 1)
1993	$7,210,575,975	$7,073,962,345	1.9%
1994	$7,218,242,134	$7,142,382,628	1.1%
1995	$7,494,846,972	$7,328,838,986	2.2%
1996	$7,684,493,886	$7,654,775,852	0.4%

As mentioned previously the data collected by the SAB is reported separately for several different types of coverage. The legally required insurance only covers BI and PD. Theoretically BI and PD should always be sold together. Some companies do not even sell the coverages separately. These companies report their sale of BI and PD under the category of CSL. If joint sale always occurred, the number of months of BI exposure would always equal the number of months of PD exposure. For an unknown reason, the actual data do not reflect this and BI and PD exposures differ. This raises the issue of which measurement of exposure should be used in estimating the number of vehicles with insurance. Options include:

- arbitrarily select one coverage and consistently use it,
- select the coverage with the largest number of exposures,
- select the coverage with the smallest number of exposures, or
- average the two coverages together.

Table 10 shows the amount of BI + CSL, and PD + CSL exposures for 1991 to 1996.

Table 10
Number of Years of Insurance Coverage

Year	BI + CSL	PD + CSL
1991	13,915,140	13,903,879
1992	13,652,545	13,647,018
1993	13,434,840	13,427,029
1994	13,628,312	13,627,817
1995	13,887,382	13,886,939
1996	14,563,084	14,200,651

The data in Table 10 show a fairly close agreement (less than 5,000 difference) for 1994 and 1995. The largest difference is more than 0.36 million for 1996. However, at this time the 1996 counts are preliminary and are under going frequent revisions. In general, exposures for BI coverage are higher than exposures for PD coverage. It is not clear exactly why this difference occurs. There has been some evidence that a few companies may have not been able to breakout the PD portion of CSL when reporting PD exposures. Given the problems experienced with incomplete and erroneous reporting, it seems reasonable to assume that the lower PD exposure count is due to some type of reporting problem. If this is the case, the best estimate of the number of years of insurance coverage would be the BI + CSL count. The model described below used BI + CSL earned exposure as the measure of insurance coverage.

MODEL SPECIFICATIONS

The basic model to estimate the UV rate can be written algebraically as follows:

$$\text{UV rate} = (\text{TV} - \text{IV}) / \text{TV} \qquad [1]$$

where,

TV = the number of vehicles (excluding motorcycles) that are used for personal purposes and should have insurance, and

IV = the number of vehicles (excluding motorcycles) that are used for personal purposes and do have insurance

The TV and IV are calculated according to the following formula:

$$\begin{aligned}
\text{TV} = \;& (A.1 + A.2) && \textit{\{registered vehicles\}} \\
& + (B.1 * A.1 + B.2 * A.2) && \textit{\{unreg. vehicles\}} \\
& - C * A.2 * (1 + B.2) && \textit{\{comm. non-trucks\}} \\
& - D.1 * A.1 * (1 + B.1) && \textit{\{comm. autos\}} \\
& - D.2 * [A.2 * (1 + B.2) - C * A.2 * (1 + B.2)] && \textit{\{comm. trucks\}} \qquad [2]
\end{aligned}$$

$$IV = E * (1 + F) \qquad [3]$$

where,

A = the total number of registered vehicles as of July 1st

A.1 = the count for autos

A.2 = the count for commercially registered vehicles

B = the estimated percent of unregistered vehicles

B.1 = the percent of unregistered autos

B.2 = the percent of unregistered commercial vehicles

C = the percent of commercial vehicles that are not trucks

D = the estimated percent of vehicles used primarily for business purposes

D.1 = the percent of autos used for business

D.2 = the percent of trucks used for business

E = the unadjusted count of the reported number of vehicle years of private passenger auto and California Assigned Risk Program insurance purchased

F = the estimated percent of under reporting of insurance purchases

Initial Results:

Using the best estimates that are currently available for the input parameters an initial estimate of the UV rate was calculated. The registered vehicle count estimates were based on the Currently Registered Vehicles by Zip Codes (Report #1) prorated to estimate the count as of mid year. The percent of unregistered vehicles were based on the weighted average shown in Table 8. The CEC estimates from the 1995 VR database were used to establish the separate percents for autos and trucks. The percent of commercial vehicles that are not trucks was based on data from the 1997 VR database. The estimated business use of vehicles was based on the CEC estimates from the 1995 VR database. Unadjusted vehicle counts are from the SAB, and the estimated rate of under reporting insurance purchases were based on data from the SAB and the NAIC.

A time series exists for the data on vehicle counts, estimated rate of unregistered vehicles, insured vehicles, and the estimated rate of under reporting of insurance sales. Unfortunately, the best available data for the percent of commercial vehicles that are not trucks, and the percent of business use of vehicles are limited to a single point in time. It may be that these rates are changing systematically over time, but until more data can be collected, these single point estimates are the best that are available and were used for all time periods. Examining the sensitivity of the UV rate to these estimates gives some idea of the effect in the overall model. Table 11 shows the initial input data the resulting UV rates.

