Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 808 324		

4. Title and Subtitle SAFETY BELT USE LAWS: EVALUATION OF PRIMARY ENFORCEMENT AND OTHER PROVISIONS	5. Report Date OCTOBER 1995 6. Performing Organization Code NRD-31
7. Author(s) JOHN WINNICKI	8. Performing Organization Report No.
9. Performing Organization Name and Address RAINBOW TECHNOLOGY INC. AND NHTSA 17106 THATCHER COURT / 400 7TH ST SW OLNEY, MD 20832 / WASH D.C. 20590	10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTNH22-94-D-07005
12. Sponsoring Agency Name and Address RESEARCH AND DEVELOPMENT NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION 4007th ST SW WASHINGTON, DC 20590	13. Type of Report and Period Covered FINAL REPORT OCTOBER 1994 - MARCH 1995 14. Sponsoring Agency Code

15. Supplementary Notes

PROJECT NUMBER IS NRD-01-4-07464.

16. Abstract

As of January 1995, all states except Maine and New Hampshire had laws requiring safety belt use. These laws vary widely in their enforcement options (primary or secondary), scope of coverage (vehicles covered and seats covered), fine levels, and other provisions.

In this study, FARS data on restraint use among fatally injured motor vehicle occupants from 1983 to 1994 were analyzed for the effects of the laws. Particular attention was given to the effects of different enforcement options on safety belt use. Conclusions pertaining to a larger population than the fatally injured were obtained utilizing the concept of use rate for individuals involved in potentially fatal crashes.

17. Key Words	18. Distribution Statement
safety belt use law, highway safety	Document is available to the public through the National Technical Information Service Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	113	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Executive summary

As of January 1995, all states except Maine and New Hampshire had laws requiring safety belt use. These laws vary widely in their enforcement options (primary or secondary), scope of coverage (vehicles covered and seats covered), fine levels, and other provisions.

In this study, FARS data on restraint use among fatally injured motor vehicle occupants from 1983 to 1994 were analyzed for the effects of the laws. Particular attention was given to the effects of different enforcement options on safety belt use. Conclusions pertaining to a larger population than the fatally injured were obtained utilizing the concept of use rate for individuals involved in potentially fatal crashes.

The present study appears to be the first comprehensive assessment of the effects of state safety belt use laws based on a national data system. Several previous studies utilized observational survey data or telephone survey data from selected states to examine the same issue. Because the present study is based on FARS, which is a complete national collection of traffic accident data covering the entire period since state safety belt use laws began to be enacted, it was possible, for the first time, to give definitive answers as to the relationship between the state laws (as well as other factors) and the belt use in the populations of particular concern -- the fatally injured and those involved in potentially fatal crashes. The present study confirms many of the qualitative findings of the earlier studies, and additionally provides a quantitative assessment of the impact of safety belt use laws and other factors.

A number of statistical techniques were used to assess the effects of safety belt use laws. The results confirm beyond any doubt that the enactment of a law is associated with increased safety belt use. This effect is observed, to at least some degree, in all but one of the state jurisdictions which had a safety belt use law during the period covered by this study.

The results also show that primary enforcement is the most important aspect of a safety belt use law affecting the use rates. For virtually all states with a primary enforcement law, statistically significant increases associated with the presence of a law were detected using several different methods. Higher fines are also associated with higher use rates.

Other factors affecting safety belt use include:

- vehicle type (lower use in pickups and vans)
- vehicle age (presumably reflecting the influence of social and economic status of occupants, lower use in older vehicles)
- alcohol involvement (strong negative association)
- time of the day (lower use at night)
- gender (higher use for women)
- age (use increases with age)
- seating position (lower use in rear seats)

The analysis suggests that the increase in use rates among the fatally injured attributable to the enactment of a law can be estimated to be (on the average) at least 25 percent, while the additional increase attributable to primary enforcement of the law is at least 15 percent. The fine levels are found to be the second most influential aspect of a law affecting safety belt use. The regression models used indicate that a $1 increase in fines is associated with about a 0.8 percent higher use rate.

These increases in safety belt use translate into an estimated 12.6 percent decrease in fatalities in a state where a safety belt use law is enacted, and an additional 5.9 percent decline in fatalities due to primary enforcement of the law.

The above benefits of safety belt use laws can be illustrated by giving estimates of the numbers of lives saved attributable to the laws. For adult occupants of passenger vehicles in 1993, the figures are 2,838 lives saved in states with safety belt use laws and 137 lives that could have been saved in the remaining eight states that had no law in 1993. The effect of primary enforcement option is illustrated by the estimated 367 additional lives saved in primary enforcement states in 1993, and 880 lives that could have been saved if the other states had primary enforcement laws.

Safety Belt Use Laws: Evaluation of primary enforcement and other provisions

Table of Contents

1. Introduction.

This report presents the findings of a study on how state safety belt use laws affect safety belt use. Particular attention was given to the question of whether different enforcement options in the laws result in different levels of compliance. The enforcement options are primary enforcement (which means that law enforcement officers can stop a vehicle and issue a citation solely because of a violation of the law), and secondary enforcement (which means that the only time a citation for violation of the law can be issued is when the vehicle is stopped for another offense). In addition to enforcement options, state safety belt use laws differ by penalties (that is fine levels, court costs, and points on driver's license for violation of the law), scope of coverage (that is, which vehicles are covered by the law and which occupants of these vehicles are covered), and other provisions, such as negligence considerations in mitigating damages associated with noncompliance, mandated public information activities and evaluation, etc.

As of January 1995, all states except for Maine and New Hampshire had safety belt use laws. However, these laws varied widely in their strength from laws with minimal enforcement, no penalties and limited coverage to strictly enforceable laws with high penalties and broad coverage. Section 2 of this report is devoted to a discussion and classification of safety belt use laws in various states.

Given the differences in the laws, the objective of the study was to determine which aspects of the laws have impact on safety belt use rates and to assess the degree of this impact. In order to accomplish this objective, a statistical analysis of belt use data was performed. The data used for this study were derived from the FARS (Fatal Accident Reporting System) database at NHTSA. The main reason for this choice is that FARS data are collected and coded in all states in a consistent way utilizing standardized forms and procedures. In particular, safety belt use recording in FARS is generally reliable. It contains information on all fatal crashes in the country since 1975, and thus is suitable for the comprehensive analysis presently undertaken.

Only information on fatally injured occupants of motor vehicles was used in this study. While the use rates among these individuals do not directly represent the use rates in the general population, there is a close correlation between the two rates. Klein and Walz (1993) examined the relationship between safety belt use rate in potentially fatal crashes (which is given by $(u/0.55)/((u/0.55)+(1-u))$, where u is the use rate for fatally injured occupants) and use rates reported in observational surveys conducted by the states, and found a linear relationship between them. The present analysis is predicated upon the assumption that the effects of safety belt use laws on the general population are reflected in the use rates observed among the fatally injured. The conclusions drawn from the statistical analysis of the data on the latter are generalized to the former.

Several statistical techniques are employed in the analysis. As a preliminary and exploratory step, monthly use rates were calculated for each state for a period of about one year before and after a safety belt use law went into effect or a major change in the law took effect. These monthly rates before and after a law were treated as independent samples, and when their distributions appeared approximately normal, t-test comparisons were performed. The results of this analysis are presented in Section 4.

The next step in the analysis was to examine the monthly safety belt use rates in each state over the period of twelve years (1983 to 1994) to detect the effects of the introduction (and changes in provisions) of safety belt use laws. Time series models were employed at this stage of the analysis. These models account for possible autocorrelations in the data and they reduce to linear regression models in the absence of autocorrelations. The approach is in the spirit of Box and Tiao intervention analysis, although the main model considered is not the ARIMA process. The results are discussed in Section 5.

In order to analyze the overall effects of safety belt use legislation across the states, a cross-sectional regression model was developed, with yearly use rate as the dependent variable and with the independent variables including a time trend (in years), indicators of the presence of a safety belt use law and indicators of its key provisions, and state-level covariates, such as per capita personal income, per capita state spending on highway law enforcement and safety, unemployment rate, crime index, percentage of high school-educated population, and percentage of urban population. The possibility of adjusting for state differences by including dummy variables for states was also considered. The models developed are cross-sectional in the sense that they simultaneously incorporate observations at different times and in different states. The analysis using cross-sectional regressions is reported in Section 6, where cross-sectional time series analysis results are also mentioned.

The final approach to modeling safety belt use was the use of logistic regression model. Here the response variable was the use of safety belts for each fatally injured motor vehicle occupant and the regressors included safety belt use law indicators and state-level covariates mentioned above, as well as individual level covariates, such as age, sex, time of crash, type and age of vehicle, etc. The inclusion of this information in the model results in very accurate adjustment for factors affecting safety belt use other than the safety belt use laws. Section 7 gives details of this approach.