Table 11
Initial Model Inputs and UV Rates

INPUTS:	1991	1992	1993	1994	1995	1996	1997
A. Number of registered vehicles as of July 1st							
1. autos	16,350,550	16,451,172	16,551,657	16,667,064	16,801,894	17,072,220	17,003,924
2. commercial	4,453,148	4,471,106	4,489,040	4,504,289	4,519,317	4,567,627	4,496,174
B. Estimated percent of unregistered vehicles							
1. autos	9.4%	8.7%	9.0%	8.6%	8.0%	7.8%	8.6%
2. commercial	14.0%	13.0%	13.5%	12.9%	11.9%	11.7%	12.8%
C. Estimated percent of commercial vehicles that are not trucks							5.6%
D. Estimated percent of vehicles used for business purposes							
1. autos					7.1%		
2. commercial					33.1%		
E. Unadjusted count of vehicles reported to have insurance							
	13,915,140	13,652,545	13,434,840	13,628,312	13,887,382	14,563,084	
F. Estimated percent of under reporting of insurance purchases							
	1.7%	1.7%	1.9%	1.1%	2.2%	0.4%	
OUTPUTS:							
X. Estimated number of vehicles that should have insurance							
	19,822,315	19,807,148	19,981,033	20,034,120	20,045,974	20,323,829	
Y. Estimated number of vehicles with insurance							
	14,154,017	13,886,914	13,688,759	13,771,409	14,194,293	14,619,880	
Estimated UV rate							
	28.6%	**29.9%**	**31.5%**	**31.3%**	**29.2%**	**28.1%**	

With the initial input data the UV rate ranges from a low of 29.0% in 1996 to a high of 32.1% in 1993. Since 1993 the estimated UV rate has been gradually declining. Table 12 shows estimated ranges that the different input parameters might take. We have attempted to estimate the extreme values that each parameter might take. The probability that each parameter will fall within the estimated range has not been rigorously determined. These estimates were developed to roughly correspond to 95% confidence intervals.

Table 12
Estimated Confidence Intervals for the Input Parameters

Inputs:	+ / - Amount	Minimum Value (yr)	Maximum Value (yr)
A. Number of registered vehicles as of July 1st:			
1. autos	270,326	16,080,224 (1991)	17,342,546 (1995)
2. commercial	71,453	4,381,696 (1991)	4,639,080 (1995)
B. Estimated percent of unregistered vehicles:			
1. autos	4.0%	4.0% (1995)	13.4% (1991)
2. commercial	4.0%	7.9% (1995)	18.0% (1991)
C. Estimated percent of commercial vehicles that are not trucks:			
	2.0%	3.6%	7.6%
D. Estimated percent of vehicles used for business purposes:			
1. autos	3.5%	3.6%	10.6%
2. commercial	5.0%	28.1%	38.1%
E. Unadjusted count of vehicles reported to have insurance:			
	n.a.		
F. Estimated percent of under reporting of insurance purchases:			
	2.0%	0.0% (1996)	4.2% (1995)

The range amount for the number of registered vehicles was estimated by taking the maximum year to year difference from the years 1991 to 1997[15]. The range for the estimated percent of unregistered vehicles was selected to include the lowest estimate that has been proposed. The range for the estimated business use of vehicles was set to approximately match the 95% confidence interval level for California in the Census Bureau's Truck Inventory and Use Survey. Table 13 shows the sensitivity of the UV rate to each individual parameter.

[15]Note that this estimate of the variability of the count of registered vehicles assumes that the report providing the best estimate was selected. If this measure of variability also included the differences among the different DMV reports described earlier, the range of variation would be much larger and the estimated UV rate would have a correspondingly greater sensitivity to this parameter.

Table 13
Sensitivity of UV Rate to Individual Parameters

A. Number of registered vehicles as of July 1st

	1,991	1,992	1,993	1,994	1,995	1,996	1997
INITIAL VALUE:							
1. autos	16,350,550	16,451,172	16,551,657	16,667,064	16,801,894	17,072,220	17,003,924
2. commercial	4,453,148	4,471,106	4,489,040	4,504,289	4,519,317	4,567,627	4,496,174
Estimated UV rate	28.6%	29.9%	31.5%	31.3%	29.2%	28.1%	
MINIMIZING VALUES:							
1. autos	16,080,224	16,180,847	16,281,332	16,396,738	16,531,569	16,801,894	16,733,598
2. commercial	4,381,696	4,399,653	4,417,587	4,432,836	4,447,865	4,496,174	4,424,721
Estimated UV rate	28.0%	29.2%	30.8%	30.6%	28.5%	27.8%	
MAXIMIZING VALUES:							
1. autos	16,620,876	16,721,498	16,821,983	16,937,390	17,072,220	17,342,546	17,274,249
2. commercial	4,524,601	4,542,559	4,560,492	4,575,742	4,590,770	4,639,080	4,567,627
Estimated UV rate	30.4%	31.4%	33.1%	32.8%	30.7%	30.0%	
							average:
MIN / MAX DIFF:	2.3%	2.3%	2.2%	2.2%	2.3%	2.2%	**2.3%**

B. Estimated percent of unregistered vehicles

	1,991	1,992	1,993	1,994	1,995	1,996	1997
INITIAL VALUE:							
1. autos	9.4%	8.7%	9.0%	8.6%	8.0%	7.8%	8.6%
2. commercial	14.0%	13.0%	13.5%	12.9%	11.9%	11.7%	12.8%
Estimated UM rate	28.6%	29.9%	31.5%	31.3%	29.2%	28.1%	
MINIMIZING VALUES:							
1. autos	5.4%	4.7%	5.0%	4.6%	4.0%	3.8%	4.6%
2. commercial	10.0%	9.0%	9.5%	8.9%	7.9%	7.7%	8.8%
Estimated UM rate	25.9%	27.2%	28.9%	28.6%	26.5%	25.3%	
MAXIMIZING VALUES:							
1. autos	13.4%	12.7%	13.0%	12.6%	12.0%	11.8%	12.6%
2. commercial	18.0%	17.0%	17.5%	16.9%	15.9%	15.7%	16.8%
Estimated UM rate	31.1%	32.4%	33.9%	33.7%	31.7%	30.6%	
							average:

MIN / MAX DIFF:	5.2%	5.1%	5.0%	5.0%	5.2%	5.3%	**5.2%**

C. Estimated percent of commercial vehicles that are not trucks

	<u>1,991</u>	<u>1,992</u>	<u>1,993</u>	<u>1,994</u>	<u>1,995</u>	<u>1,996</u>	<u>1997</u>
INITIAL VALUE:							5.6%
Estimated UM rate	28.6%	29.9%	31.5%	31.3%	29.2%	28.1%	
MINIMIZING VALUES:							7.6%
Estimated UM rate	29.0%	30.1%	31.7%	31.5%	29.4%	28.7%	
MAXIMIZING VALUES:							3.6%
Estimated UM rate	29.4%	30.6%	32.2%	31.9%	29.9%	29.2%	
							average:
MIN / MAX DIFF:	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	**0.5%**

D. Estimated percent of vehicles used for business purposes

	<u>1,991</u>	<u>1,992</u>	<u>1,993</u>	<u>1,994</u>	<u>1,995</u>	<u>1,996</u>	<u>1997</u>
INITIAL VALUE:							
1. autos					7.1%		
2. commercial					33.1%		
Estimated UM rate	28.6%	29.9%	31.5%	31.3%	29.2%	28.1%	
MINIMIZING VALUES:							
1. autos					10.6%		
2. commercial					38.1%		
Estimated UM rate	26.0%	27.2%	28.9%	28.6%	26.4%	25.7%	
MAXIMIZING VALUES:							
1. autos					3.6%		
2. commercial					28.1%		
Estimated UM rate	32.2%	33.2%	34.8%	34.5%	32.6%	31.9%	
							average:
MIN / MAX DIFF:	6.2%	6.1%	5.9%	5.9%	6.1%	6.2%	**6.1%**

F. Estimated percent of under reporting of insurance purchases

	<u>1,991</u>	<u>1,992</u>	<u>1,993</u>	<u>1,994</u>	<u>1,995</u>	<u>1,996</u>	<u>1997</u>
INITIAL VALUE:	1.7%	1.7%	1.9%	1.1%	2.2%	0.4%	

Estimated UM rate	28.6%	29.9%	31.5%	31.3%	29.2%	28.1%	
MINIMIZING VALUES:	3.7%	3.7%	3.9%	3.1%	4.2%	2.4%	
Estimated UM rate	27.8%	29.0%	30.6%	30.3%	28.3%	27.5%	
MAXIMIZING VALUES:	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	
Estimated UM rate	30.4%	31.5%	33.2%	32.4%	31.0%	29.2%	**average:**
MIN / MAX DIFF:	2.6%	2.5%	2.6%	2.1%	2.8%	1.7%	**2.4%**

Of the five different parameters in the model, the estimated percent of vehicles used for business purposes and the estimated percent of unregistered vehicles had the largest impact on the estimated UV rate. The estimated percent of commercial vehicles that are not trucks had the least impact.