The present study has implications in the area of public policy. Safety belt use legislation has been passionately argued in state legislatures since the 1970's, when it was first introduced. In some states, safety belt use bills were introduced repeatedly almost every year for ten years before they passed and were enacted. Now, when the battle over putting some form of safety belt use legislation in place is largely over with all but two states having such laws in effect, attention must focus on the effectiveness of these laws. At this stage of the debate, the question of enforcement options arises. Presently, only nine state jurisdictions out of 49 jurisdictions with safety belt use laws allow primary enforcement. Proponents of traffic safety have long argued that primary enforcement (together with meaningful fines and broad coverage) is necessary for the laws to be fully effective. The present study contributes to this debate by providing a quantitative assessment of the effects of the differences in the provisions of safety belt use laws.

2. Background.

The subject of the effects of safety belt use laws on safety belt use has been investigated by a number of researchers in the past. A collection of papers (National Highway Traffic Safety Administration, 1986) contains works of several traffic safety experts from the U.S. and abroad on the effectiveness of safety belt use laws in about 20 countries as of 1985. Campbell and Campbell (1986) compare the effects of early safety belt use laws in the U.S. (1984-1986) with the effects of similar legislation in four foreign countries, which have had such laws much earlier.

A more detailed examination of the effects of safety belt use laws on use rates in New York, New Jersey, Illinois, and Texas is reported by Williams et al. (1987). They report the results of observational surveys at selected locations in these states before and after the laws went into effect. One of the main conclusions of the paper was that the use rates increased substantially in the first month the laws were effective, but declined in the following months. It also found use rates lower among passengers compared to drivers, males compared to females, younger individuals compared to older individuals, and at night compared to day. This relatively early work stresses the importance of enforcement of the law to achieve high use rates, and in particular, mentions primary enforcement as a crucial factor for safety belt use laws to be successful in increasing the use rates.

Campbell (1988) studied the relation between enforcement levels and safety belt use based on data on the number of safety belt citations and observational survey results from a group of about 20 states. Measures of statistical association such as Kendall's tau and simple regression slopes were calculated and discussed. The author observed that the association was stronger in primary enforcement states than in secondary enforcement states. Similar results are given in a more extensive report on state safety belt use laws by Campbell et al. (1988), where additional findings (based on belt use data in North Carolina) are reported, such as higher compliance among females than males, much lower compliance among drivers of trucks than drivers of passenger cars, lower belt use in rural areas than in urban areas.

The report by Hunter et al. (1990) presents the results of a three-year project sponsored by NHTSA and addresses several issues related to safety belt use, among them the effects of state laws. Much of the discussion in the section on this issue focuses on the problem of "lie factor" - that is overreporting of belt use in police accident reports due to the fact that crash-involved vehicle occupants tend to claim safety belt use to the investigating officer even when the belts were in fact not worn, presumably for fear of citation and fine. This problem with safety belt use data from crash reports has become particularly severe since safety belt use laws have become wide spread. The authors of this report conclude that "In short, the question, 'How does a State law affect seat belt use?' can at best only approximately be described from the accident data and more appropriately can be gleaned from the various observational studies that are being carried out in the belt law states. Inferences can be made from changes in injury patterns over time but are especially difficult to quantify. Clearly, the accident data is flawed and hence does not provide adequate direct answers to the question."

Unfortunately, the results of observational state surveys of safety belt use are of varying and uncertain quality and timing, provide only partial information in terms of time and locations covered, and their reporting is not always reliable. They are not suitable for the kind of comprehensive investigation undertaken in the present study.

The work of Escobedo et al. (1992) examines the relationship between safety belt use laws and safety belt use rates based on telephone surveys in a number of states participating in Behavioral Risk Factor Surveillance System (BRFSS) between 1984 and 1989. These authors performed comparisons of safety belt use rates between states with primary enforcement laws, states with secondary enforcement laws, and states with no safety belt use laws. They also compared use rates before and after laws became effective. These comparisons were done on data adjusted (standardized) for differences in distributions of age, race, sex and educational attainment in different states and aggregated across states. For several states which enacted safety belt use laws during the period covered by the study, the authors developed time series models (of exponentially weighted moving average type) with interventions to find changes in use rates when the laws became effective or when fines were imposed. The obvious limitation of the paper is that it only examines self-reported belt use in telephone surveys, which the authors themselves mention is subject to overreporting, in addition to other errors inherent in such surveys. However, they argue that past analyses suggest that overreporting is similar in states with and without safety belt use laws and relatively easy to predict, thus unlikely to invalidate the analysis. Another shortcoming of the study is that it uses data from only 15 states that participated in BRFSS continuously from 1984 to 1989 (only one of which had a primary enforcement law) to analyze trends in safety belt use, and aggregated data from states with secondary enforcement law, as well as those from states with no law. Thus, the analysis provides a fairly crude assessment of the effects of the laws. The time series intervention models are not described in the paper in much detail, but the choice of the models appears arbitrary. All these shortcomings notwithstanding, the results presented in the paper give substantial evidence of the effectiveness of safety belt use laws in increasing use rates and a strong case for primary enforcement laws.

A recent NHTSA-sponsored study (Ulmer et al., 1994) of the effects of the change in the California safety belt use law from secondary to primary analyzes observational data from six California counties, and from a survey by the California Department of Motor Vehicles given to applicants for renewal of driver licenses in these six counties. The statistical results presented in that study, which consist of simple rate comparisons, strongly indicate that the change to primary enforcement was associated with an increase in safety belt use. But, quite clearly, these results are very limited in their scope (area covered, time frame, amount of data), so they cannot be generalized.

A large number of papers in the literature have been devoted to analyzing the effects of state safety belt use laws on the numbers of fatalities and injuries resulting from motor vehicle crashes. Inasmuch as the purpose of safety belt use laws is to reduce fatalities and injuries, the papers attempting to model these numbers in relation to safety belt use laws directly address the issue of main concern to the lawmakers, traffic safety community, and the public. For example, Hoxie and Skinner (1987) developed a pooled cross-sectional regression model for quarterly per capita fatality rates among front seat occupants of passenger vehicles, covering all states and the period of 1975 to 1985. The results of Hoxie and Skinner have been used by the National Highway Traffic Safety Administration to estimate the effect of safety belt use laws on highway fatalities for its annual publications and in developing its legislative agenda. The present study provides the same type of estimates using an alternative approach. Because of the importance of these estimates for the programmatic needs of the agency, an update of the Hoxie and Skinner work has been done, in order to compare it with the results in the present study. This analysis is reported in Appendix 5.

It should be noted that the Hoxie and Skinner study does not emphasize the issue of primary enforcement, and does not consider the effects of the other differences in states' safety belt use laws. At the time when their study was done, enforcement options were not the focus of the debate over safety belt use laws. Furthermore, the data available to Hoxie and Skinner represented early experience with safety belt use laws and did not allow proper evaluation of the effects of primary enforcement. Finally, the model of fatality rates used by Hoxie and Skinner is rather simplified and raises concerns as to the accuracy of its predictions. The present study, which highlights the effects of primary enforcement and other provisions of the safety belt use laws, and which is based on belt use rates among motor vehicle occupants who were fatally injured or were involved in a potentially fatal crash, appears to be a preferred approach to evaluate the benefits of the laws and their different provisions in terms of lives saved. In fact, the two approaches ultimately lead to the same conclusions, and in particular, agree quite well on the critical issue of the benefits of primary enforcement.

In those studies which analyze traffic fatality data for the effects of safety belt use laws, time series methods are typically used, partially due to the seasonal nature of the numbers and severities of motor vehicle crashes. One should note that changes in the numbers of killed and injured in the crashes are not a direct consequence of the safety belt use legislation, but rather are induced by such legislation through the changes in safety belt use. They are also affected by other factors, such as changes in driving conditions (road conditions), technological progress changing motor vehicle safety, changes in risk exposure (measured by miles driven and speed limits), changes in driving skills and driving styles (related to social changes), susceptibility of individuals to injury, etc. Comprehensive models that would adequately explain fatality and injury rates must be more complicated (and consequently less reliable) than models pertaining to safety belt use only.

The approach of the present paper is that once a relationship between safety belt use law and use rate is established, one can estimate the effect of the law on fatalities and injuries using available information on the effectiveness of safety belts in preventing injuries, which has been quite well studied. Safety belt use in fatal crashes is modeled through several analytical approaches, which incorporate different factors as covariates. The choice of the data on safety belt use for this study was dictated by the desire to build a comprehensive model of safety belt use that would cover the whole country and the entire period from the time when the first safety belt use laws were enacted till the present. The FARS data appear well suited for this purpose since they have been systematically and consistently collected over this period of time in each state.