In order to estimate the impact of each parameter two different versions of the initial model were developed. A set of two models was developed for each of the five parameters, for a total of ten new models. Each set of two models used one end of the estimated range of the parameter values. One value of the parameter tended to minimize the estimated UV rate, the other tended to maximize it. These modified models were applied to the yearly data from 1991 to 1996 with all the remaining parameters unchanged from their value in the initial model. The difference between the model that maximized the UV rate and the model that minimized the UV rate was calculated for each of the six years. These six differences were then averaged. The average differences for each parameter were as follows:

Table 14
Model Parameter Sensitivity Estimates I

Parameter	Average Difference Between Min. & Max. Models
Percent of vehicles used for business	6.1%
Percent of unregistered vehicles	5.2%
Percent of under reported ins. coverage	2.4%
Number of vehicles	2.3%
Percent commercial vehicles not trucks	0.5%

Probability Distribution of UV Rate

The sensitivity of the UV rate to the various model parameters shown in Table 14 reflects the affect of each individual parameter leaving all else unchanged. If all the model parameters are allowed to vary simultaneously different results could be obtained. At the extreme if *each* parameter took on the *lower* value of its estimated range, the estimated UV rates would fall in the 18.8% to 22.7% range. At the other extreme if each parameter took on the *upper* value of its estimated range, the estimated UV rates would fall in the 36.1% to 39.1% range. However, both of these situations are extremely unlikely. If the estimated ranges for the parameters approximately reflect 95% confidence intervals, the probability of all minimum values or all maximum values would be $(2.5\%)^5$, or 0.000 000 010 (about 1 in 100 million).

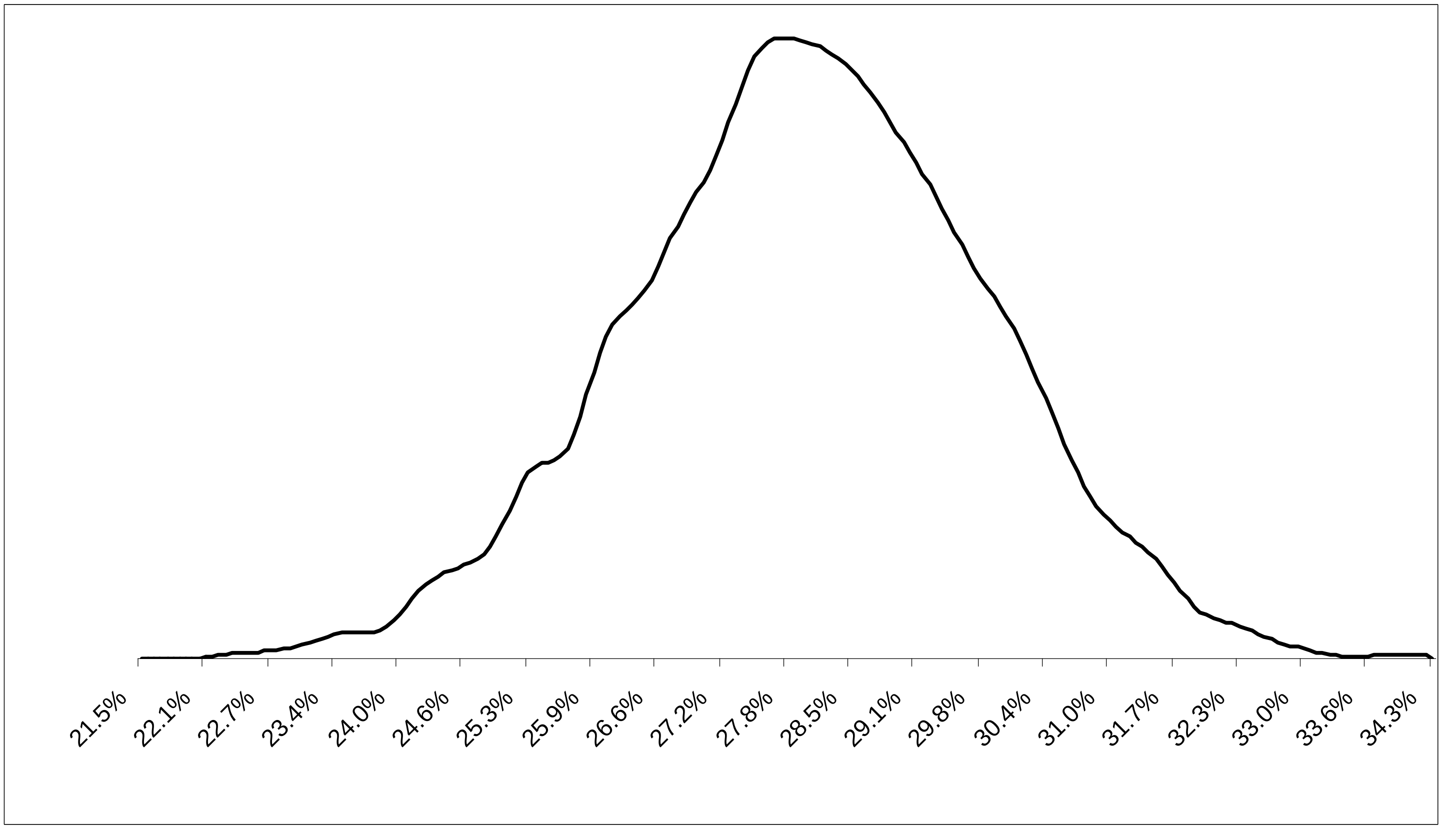
In order to better estimate the variability of the UV rate and also reflect the uncertainty associated with the individual model parameters a technique called Monte Carlo simulation was used. This technique randomly selects the input parameters based on their estimated probability distribution and then computes the estimated UV rate. The process of randomly varying the input parameters and recalculating the estimated UV rate is repeated thousands of times. This results in thousands of estimates for the UV rate. From all these estimates an estimate of the variability of the UV rate can be made.