The restriction to using in this study information in FARS on only those fatally injured was necessary because of the "lie factor" mentioned above. Since restraint use in FARS is entered based on police reports, which in turn are subject to overreporting by those questioned by the investigating officer, it is certain that some of the data do not reflect true safety belt use. The degree of overreporting is not known and probably varies between states and over time. Thus, adjustments are not possible. On the other side, the information on safety belt use reported for those fatally injured is much less likely to be distorted. It is most often based on direct observation by police officers or other emergency services arriving on the scene of an accident, and there is less incentive to overreport it by the witnesses. When the data indicated restraint use as "unknown", the case was deleted from the analysis.

Furthermore, only persons age 16 years or older were included in the study. The use of restraints by children is subject to separate state laws and probably follows different patterns than in the adult population. Also, heavy trucks and buses were excluded from the analysis. The number of fatalities in these types of vehicles is very small compared to fatalities in passenger cars, light trucks and vans, so this exclusion does not affect the results. The use of safety belts by occupants of interstate trucks and buses is subject to federal regulations, so it again might follow different patterns than in the population of main interest for this study.

In this way, quite reliable information on safety belt use in a particular population was obtained. As mentioned above, the relationship between this population and the general population of motor vehicle occupants has been studied, and thus conclusions about the latter are possible. The present study appears to be the first comprehensive study of safety belt use based on FARS data. It provides definitive answers as to safety belt use among fatally injured in relation to safety belt use laws and strong evidence as to the effects of safety belt use laws on the general population.

3. State safety belt use laws.

Safety belts have been mandatory standard equipment in automobiles manufactured since Jan. 1, 1968, with the single-unit combined lap and shoulder belt standard on all cars manufactured since 1973 (Federal Motor Vehicle Safety Standard No. 208, as amended). However, mandatory safety belt use laws were enacted in the United States much later than in most countries in Europe, in Canada, and in Australia.

The first safety belt use laws were enacted in Australia, starting with the state of Victoria in 1970, and followed by other Australian states and New Zealand in the next two years. France was the first European country to pass a safety belt use law (July, 1973), followed in 1974 by Spain (law covering only roads outside of urban areas), and in 1975-1976 by the Scandinavian countries, Belgium, the Netherlands, Germany, Austria, and Switzerland. (The Swiss law was repealed in 1977 and reenacted in 1981). In 1976, two of the Canadian provinces (Ontario and Quebec) passed safety belt use legislation, followed one year later by Saskatchewan and British Columbia. By early 1984, all Canadian provinces, as well as Ireland and the United Kingdom had mandatory safety belt use laws. Most of these laws provide for primary enforcement (exceptions are Sweden and the Canadian province of Saskatchewan).

The first state to enact a safety belt use law in the U.S. was New York in July of 1984 (effective December 1984). The next several years saw unprecedented legislative activity related to safety belt use. For example, in 1985 a total of 112 bills requiring safety belt use were considered. Eight states (Hawaii, Illinois, Michigan, Missouri, Nebraska, New Jersey, North Carolina, Texas) and the District of Columbia put safety belt use laws in effect during that year. Laws in California, Connecticut and New Mexico became effective January 1, 1986, and eleven other states followed in the same year. In some states, the laws were repealed in public referenda after being enacted, but all of them were later reenacted. By January 1995, 48 states and the District of Columbia had safety belt use laws, and the only states remaining without a law in effect were Maine and New Hampshire.

As regards enforcement options provided by these laws, only nine states (California, Connecticut, Hawaii, New Mexico, New York, Iowa, North Carolina, Oregon, and Texas) currently allow primary enforcement, and the remaining 40 jurisdictions have secondary enforcement laws in effect. In 1993, California became the first state to upgrade its safety belt use law from secondary to primary. A number of states have considered such upgrades over the last several years. In 1986, Illinois amended its law to change its enforcement from primary to secondary but there is evidence that, in fact, the law has never been enforced on a primary basis (Illinois State Police, 1985). Another state that changed the provisions of its safety belt use law from primary to secondary is Mississippi (amendment effective July 1994). In this case, the original primary enforcement law provided for no penalty for offenders, which makes the significance of the primary enforcement questionable. The amended law (which provides for a $25 fine) may be more effective.

In spite of these examples, the current focus of the traffic safety community in the area of safety belt use laws is to increase their effectiveness through upgrades to primary enforcement with meaningful penalties. The present study is intended to assess the effectiveness of primary enforcement based on available safety belt use data.

The fine levels that are imposed on offenders are an important aspect of safety belt use laws affecting compliance levels. Here, the state laws vary widely, from those with no fine (Rhode Island and Wyoming) to $50 fines (New York and Oregon). In California, the fine is $22 for first time offenders and $55 for subsequent offenses. The typical fine is $25 (in about 20 states), $20 (8 states), or $10 (7 states). In some states, the law prescribes specific court costs or surcharges in addition to fines, and sometimes minimum or maximum fine levels are specified. In those cases, judgment had to be made for the purposes of the present analysis as to what was the penalty level associated with noncompliance. Court costs were generally added to the fine if they were explicitly mentioned in the law. For states where the penalty differed for the first-time offense and subsequent offenses, the penalty applicable to first-time offense was used in the analysis. In many states, the introduction of the safety belt use law was followed by a warning period with no fine, or with a reduced fine, before full penalty went into force. Fine levels were also upgraded by some states at different times. These variations in fine levels were utilized in this study to examine how penalty levels affect safety belt use.

The provisions of a safety belt use law determining whether its violation is a primary or a secondary offense and the penalty for its violation, characterize the enforcement aspect of the law. The laws also differ in the breadth of their coverage. In terms of the types of vehicles covered, three categories can be delineated: coverage restricted to passenger cars only (Georgia, Indiana, Missouri, New Jersey, New Mexico, Washington), coverage includes passenger cars, light trucks and vans (California, Connecticut, Florida, Idaho, Kansas, Louisiana, Maryland, Massachusetts, Minnesota, Nevada, New York, Oregon, Tennessee, Texas), and coverage includes all vehicles required to be equipped with safety belts (all other states).

From the point of view of traffic safety, the important concern is coverage of light trucks and vans. There is evidence (e.g. Campbell et al., 1988) that safety the belt use rate among drivers of vans is lower than the analogous rate among passenger car drivers, and the rate for pickup truck drivers is the lowest of all. Thus, the exclusion of these classes of vehicles leaves a large number of high-risk occupants outside of the scope of the safety belt use law.

The breadth of coverage of a safety belt use law is also affected by restricting coverage to the front seats. Currently, only twelve states have laws which cover all occupants. While a substantial majority of vehicle occupants travel in the front seats, the safety of rear-seat passengers is also affected by the use or non use of safety belts. The provisions of safety belt use laws determining if all seats are covered can potentially impact the use rates. The present analysis treats both vehicle type and seat coverage provisions as distinguishing factors among safety belt use laws.

All state laws contain certain provisions that exclude from safety belt use requirements occupants of special classes of vehicles, such as vehicles manufactured before safety belts had become standard equipment, vehicles used for deliveries and services requiring frequent stops (news, mail, utility readers, etc.), emergency vehicles, vehicles in farm work, public conveyances, buses, etc. The laws generally allow for exclusion from coverage of persons with valid medical excuses. Since these exclusions are limited to a small percentage of motor vehicle occupants, it can be presumed that they have little or no effect on general safety belt use rates, and consequently were not taken into account in this analysis.

In some states, safety belt use laws contain provisions mandating public information and education activities by various state government offices, and require evaluation of the effects of the law. These provisions do not specify in any detail the activities to be carried out, their scope or time frame. Thus, it is difficult to determine if and how they were implemented. It is possible that in some states without such mandates, more vigorous safety belt use campaigns were carried out than in states which had them. In the absence of such information, the provisions of the laws relating to public information programs cannot be usefully incorporated in the analysis of the effects of the laws.

It is also doubtful that the provisions pertaining to the effects of the law on civil actions, such as admission of evidence of non compliance to mitigate damages, have any effect on the use rates. Thus the provisions of safety belt use laws that entered into the statistical models in this study are: enforcement options (primary or secondary), fine level (penalty), vehicles covered (pickup trucks/vans or passenger cars only), and seats covered (all seats or front only).