In the Monte Carlo simulation each input parameter was assumed to be normally distributed[16] with a mean based on the initial input value shown in Table 11. The estimated standard deviation was based on half the +/- amount shown in Table 12. After simulating the model for 1996 10,000 times, the average estimated UV rate was 28.1%. A 95% confidence interval for the 1996 UV

[16] The variable for the estimated percent of insurance underreporting is the one exception to the normal distribution assumption. To keep simulation values from becoming negative for the 1996 estimate, this variable was modeled with a triangular distribution. This distribution had a minimum of 0.000, a most likely value of 0.039, and a maximum value of 0.078.

rate was 25.5% to 30.9%. The distribution of the UV estimate is shown in Figure 7.

Figure 7
Results of Monte Carlo Simulation Showing Distribution of 1996 UV Rate



Another way of estimating the sensitivity of the UV rate to the model's parameters is to regress the values of the input parameters against the calculated UV estimates. The data from the 10,000 simulations was used to perform such a regression analysis. In this analysis the parameters were considered in a slightly different manner. Number of registered vehicles, percent unregistered vehicles, and percent of vehicles used for business were each subdivided into auto and commercial parts, creating six parameters from three. The percent of commercial vehicles that were not trucks and the percent of insurance under reporting were the final two parameters. The regression coefficients associated with each parameter were as follows:

Table 15
Model Parameter Sensitivity Estimates II

Parameter	Coefficient
Business use of autos	-0.650
Unregistered autos	0.640
Registered autos	0.273
Business use of commercials	-0.243
Unregistered commercials	0.117
Non-truck commercials	-0.069
Insurance underreporting	-0.065
Registered commercials	0.051

As the prior sensitivity analysis that looked at the average difference caused by the lower and upper range of the parameter, the regression approach found the percent of unregistered vehicles and the percent used for business to be the most important determents of the estimated UV rate. Unlike the prior sensitivity analysis, the extent of insurance underreporting received a relatively low rank. Because the number of autos is so much larger than the number of commercially registered vehicles, the auto related parameters were measured to be more influential than the commercial related parameters. All four of the parameters referring to the commercial vehicles ranked below the parameters referring to autos.

CONCLUSIONS

It is not too surprising to observe in the previous literature on the rate of UV a variety of divergent estimations even for a specific year. Without an agreed upon standardized method for developing the estimate the situation could hardly be any different. There is a real difficulty in obtaining accurate data upon which an estimation of the UV rate can be developed. The varying UV rates presented by different sources use different data and different methods for producing the estimated UV rate. Given these differences it is to be expected that the derived UV rates should differ from each other.

The factors that seem to have the largest influence on the estimated UV rate, the percent of unregistered vehicle and the percent of vehicles used for business, are also the most poorly measured. As more accurate measurements of these factors are developed, a more precise measurement of the UV rate will be possible. Using the best data that is currently available it was estimated that the 1996 UV rate was approximately 28.1%. A 95% confidence interval around this UV estimate was approximated to range from 25.5% to 30.9%.

Analysts developing estimates of the UV rate need to clearly document the sources of the data used and the methods used for developing the estimate. Without these detailed information users of the estimated UV rate cannot adequately assess the accuracy of the estimate. Data evaluated in this analysis have indicated that variations in a single factor can cause the estimated UV rates to differ by up to six percentage points.

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Attachment A

CHP Citation Data

CHP Citation Data

This attachment contains a summary of citation data from the California Highway Patrol (CHP). The tables and graphs included are primarily based on an analysis of data files of citation records obtained from the CHP. The data files contained records for all citations that involved an uninsured (CVC 16020a or 16028a), unregistered (CVC 4000a), or a hit-and-run (CVC 20001a or 20002a) violation. These data only reflect citations issued by the CHP. Data on the total number of all types of citations and the total number of accident related citations were obtained from the CHP's Information Services Unit.

Table A-1 summarizes the raw data counts. Table A-2 expresses much of the same data found in Table A-1, but in percentages. Table A-3 shows the actual number of person years of patrol related positions that were “in the field” (i.e., not assigned to headquarters, training, or some other non-enforcement function). These data were obtained to explore the relationship between the number of officers in the field and the number of citations issued. Figure A-1 shows the number of citations and the number of officers. There seems to be a lag of one or more years between a change in staffing levels and the resulting change in the total number of citations. If this is an accurate description, there should be a sizable increase in the number of citations issued in 1998. Figure A-2 shows the percent of citations for unregistered vehicle and the number of officers in the field. There appears to be little relationship between staffing levels and the percent of citations for unregistered vehicle.