4. Comparisons of safety belt use rates before and after a law.

For each of the states with a safety belt use law, monthly use rates among fatally injured vehicle occupants were computed for twelve months before and after the law went into effect. In this part of the analysis, only individuals covered (or to be covered) by the specific state law were included in the calculation. The collections of use rates for the periods before and after the law were then tested for normality with the Shapiro-Wilk test, which is part of PROC UNIVARIATE of SAS. It is reasonable to expect that the use rates are approximately normally distributed, since they can be viewed as a result of summing the Bernoulli (zero-one) random variables indicating use or non use of safety belts across fatalities in a given month. Indicators of safety belt use in fatalities occurring in different vehicles can be treated as statistically independent. Since almost all fatalities occur in different vehicles (with occasional cases of two fatalities in the same vehicle and very rare cases of more than two), the use rate is in fact a (normalized) sum of (approximately) independent random variables. As long as the number of summands is large, the Central Limit Theorem indicates that the use rate is normally distributed.

The normality tests performed on the data confirm this conclusion. Even for states with moderate numbers of fatalities counted (e.g. Connecticut or Massachusetts with 15-25 cases per month), the p-values of the Shapiro-Wilk test of the null hypothesis that the distribution is normal are above 0.20, strongly suggesting that the hypothesis is not to be rejected. The occasional p-values indicating possible departure from normality (which were observed even for some larger states) can be explained by relatively small sample sizes of 12 months or less. For the t-test to be valid, it is necessary that the samples be not only normally distributed, but also independent and stationary. Again, these assumptions appear to hold, at least approximately, for the monthly rates considered here. Although some autocorrelations were detected by Durbin-Watson tests for the series of monthly use rates spanning about a decade (cf. Section 5), in general the effect was not very strong. Also, a positive time trend, which is certainly present in most of the data, is significant on the scale of years, but can be neglected when considering samples consisting of 12 consecutive months or less. Thus, t-tests are a useful diagnostic tool to give a preliminary assessment of whether the enactment of a safety belt use law resulted in a change in the safety belt use rate.

In many states, the law became effective a few months to one year before a fine was imposed. If the time period between the effective date of the law and the fine was at least 4 months, three periods were considered (before law, between law and fine, and after fine) and two pairwise comparisons were performed. Also, when fine levels were changed, or a change occurred in enforcement options in a state's law, then the additional comparisons were made to assess the effects of the changes. The results of t-tests expressed by the p-values are presented below for those states for which such tests appeared appropriate based on Shapiro-Wilk tests and the sample sizes for each month. The p-values are adjusted for unequal standard deviations in cases when the test of equality of the variances turned out significant.

Listed first are those states for which the t-tests show a significant increase in safety belt use rates for the periods before and after a law, and for which a fine was effective coincidentally with the law. A majority of the states belong to this group. The enforcement option is indicated for each state, followed by mean use rates among fatally injured for the before and after the law periods, and the p-value of a t-test for the difference in mean use rates. An asterisk following a p-value means that the Shapiro-Wilk test for normality indicated possible lack of fit for one of the periods before or after the law; however, sample sizes appeared sufficiently large, and a direct examination of the mean use rates together with their standard deviations strongly suggested an effect of the law.

Arizona (secondary)	15.89% - 25.61%	p=0.0021
Arkansas (secondary	21.76% - 28.79%	p=0.0353
California (secondary)	2.97% - 9.05%	p=0.0001
upgrade to primary:	30.45% - 40.66%	p=0.0001
Colorado (secondary)	11.64% - 24.36%	p=0.0004(*)
Connecticut (primary)	9.43% - 25.51%	p=0.0006
(later increase in fine did not appear to change use rate:	25.13% - 26.11%	p=0.846)
Indiana (secondary)	10.11% - 27.45%	p=0.0001
Kansas (secondary)	5.35% - 11.55%	p=0.0216
Louisiana (secondary)	6.17% - 20.23%	p=~~0.0001(*)~~
Massachusetts (secondary)	16.90% - 26.49%	p=0.0115
Kentucky (secondary)	17.68% - 29.75%	p=0.0165
Maryland (secondary)	7.89% - 26.47%	p=0.0001
New Jersey (secondary)	5.27% - 31.09%	p=0.0001
New Mexico (primary)	6.15% - 16.22%	p=0.0256
(later upgrade to include trucks did not appear to change the use rate:	16.77% - 20.62%	p=0.1481)
New York (primary)	7.24% - 36.07%	p=0.0001
Ohio (secondary)	8.85% - 20.58%	p=0.0001
Oklahoma (secondary)	10.37% - 23.02%	p=0.0014
upgrade to include trucks:	11.67% - 18.57%	p=0.0478
Oregon (primary)	20.80% - 44.86%	p=0.0001
Pennsylvania (secondary)	15.42% - 24.85%	p=0.0001
South Carolina (secondary)	12.51% - 27.46%	p=0.0001
Texas (primary)	4.87% - 25.65%	p=0.0001
Virginia (secondary)	11.85% - 26.52%	p=0.0001
West Virginia (secondary)	18.75% - 34.10%	p=0.0018
Wisconsin (secondary)	10.02% - 27.29%	p=0.0006

For a number of states, the law took effect before fines were imposed. When the warning period between the effective date of the law and the fine was sufficiently long, t-test comparisons were performed for the periods before and after the fine, in addition to testing for the effect of the law itself. Listed below are the states for which the tests indicated a difference both between pre-law and post-law periods and between pre-fine and post-fine periods.

Florida (secondary)	law:	9.95% - 18.95%	p=0.0009
	fine:	18.95% - 24.65%	p=0.0267
Missouri (secondary)	law:	6.40% - 12.36%	p=0.0155
	fine:	13.96% - 25.79%	p=0.0013
Tennessee (secondary)	law:	5.01% - 10.80%	p=0.0039
	fine:	10.80% - 18.53%	p=0.0027

North Carolina (primary)	**law:**	**4.48% - 12.84%**	**p=0.0001**
	fine:	**17.29% - 31.85%**	**p=0.0001**
Washington (secondary)	**law:**	**10.23% - 16.04%**	**p=0.0570**
	fine:	**16.04% - 24.21%**	**p=0.0288**

In one state, enactment of the law appeared to have increased the use rate significantly, but the imposition of a fine did not seem to have significant additional effect (in fact, the mean rate is slightly lower for the period after the fine became effective).

Michigan (secondary)	**law:**	**10.01% - 32.15%**	**p=0.0001**
	fine:	**32.15% - 27.11%**	**p=0.1586(*)**

In one state, the enactment of the law did not mark a significant change in use rate, but a subsequent fine did increase the use rate.

Alabama (secondary)	**law:**	**12.95% - 15.06%**	**p=0.1863**
	fine:	**15.05% - 25.81%**	**p=0.0121**

In some states, the law did not seem to have affected safety belt use. In the following states the law and a fine were effective on the same date.

Georgia (secondary)	**28.26% - 28.42%**	**p=0.9135**
Illinois (primary)	**8.95% - 14.64%**	**p=0.0904**
change to secondary:	**14.91% - 15.87%**	**p=0.8582(?)**
Mississippi (primary)	**5.35% - 7.13%**	**p=0.2965**
change to secondary:	**17.64% - 16.06%**	**p=0.5979**

In the following states, neither the enactment of the law nor the imposition of a fine later resulted in statistically significant changes in use rates.

Iowa (primary)	**law:**	**10.83% - 17.20%**	**p=0.0776**
	fine:	**17.20% - 25.57%**	**p=0.1318(*)**
Minnesota (secondary)	**law:**	**12.21% - 13.31%**	**p=0.8091**
	fine:	**23.83% - 27.56%**	**p=0.4286**

(another increase in fine also had no significant effect: 26.40% - 30.27% p=0.3829)

Three states (Maine, New Hampshire, and South Dakota) had no safety belt use law during the period covered by this study. (The South Dakota safety belt use law took effect January 1, 1995.) For the remaining states, the sample sizes (numbers of fatalities per month) were too small to give reliable use rates that could be used to perform t-tests. The tests of normality indicated lack of fit for all periods for Alaska, District of Columbia, North Dakota, Rhode Island, Utah, and Wyoming. Of these states, only Utah had relatively stable sample sizes, and the mean use rates for persons killed in traffic accidents there were 6.56 percent for the 12 months before the law and 8.43 percent for the 12 months after the law. The Shapiro-Wilk test rejected the normality hypothesis for one of the periods before-the-law or after-the-law for Hawaii, Idaho, Montana, and Nevada. In Hawaii (primary enforcement state), the enactment of a safety belt use law was associated with an increase in mean use rate from 5.62 percent to 36.79 percent and in Montana the change was from 9.12 percent to 16.23 percent. A slight drop was recorded in Idaho and in Nevada (14.59 percent vs. 11.56 percent and 19.16 percent vs. 14.45 percent). A closer look at the sample sizes and the plots of the data suggested that using t-test p-values may not be appropriate, although the data for these states seem to carry more information than in the case of the previously mentioned six jurisdictions. In Delaware (29.37 percent vs. 32.95 percent) and Vermont (24.05 percent vs. 63.89 percent) the Shapiro-Wilk test did not reject normality hypothesis, but sample sizes were too small to produce reliable results. In Nebraska, the mean use rate increased from 7.89 percent before the law (Sep.'84 to Aug.'85) to 20.19 percent after the law (Oct.'85 to Oct.'86), and then declined to 9.72 percent (Dec.'86 to Dec.'87) when the law was repealed in November of 1986. The law was reenacted at the beginning of 1993, and the use rates climbed from 17.12 percent (Jan.'92 to Dec.'92) to 25.85 percent (Jan.'93 to Dec.'93). Again, although the test for normality did not reject the hypothesis, it was felt that the monthly sample sizes were too small to perform t-tests.

For the states with primary enforcement laws, a significant increase in safety belt use is indicated by the t-tests in all but three cases, which are discussed next. In Illinois, a p-value of 0.09 does not suggest much evidence of a change in the use rate. The observed mean use rate was 8.95 percent before the law and 14.64 percent after the law. A word of caution is in order about the Illinois data before the law (mid-1985): the sample sizes for that period are very small, apparently due to lack of recording of safety belt use in FARS. One also has to bear in mind that, as mentioned in Section 3, the Illinois law was most likely enforced as a secondary law (it was later amended to become secondary). In the case of Mississippi, the primary law provided for no fine, which casts much doubt on the effectiveness of its enforcement. Finally, Iowa, with its p-values 0.0776 and 0.1318, is a borderline case. The observed mean use rates for before-the-law, warning, and after-the-law periods are 10.83 percent, 17.20 percent, and 25.57 percent, respectively, showing an increasing tendency. However, the associated standard deviations were rather large.

Overall, the results of t-tests show very clearly that the enactment of safety belt use laws increased belt use rates. Except for the three cases discussed above, the primary enforcement states are among those with the most significant p-values.

5. Time series models of safety belt use rates in fatal crashes.

A more sophisticated approach to the analysis of monthly safety belt use rates than the simple before and after the law comparisons is to develop a linear model in which the use rate depends on a time trend (in months), an indicator of the presence of a law, and additional explanatory variables (covariates). In this analysis, the following covariate variables were used: crime index (per 100,000 population (CRIME_RT) (data provided by Federal Bureau of Investigations, Criminal Justice Information Services Division), per capita personal income (INCOME_P) (provided by U.S. Department of Commerce, Bureau of Economic Analysis), state per capita spending on highway law enforcement and safety (HW_SPEND) (from 'Highway Statistics', Federal Highway Administration), unemployment rate (UNEMP_RT) (provided by U.S. Department of Labor, Bureau of Labor Statistics). A time series model also takes into account possible correlations between successive observations by allowing autoregressive or moving average structure of the error terms and/or the dependent variable. For the states in which a fine took effect after the effective date of the safety belt use law, it is possible to include a variable indicating the fine in the model, and for those states which had both a secondary and a primary law at different times, an indicator of the type of law can be included.

After estimating the model, the effects of the law (and possibly of the fine, or of the enforcement option) can be assessed from the magnitude of the coefficient of the corresponding variable. Using this coefficient, one can also estimate the change in the use rate attributable to the law (or the fine, or the enforcement option). The covariates serve to adjust for the influence of factors other than the law on the use rate. However, an examination of their coefficients in the model may reveal additional information of interest about safety belt use rates and their relationship to the social and economic conditions. In this analysis, the pattern of use rates in each state is traced over a period of twelve years (1983 to 1994), and thus utilizes much more data than the simple comparisons presented in Section 4.

An important consideration in developing linear models for rates, proportions, and other variables with a restricted range, is the choice of transformation to be applied to the variable before the analysis. It is often advisable to transform the variable to improve the fit of the linear model, and to achieve an approximately normal distribution of the residuals. This is particularly important when the relation between the dependent and the independent variables is intrinsically nonlinear (for example, a multiplicative relationship). Several families of transformations are commonly used, the most popular being the logarithmic transformation of the form $y = \log(x+a)$, or a more general family of the form $y = ((x+a)^r - 1)/r$.

To determine the most suitable transformation to be applied to safety belt use rates, normality tests were performed on the rates transformed according to the above formula with different values of the parameters. It appeared that the logarithmic transformation was most suitable, with the value of $a \approx 0.07$ providing for the best fit. Thus, in this study, the actual dependent variable in all linear models is the logarithm of use rate shifted by 0.07. (Note that some shift is necessary because some use rates are zero.)

The first step in building the time series models was to perform the Durbin-Watson tests for serial correlations and the tests for heteroscedasticity (i.e., tests for constancy of the variance of the error terms). In general, after adjusting for the effects of the safety belt use law and the covariates, the state time series exhibit relatively little autocorrelation. For the states with reliable monthly use rates (judged by the sample sizes of monthly fatalities as in Section 4), significant p-values of the Durbin-Watson statistic are given below. The subscript indicates lag order at which autocorrelation was detected (i.e., p_5=0.0004 means that the lowest lag order at which a significant autocorrelation was detected is 5 and the p-value is 0.0004).

Alabama	p_1=0.0079	Mississippi	p_6=0.0278
Arizona	p_5=0.0259	Missouri	p_3=0.0428

Arkansas	p_1=0.0013	New Jersey	p_4=0.0157
California	p_1=0.0046	New Mexico	p_6=0.001
Colorado	p_5=0.0004	New York	p_6=0.0051
Connecticut	p_7=0.0123	North Carolina	p_1=0.011
Georgia	p_4=0.0101	Oklahoma	p_1=0.0002
Illinois	p_2=0.034	Oregon	p_{12} =0.0338
Iowa	p_3=0.0006	Pennsylvania	p_4=0.0382
Louisiana	p_7=0.001	Texas	p_1=0.0002
Massachusetts	p_1=0.0226	Virginia	p_4=0.0036
Michigan	p_1=0.0008	Wisconsin	p_1=0.0064
Minnesota	p_{11} =0.0232		

A linear model was then fit to the data with the regressors mentioned above (income, unemployment, crime, traffic safety spending) and with autoregressive error structure. That is, a model $y_t=b_1x_{1t}+...+b_kx_{kt}+\varepsilon_t$ was fit, where

y_t - use rate in month t,

x_{it} - i-th covariate in month t (including indicators of the presence of a law, etc.),

ε_t - error term, assumed to have the structure $\varepsilon_t=a_1\varepsilon_{t-1}+...+a_m\varepsilon_{t-m}+\eta_t$ and η_t are independent.

In general, it may be difficult to interpret the coefficients a_1, ... , a_m and to explain why in some states they proved significant. However, including them in the model improves the fit by adjusting for possible autocorrelations in the data, which might otherwise cause misleading results of fitting the terms of main interest (those relating to safety belt use laws in particular).

A backward elimination procedure of PROC AUTOREG of SAS was employed to successively eliminate autoregressive error terms with nonsignificant coefficients. The maximum order of autoregression was m=13. For most states, the method eliminated all autoregressive terms, resulting in ordinary linear regression models. The states for which the procedure resulted in models with autocorrelation terms are listed next, together with an indication of which coefficients were left and their associated significance probabilities (based on the Durbin-Watson tests).

Arkansas	a_1 (p=0.0092), a_5 (p=0.0176)
Colorado	a_4 (p=0.0196), a_5 (p=0.0029)
Georgia	a_6 (p=0.0002), a_7 (p=0.0274), a_{13} (p=0.0019)
Illinois	a_8 (p=0.003), a_{10} (p=0.0078)
Iowa	a_3 (p=0.0066)
Louisiana	a_7 (p=0.0068)
New Mexico	a_4 (p=0.0272), a_5 (p=0.0094), a_6 (p=0.0033), a_8 (p=0.0239)
Ohio	a_9 (p=0.026)
Oklahoma	a_1 (p=0.0042), a_3 (p=0.024)
South Carolina	a_7 (0.0176)
Tennessee	a_2 (p=0.0004)
Texas	a_7 (p=0.0025)
Virginia	a_9 (p=0.0045)

Washington a_{10} (p=0.005), a_{11} (p=0.0299)
West Virginia a_2 (p=0.03)

The results of estimating the time series models are first presented for the states where the enactment of the safety belt use law (or imposition of a fine later) appeared to affect the use rate significantly. The enforcement option is specified and the estimate of the coefficient of the law indicator (or fine indicator, or enforcement option indicator) is given, followed by the coefficient's standard deviation (in parentheses) and a p-value for its significance.