Table A-1
CHP Citation Data

(Counts)

					Uninsured							
					no				yes			
					Unregistered				Unregistered			
	Total	Total	Total	Total	no		yes		no		yes	
	All Types	Uninsured	Unregistered	Hit & Run	Hit & Run		Hit & Run		Hit & Run		Hit & Run	
Year	Citations	Citations	Citations	Citations	no	yes	no	yes	no	yes	no	yes
					0	1	10	11	100	101	110	111
1988	2,975,659	644,643	391,380	3,743	n.a.	2,990	230,733	205	483,699	502	160,396	46
1989	3,164,693	304,329	197,940	2,878	n.a.	2,360	129,021	168	235,252	326	68,727	24
1990	3,192,508	449,360	319,040	4,396	n.a.	3,654	215,432	313	345,682	383	103,249	46
1991	3,036,017	303	296,289	4,040	n.a.	3,685	295,865	348	220	7	76	
1992	2,821,204	124	255,968	4,632	n.a.	4,222	255,547	409	111	1	12	
1993	2,812,810	308	242,611	3,896	n.a.	3,590	242,285	303	283	2	22	1
1994	2,580,566	280	291,442	3,578	n.a.	3,325	291,164	250	249	3	28	
1995	2,362,706	184	247,870	3,236	n.a.	3,074	247,695	159	165	3	16	
1996	2,224,055	190	264,903	3,070	n.a.	2,937	264,759	131	175	2	13	
1997	2,275,812	316,315	277,239	2,953	n.a.	2,523	204,758	118	243,657	295	72,346	17

					Uninsured							
					no				yes			
					Unregistered				Unregistered			
	Total	Total	Total	Total	no		yes		no		yes	
	All Types	Uninsured	Unregistered	Accident Related	Accident Related		Accident Related		Accident Related		Accident Related	
Year	Citations	Citations	Citations	Citations	no	yes	no	yes	no	yes	no	yes
					0	1	10	11	100	101	110	111
88	2,975,659	644,643	391,380	78,601	614	2,376	229,983	955	451,977	32,224	156,693	3,749
89	3,164,693	304,329	197,940	73,002	603	1,757	128,499	690	217,739	17,839	66,888	1,863
90	3,192,508	449,360	319,040	67,831	956	2,698	214,813	932	320,776	25,289	100,345	2,950
91	3,036,017	303	296,289	30,618	1,445	2,240	295,494	719	166	61	65	11
92	2,821,204	124	255,968	42,583	1,684	2,538	255,189	767	56	56	5	7
93	2,812,810	308	242,611	41,802	1,405	2,185	241,792	796	153	132	18	5
94	2,580,566	280	291,442	39,741	1,319	2,006	290,605	809	149	103	22	6
95	2,362,706	184	247,870	42,101	1,115	1,959	246,998	856	72	96	8	8
96	2,224,055	190	264,903	37,665	1,165	1,772	264,225	665	93	84	7	6
97	2,275,812	316,315	277,239	27,806	1,089	1,434	204,523	353	233,143	10,809	71,549	814

Table A-2
CHP Citation Data: Percentages

Year	Uninsured	Unregistered	Hit & Run	Uninsured given Unregistered	Unregistered given Uninsured	Uninsured given Hit & Run	Unregistered given Hit & Run
1988	21.7%	13.2%	0.1%	41.0%	24.9%	14.6%	6.7%
1989	9.6%	6.3%	0.1%	34.7%	22.6%	12.2%	6.7%
1990	14.1%	10.0%	0.1%	32.4%	23.0%	9.8%	8.2%
1991	0.0%	9.8%	0.1%	0.0%	25.1%	0.2%	8.6%
1992	0.0%	9.1%	0.2%	0.0%	9.7%	0.0%	8.8%
1993	0.0%	8.6%	0.1%	0.0%	7.5%	0.1%	7.8%
1994	0.0%	11.3%	0.1%	0.0%	10.0%	0.1%	7.0%
1995	0.0%	10.5%	0.1%	0.0%	8.7%	0.1%	4.9%
1996	0.0%	11.9%	0.1%	0.0%	6.8%	0.1%	4.3%
1997	13.9%	12.2%	0.1%	26.1%	22.9%	10.6%	4.6%