Alabama (secondary)	b=0.0958	(0.1457)	p=0.5122
fine:	b=0.0146	(0.0058)	p=0.0132
California (secondary)	b=0.0959	(0.0951)	p=0.3151
upgrade to primary:	b=0.2502	(0.0789)	p=0.0019
Colorado (secondary)	b=0.4958	(0.1235)	p=0.0001
Connecticut (primary)	b=0.6810	(0.1733)	p=0.0001
Florida (secondary)	b=0.3392	(0.0827)	p=0.0001
fine:	b=0.0044	(0.0036)	p=0.2314
Georgia (secondary)	b=0.2721	(0.0892)	p=0.0027
Illinois (primary)	b=0.6944	(0.2144)	p=0.0015
change to secondary:	b=0.1466	(0.1197)	p=0.2229
Indiana (secondary)	b=0.5199	(0.1091)	p=0.0001
Kansas (secondary)	b=0.4171	(0.1753)	p=0.0188
fine:	b=0.0419	(0.0153)	p=0.0071
Louisiana (secondary)	b=0.6954	(0.2317)	p=0.0032
fine:	b=-0.0102	(0.0092)	p=0.2696
Maryland (secondary)	b=0.5655	(0.1081)	p=0.0001
Michigan (secondary)	b=0.7507	(0.1031)	p=0.0001
Minnesota (secondary)	b=0.3241	(0.1592)	p=0.0437
fine:	b=0.0085	(0.0112)	p=0.4513
Missouri (secondary)	b=0.3563	(0.1201)	p=0.0036
fine:	b=0.0310	(0.0138)	p=0.0260
New Jersey (secondary)	b=1.0656	(0.1057)	p=0.0001
New Mexico (primary)	b=0.4603	(0.1433)	p=0.0017
New York (primary)	b=1.0851	(0.0672)	p=0.0001
North Carolina (primary)	b=0.6164	(0.0712)	p=0.0001
fine:	b=0.0196	(0.0033)	p=0.0001
Ohio (secondary)	b=0.4926	(0.1467)	p=0.0010
fine:	b=0.0032	(0.0079)	p=0.6842
Oklahoma (secondary)	b=0.7633	(0.1603)	p=0.0001
Oregon (primary)	b=0.6381	(0.1387)	p=0.0001
South Carolina (secondary)	b=0.6278	(0.0876)	p=0.0001
Tennessee (secondary)	b=0.2760	(0.0836)	p=0.0012
fine:	b=0.0071	(0.0029	p=0.0144
Texas (primary)	b=0.6768	(0.0754)	p=0.0001
fine:	b=0.0093	(0.0026)	p=0.0005
Virginia (secondary)	b=0.4752	(0.0948)	p=0.0001
Washington (secondary)	b=0.1414	(0.1062)	p=0.1855
fine:	b=0.0096	(0.0032)	p=0.0037
West Virginia (secondary)	b=0.4105	(0.1135)	p=0.0004
Wisconsin (secondary)	b=0.7098	(0.1715)	p=0.0001

The analogous results for the states where the law did not appear to have any significant effect are as follows.

Arizona (secondary)	b=0.2234	(0.1464)	p=0.1293
Arkansas (secondary	b=0.0827	(0.2506)	p=0.7420
Iowa (primary)	b=0.2953	(0.2149)	p=0.1716
fine:	b=0.0078	(0.0090)	p=0.3904
Kentucky (secondary)	b=0.1626	(0.1318)	p=0.2193
Massachusetts (secondary)	b=0.1219	(0.2677)	p=0.6497
Mississippi (primary)	b=-0.1958	(0.1541)	p=0.2062
change to secondary:	b=0.0497	(0.1061)	p=0.6402
Pennsylvania (secondary)	b=0.0164	(0.0987)	p=0.8686
fine:	b=0.0084	(0.0100)	p=0.4056

The above results generally confirm the results of comparisons of safety belt use rates immediately before and immediately after enactment of the law. The coefficients of the variables indicating presence of the laws are positive and highly significant for most states, showing that the laws resulted in increases in use rates. The time series models allow one to see this effect on a time scale of about twelve years, as opposed to studying the local effects of the laws, which was done when comparing the rates for periods of one year before and after the enactment.

However, there are some notable differences, discussed next. For six states (Arizona, California, Kentucky, Massachusetts, Pennsylvania, Washington), the time series models show no significant effect of the law, where the before-and-after t-tests were significant. In these cases, the coefficients of the variable indicating presence of a law were positive, but the corresponding standard deviation was large, resulting in a p-value in the range of 10% to 30% (except for Massachusetts and Pennsylvania, where the p-values are larger). For three states (Georgia, Minnesota, Illinois), the opposite effect is observed: the time series model indicates a significant effect of safety belt use law, while the t-test comparisons do not indicate a difference in safety belt use rates.

The magnitude of the discrepancy is somewhat surprising in the case of Georgia and Pennsylvania. For these states, a visual examination of the plot of use rates over time quite clearly shows a change at about the point where the law went into effect. In Massachusetts and Kentucky, a safety belt use law was enacted in 1994, which corresponds to the end segment of the time series. Thus, the analysis for these states is based on use rates for only a few months when a law was in effect, which may be responsible for a loss of accuracy in the analysis. Also, the FARS database for 1994 is not yet complete.

Finally, comments are in order for California and Illinois, which are particularly interesting cases. In California, the law became primary in 1993 (both the t-test and time series analysis results show a very significant effect of this change), and Illinois changed its law from primary to secondary in 1988 (as mentioned earlier, the law was probably always enforced as secondary). Unfortunately, in both of these states the safety belt use data in FARS for the period before the enactment of their original safety belt use laws (second half of 1985) are not satisfactory. Apparently, safety belt use was mostly coded as "unknown" in FARS during this period, resulting in only a fraction of fatalities available for the present analysis. This problem is particularly severe in Illinois before Aug. 1985.

In general, one can explain the differences between local use rate comparisons before and after a safety belt use law and the results of time series analysis by saying that the latter indicate a long term effect of a law, while the former pertain to the immediate effects, possibly due to increased publicity associated with the passage of a law and public information and enforcement campaigns undertaken by state authorities. It has been observed in previous studies (e.g., Williams et al., 1987) that after an initial surge in safety belt use, there is a tendency for the rates to decline when the campaign is over.

In this context, primary enforcement laws appear even more effective in increasing use rates than the results of t-test comparisons indicated. Except for the three states discussed earlier (Mississippi, Illinois, and Iowa), the results of the time series analysis show that for primary enforcement states the coefficients of the variable indicating that a safety belt use law was in effect are among the largest and most significant in a smaller group of states where a significant effect of the law can now be observed.

The time series models presented in this section incorporate the effects of factors other than the laws requiring safety belt use. The coefficients corresponding to these variables turned out to be nonsignificant in most cases, with the following exceptions.

California	CRIME_RT	b=-0.0038	(p=0.0401)
Colorado	INCOME_P	b=-1.5028	(p=0.0299)
Florida	CRIME_RT	b= 0.0024	(p=0.0001)
	INCOME_P	b=-1.6207	(p=0.0001)
Georgia	UNEMP_RT	b= 0.0724	(p=0.0083)
Kentucky	UNEMP_RT	b=-0.0599	(p=0.0477)
Louisiana	CRIME_RT	b=-0.0045	(p=0.0043)
	INCOME_P	b=-2.6399	(p=0.0005)
Massachusetts	UNEMP_RT	b=-0.1207	(p=0.0296)
Mississippi	CRIME_RT	b= 0.0083	(p=0.0024)
	HW_SPEND	b=-0.2405	(p=0.0249)
New York	CRIME_RT	b=-0.0018	(p=0.0214)
Ohio	CRIME_RT	b=-0.0024	(p=0.0370)
Oklahoma	CRIME_RT	b= 0.0028	(p=0.0022)
	HW_SPEND	b=-0.2645	(p=0.0186)
Oregon	UNEMP_RT	b= 0.0792	(p=0.0154)
Pennsylvania	UNEMP_RT	b=-0.0713	(p=0.0001)
South Carolina	CRIME_RT	b= 0.0033	(p=0.0399)
Tennessee	UNEMP_RT	b=-0.0589	(p=0.0008)
Texas	HW_SPEND	b=-0.0975	(p=0.0079)
Virginia	UNEMP_RT	b=-0.1230	(p=0.0003)
	HW_SPEND	b=-0.1569	(p=0.0202)
Washington	UNEMP_RT	b=-0.0502	(p=0.0089)

One notices that rising unemployment rates are associated with declining safety belt use rates (except for Georgia). Also, higher crime rates seem to be associated with higher safety belt use rates in several states where the coefficient of the crime index variable is very significant, but the opposite relationship is observed in a few other states. Surprisingly, a significant negative coefficient of the variable "highway safety spending" is observed for four states. In general, the socio-economic variables do not appear to explain belt use rate patterns very well in the analysis of individual states. However, they were very useful in the cross-sectional analysis discussed in the next section.

The linear model with autoregressive error terms is not the only time series model that could be used for the data. Another approach to modeling dependencies in time series is to introduce autoregressive terms for the dependent variable; that is to consider the model $y_t = c_1 y_{t-1} + c_2 y_{t-2} + \ldots + c_p y_{t-p} + b_1 x_{1t} + \ldots + b_k x_{tk} + \varepsilon_t$, where ε_t are independent and identically distributed random variables. Models of this form were estimated for different numbers of autoregressive terms p. The results were in agreement with those presented above for the autocorrelated error term structure, producing in most cases remarkably close estimates of the coefficients, particularly in cases when these coefficients are significant. Finally, mixed "autoregressive-moving average" models were fit, which incorporate autoregressive terms for the dependent variable and moving average error term structure (i.e. $\varepsilon_t = \eta_t - d_1 \eta_{t-1} - \ldots - d_q \eta_{t-q}$, where η_t are independent and identically distributed random variables). The results were again similar. The estimates of the coefficients of the safety belt use law variables for some of these models are presented in Appendix 3.

6. Linear regression analysis of safety belt use rates.

While the state-by-state analysis of the time series of safety belt use rates provides much useful information on the effects of safety belt use laws on safety belt use, it does not allow a direct assessment of the overall effect of the enactment of the laws, their enforcement options and their other provisions. The magnitude of the effect of the law (and the primary enforcement provision) cannot be compared directly between states based on the coefficients in the linear models for individual states, since each model has a different structure, which complicates such comparisons. A possible remedy to this situation is to develop cross-sectional regression models encompassing all states. In such models, observations correspond to different states at different times.

The simplest such model assumes that all error terms are uncorrelated. Yearly safety belt use data were modeled as the dependent variable. This allows the use of data from all states over the period of twelve years. Even for states with low monthly numbers of fatalities with known safety belt use, the yearly totals are sufficient to provide reasonable estimates. (The only data that had to be excluded from the analysis were Mississippi 1983-85 data, where, due to an error, no safety belt use was recorded in FARS in that period.) This resulted in 12 observations for each state, and a total of over 600 observations. The cross-sectional model allowed inclusion of more state covariates than individual state models, since one can include any variable that differs from state to state (even if its variability over time is low or the information about it is not available for all months/years).

Thus, the regressors included: a time trend (in years) (YR), indicator of the presence of a safety belt use law (LAW), indicator of the primary enforcement option (PRIMARY), indicator of the coverage of all seats by the law (ALL_SEAT), indicator of the coverage of pickup trucks and vans (ALL_VEH), fine level (penalty) (FINE); and the state-level covariates: per capita personal income (in thousands of dollars) (INCOME_P), unemployment rate (unadjusted) (UNEMP_RT), per capita state spending on highway law enforcement and safety (HW_SPEND), crime index (per 100,000 population) (CRIME_RT), percentage of urban population (URB_POP), percentage of high school-educated population (EDU_HS). The last two variables could not be included in state-by-state analysis, since information about them for each state was available only from the U.S. Census data for 1980 and 1990. An interpolation was used to obtain the values for other years. However, these variables provide important characteristics of the states.

The results of fitting a linear regression model of annual state safety belt use rates for individuals killed in traffic accidents (subject to the same logarithmic transformation as before) are presented next.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|	Standardized Estimate	Tolerance
INTERCEP	1	-3.033182	0.13055197	-23.234	0.0001	0.00000000	.
FINE	1	0.007983	0.00120796	6.609	0.0001	0.21320880	0.30348919
YR	1	0.045940	0.00497586	9.232	0.0001	0.32315237	0.25784451
LAW	1	0.213870	0.04285215	4.991	0.0001	0.21754748	0.16625815
PRIMARY	1	0.138981	0.03169823	4.385	0.0001	0.09429770	0.68292652
ALL_SEAT	1	0.007242	0.03246428	0.223	0.8236	0.00443865	0.79785546
ALL_VEH	1	0.011014	0.03425653	0.322	0.7479	0.01120912	0.25988394
INCOME_P	1	0.018403	0.00448568	4.103	0.0001	0.14529070	0.25187586
UNEMP_RT	1	-0.010125	0.00476637	-2.124	0.0341	-0.04319524	0.76402979
EDU_HS	1	0.011009	0.00176425	6.240	0.0001	0.14609371	0.57631192
URB_POP	1	-0.002234	0.00101065	-2.211	0.0274	-0.06832834	0.33069333
HW_SPEND	1	0.001439	0.00074077	1.942	0.0526	0.03849911	0.80384096
CRIME_RT	1	0.000016311	0.00000886	1.840	0.0663	0.04861348	0.45250287

One immediately notices that the variables indicating presence of a safety belt use law and its enforcement option are among the most significant ones. In order to eliminate nonsignificant variables and to produce a more parsimonious model, a stepwise regression approach was employed, which resulted in a model with only time trend, indicator of law, indicator of primary enforcement, fine level, income level, unemployment rate, educational attainment, and highway spending. The stepwise procedure used (in PROC REG of SAS) had a p-value of 15% cutoff point for inclusion of a variable in the model. The estimated parameters are as follows.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|	Standardized Estimate	Tolerance
INTERCEP	1	-3.050465	0.12844776	-23.749	0.0001	0.00000000	.
FINE	1	0.008058	0.00116898	6.893	0.0001	0.21520905	0.32484004
YR	1	0.050584	0.00404553	12.504	0.0001	0.35582228	0.39099928
LAW	1	0.216422	0.03061368	7.069	0.0001	0.22014281	0.32653527
PRIMARY	1	0.143703	0.03036446	4.733	0.0001	0.09750144	0.74601164
INCOME_P	1	0.014479	0.00366203	3.954	0.0001	0.11430966	0.37881793
UNEMP_RT	1	-0.008840	0.00465450	-1.899	0.0580	-0.03771387	0.80310603
EDU_HS	1	0.010630	0.00173773	6.117	0.0001	0.14106035	0.59545327
HW_SPEND	1	0.001596	0.00072454	2.202	0.0280	0.04269973	0.84225722

These results show quite clearly that enactment of a safety belt use law results in a very significant increase in safety belt use. One can use the regression coefficients to find the percentage change in the use rates due to change in individual variables (assuming that all other variables are held constant). Since the dependent variable is a logarithmic transformation of the actual use rate translated by a small constant, it is necessary to apply an inverse transformation to the coefficient to obtain the desired result. These calculations suggest at least 25 percent increase in use rate when a law is present. The results also show that an additional increase of at least 15 percent is associated with the primary enforcement of the law. The fine level is found to be directly related to the effectiveness of the law. The estimated model indicates that each $1 increase in the fine level is associated with about 0.8 percent increase in use rate. The provisions of state laws relating to seats covered and vehicles covered did not seem to affect the use rates in this model. One ought to bear in mind that the above results represent national averages. The results do not say that passage of a safety belt use law, enactment of primary enforcement, or changes in fine levels, in any particular state should be expected to produce the changes in belt use indicated above.

It is interesting to note the association between social and economic covariates and safety belt use. The most significant ones appear to be educational attainment and income levels, both positively correlated with safety belt use rates.

The R^2 of the model is about 81%, indicating a good fit.

The social and economic covariates were used in the model mainly to account for state differences, which may determine how the laws affect safety belt use rates. Another approach to adjusting for the differences between states in the effects of the provisions of safety belt use laws is to include dummy variables for states in the model. In addition to the variables indicating the provisions of safety belt use laws in the jurisdiction where the observation comes from, there are 50 variables, each indicating whether the observation comes from a particular state. The resulting estimates of the coefficients pertaining to safety belt use laws are similar to the ones estimated for the model with socio-economic covariates, although after the stepwise elimination procedure, the estimates of the coefficients of the law and primary enforcement indicators are larger.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|	Standardized Estimate	Tolerance
INTERCEPT	1	-2.055972	0.01869355	-109.983	0.0001	0.00000000	.
FINE	1	0.005136	0.00119660	4.292	0.0001	0.13717777	0.21119285
YR	1	0.073774	0.00285152	25.872	0.0001	0.51895102	0.53612506
LAW	1	0.284466	0.03012852	9.442	0.0001	0.28935745	0.22966617
PRIMARY	1	0.230820	0.03473778	6.645	0.0001	0.15660985	0.38829722

(Coefficients of state dummy variables are not presented.)