Year	Uninsured	Unregistered	Accident Related	Uninsured given Unregistered	Unregistered given Uninsured	Uninsured given Accident Related	Unregistered given Accident Related
1988	21.7%	13.2%	2.6%	41.0%	24.9%	45.8%	6.0%
1989	9.6%	6.3%	2.3%	34.7%	22.6%	27.0%	3.5%
1990	14.1%	10.0%	2.1%	32.4%	23.0%	41.6%	5.7%
1991	0.0%	9.8%	1.0%	0.0%	25.1%	0.2%	2.4%
1992	0.0%	9.1%	1.5%	0.0%	9.7%	0.1%	1.8%
1993	0.0%	8.6%	1.5%	0.0%	7.5%	0.3%	1.9%
1994	0.0%	11.3%	1.5%	0.0%	10.0%	0.3%	2.1%
1995	0.0%	10.5%	1.8%	0.0%	8.7%	0.2%	2.1%
1996	0.0%	11.9%	1.7%	0.0%	6.8%	0.2%	1.8%
1997	13.9%	12.2%	1.2%	26.1%	22.9%	41.8%	4.2%

Table A-3
Number of CHP Traffic Officers in the Field by Year

Year	Positions	Index	
1988	4,722	1.00	
1989	4,897	1.04	finished up adding "Governor's 500"
1990	5,101	1.08	
1991	5,175	1.10	
1992	5,062	1.07	academy shut down
1993	4,877	1.03	
1994	4,685	0.99	
1995	4,800	1.02	
1996	5,076	1.07	
1997	5,308	1.12	
1998	5,210	1.10	

Figure A-1

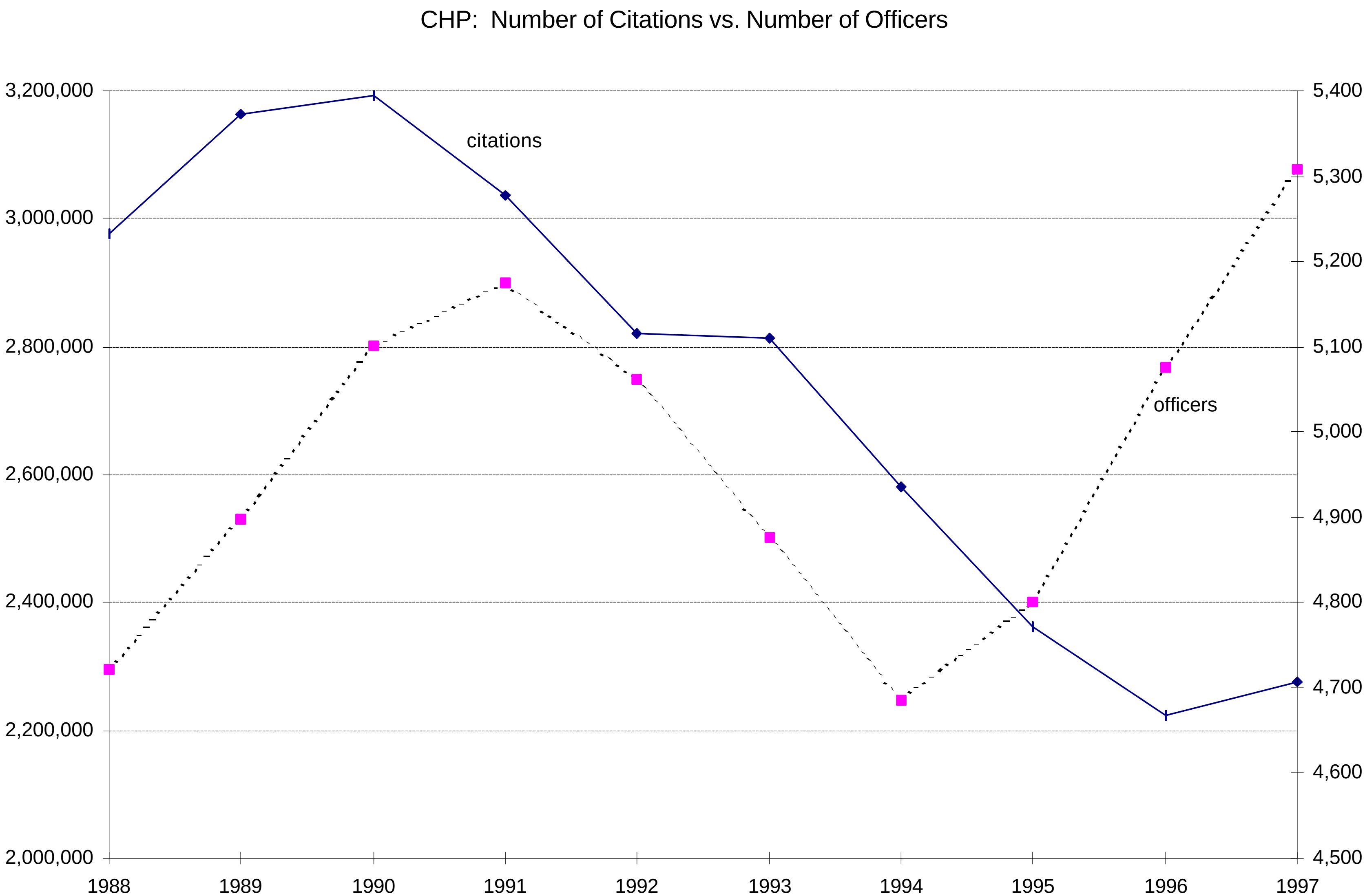
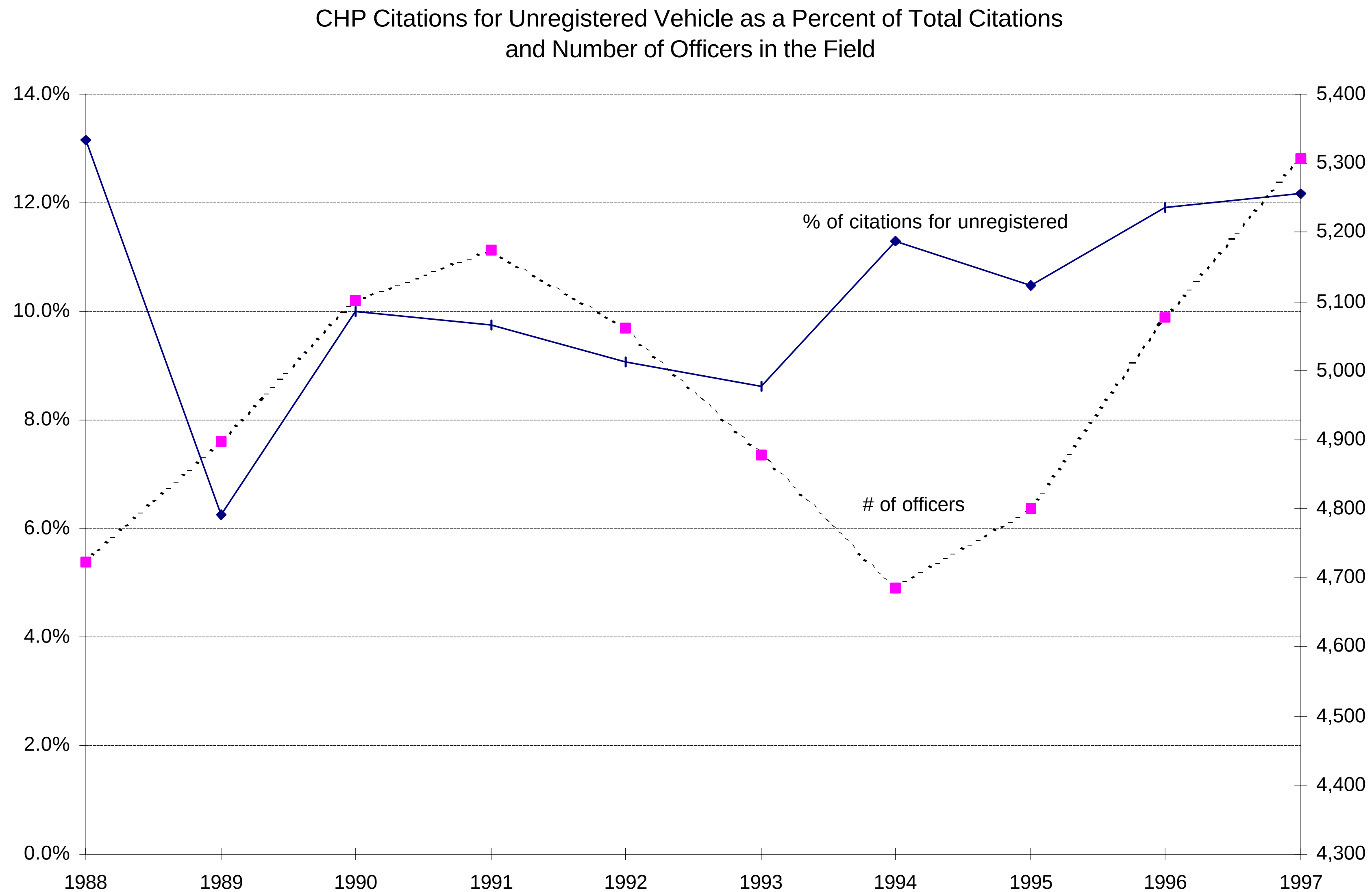

CHP: Number of Citations vs. Number of Officers
citations
officers
3,200,000
3,000,000
2,800,000
2,600,000
2,400,000
2,200,000
2,000,000
5,400
5,300
5,200
5,100
5,000
4,900
4,800
4,700
4,600
4,500
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

Figure A-2


CHP Citations for Unregistered Vehicle as a Percent of Total Citations
and Number of Officers in the Field
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
5,400
5,300
5,200
5,100
5,000
4,900
4,800
4,700
4,600
4,500
4,400
4,300
% of citations for unregistered
# of officers
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997