The model with dummy variables for states has R^2 of 87%.

One can also include both socio-economic covariates and state dummy variables together, but the estimated model does not provide any additional insights and does not improve the fit. However, it may be worth observing that stepwise regression in this model eliminates the variable INCOME_P (which originally enters the model very early), but leaves in the model the education and crime rate (both positively correlated with the use rates), as well as the unemployment rate (negatively correlated with use rates).

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|	Standardized Estimate	Tolerance
INTERCEP	1	-3.167926	0.14494804	-21.856	0.0001	0.00000000	.
FINE	1	0.004504	0.00106260	4.239	0.0001	0.12030454	0.24586349
YR	1	0.059729	0.00329575	18.123	0.0001	0.42015005	0.36844368
LAW	1	0.251356	0.02760225	9.106	0.0001	0.25567827	0.25120359
PRIMARY	1	0.192348	0.03096781	6.211	0.0001	0.13050680	0.44854869
UNEMP_RT	1	-0.024172	0.00453703	-5.328	0.0001	-0.10311972	0.52860148
EDU_HS	1	0.013046	0.00194018	6.724	0.0001	0.17311768	0.29873312
CRIME_RT	1	0.000070424	0.00001081	6.514	0.0001	0.20989493	0.19075671

(Coefficients of state dummy variables are omitted.)

The above estimates of increases in safety belt use due to enactment of safety belt use law, primary enforcement of the law and increased fine levels, pertain to use among fatally injured. In order to obtain estimates characterizing a larger population, one can use the same regression model applied to safety belt use rates for individuals involved in potentially fatal crashes. As mentioned in Section 1, this is given by (u/0.55)/((u/0.55)+(1-u)), where u is the use rate among fatally injured. Safety belt use rate in potentially fatal crashes is a hypothetical figure obtained based on the known effectiveness of safety belts in preventing fatal injuries (considered to be about 0.45, see National Highway Traffic Safety Administration, 1984). Estimates obtained for individuals involved in potentially fatal crashes are important, because it is the population at the highest risk.

The results of estimating the regression model of safety belt use in potentially fatal crashes (with stepwise elimination) are as follows.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|	Standardized Estimate	Tolerance
INTERCEP	1	-2.772798	0.14087253	-19.683	0.0001	0.00000000	.
FINE	1	0.007384	0.00127696	5.782	0.0001	0.18696713	0.32399958
YR	1	0.048666	0.00539365	9.023	0.0001	0.32455743	0.26180463
LAW	1	0.251599	0.03484097	7.221	0.0001	0.24263532	0.30005206
PRIMARY	1	0.123804	0.03319199	3.730	0.0002	0.07963841	0.74306433
INCOME_P	1	0.018300	0.00488084	3.749	0.0002	0.13697195	0.25380582
UNEMP_RT	1	-0.016178	0.00516955	-3.129	0.0018	-0.06543094	0.77487022
EDU_HS	1	0.012109	0.00191123	6.336	0.0001	0.15234515	0.58587340
URB_POP	1	-0.002957	0.00110207	-2.683	0.0075	-0.08572164	0.33178501
HW_SPEND	1	0.001502	0.00080204	1.873	0.0616	0.03811271	0.81809349
CRIME_RT	1	0.000022428	0.00000968	2.316	0.0209	0.06337554	0.45250561

If instead of state social and economic covariates, state dummy variables are used, we have these results.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|	Standardized Estimate	Tolerance
INTERCEP	1	-1.781045	0.02121771	-83.941	0.0001	0.00000000	.
FINE	1	0.004376	0.00141442	3.094	0.0021	0.11079980	0.19467773
YR	1	0.079051	0.00323618	24.427	0.0001	0.52719175	0.53611053

LAW	1	0.326238	0.03422452	9.532	0.0001	0.31461457	0.22923404
PRIMARY	1	0.211568	0.03975690	5.322	0.0001	0.13609291	0.38180752
ALL_SEAT	1	-0.057992	0.03590599	-1.615	0.1068	-0.03369840	0.5736244

(Coefficients of state dummy variables are omitted.)

The inclusion of state dummy variables in the model inflates the values of the coefficients of the variables LAW and PRIMARY, but also causes the variable ALL_SEAT to be more significant (with a negative coefficient). An analysis of several alternative models indicates that these effects may be due, at least in part, to interactions between the indicators of safety belt use laws and the state dummy variables. The tolerances of the variables in the models with the dummy variables are much lower than in the models without them. In the discussion of the results, estimators for the model with social and economic covariates only will be used. This does not change the qualitative conclusions, and appears to be a conservative approach.

The implications of the results are that: among persons involved in potentially fatal crashes, enactment of a safety belt use law in a state is associated, on the average, with 28.6 percent increase in safety belt use; primary enforcement of the law leads to an additional average increase of 13.2 percent, and when the fine is $1 higher, safety belt use is observed to be about 0.74 percent higher.

It is possible to combine the cross-sectional regression approach with time series analysis in models called time series cross-sectional regression (PROC TSCSREG in SAS). Monthly use rate time series for the selected states (as in Sections 4 and 5) were used. In this approach, one regression model is built, encompassing all the states with a common regression term, and the structure of the error term accounts for the differences between states as well as for the correlations between the observations over time. The regressors in these models were: time trend (in months), per capita personal income (in thousands of dollars), per capita state highway safety spending (in dollars), crime index (per 100,000 population), unemployment rate (unadjusted), percent urban population, educational attainment (percent of population who completed high school), and the safety belt use law indicators.

Three different models were estimated. The results, presented in Appendix 4, largely confirm the findings based on the cross-sectional regression model of this section. The estimated coefficients of the variable LAW is between 0.289 and 0.315, which is similar to the values 0.214 to 0.284 obtained for the regression models above. The coefficients of the variable PRIMARY were estimated between 0.09 and 0.19, which is a wider range, but not very far from the values of 0.14 to 0.23 resulting from the analysis of this section. The FINE variable had coefficients 0.0044 to 0.0057, compared to the estimates 0.0045 to 0.0080 of this section.

7. Logistic regression models of safety belt use.

The final, and perhaps most powerful approach to the analysis of safety belt use data across states and of the effects of safety belt use laws, is the logistic regression model. Here, instead of modeling use rates per month or per year, one directly models the variable indicating use or non-use of safety belt, (or, equivalently, the probability of motor vehicle occupants using the safety belt), as a function of the regressors. The observations correspond to individual fatalities, which allows one to incorporate among the covariates individual-level variables, such as age (AGE), gender (FEMALE), vehicle type (passenger car or truck) (TRUCK), vehicle age (VEH_AGE), type of road (urban or rural) (URBAN), time of accident (day or night) (DAY). It is also possible to distinguish between drivers and passengers, and between front seats and rear seats occupants (REAR). In addition to this, one can include in the model all the covariates that appeared in linear regression models. Given the amount of data (over 270,000 observations available for the analysis with no missing values), this type of model utilizes a lot of information and one can expect the results to be very accurate.

Alcohol involvement is well known to strongly (negatively) affect safety belt use, and a corresponding variable (DRINKING) is found in the FARS database. However, it is not included in the main analysis of the logistic regression model because of a high proportion of observations with missing or unknown values. In some states the proportion of fatally injured motorists with unknown alcohol use is over 70 percent, although some other states have nearly perfect alcohol involvement reporting. In many states' data, a tendency is evident to record the alcohol involvement variable only when alcohol was in fact involved (so that no record is made when alcohol was not involved). The problems are particularly severe in the data on passengers.

Simply omitting the observations for which alcohol involvement variable value is missing could lead to a biased analysis. For example, if the fatalities for drinking motor vehicle occupants are overrepresented in the data, then the effect of safety belt use law might be attenuated, since drunk individuals may be less concerned with whether the law requires the use of safety belts or not. In view of these problems, it is remarkable that when the variable indicating alcohol involvement is included among the explanatory variables (at the cost of losing observations with unknown alcohol involvement), the results pertaining to the effects of safety belt use laws and their provisions remain relatively little changed. This is in spite of about 27 percent missing values for drivers and 66 percent missing values for passengers.

Stepwise regression was again utilized to eliminate nonsignificant variables, as in the linear regression model. The software used was PROC LOGISTIC of SAS. One could adjust for state differences by including social and economic covariates, dummy variables for states, or both. While the coefficients of most of the variables in the model, including the variables indicating the presence of a safety belt use law (LAW) and its enforcement option (PRIMARY), are not very strongly affected by the choice of the approach to adjusting for state differences, the coefficient of the variable indicating coverage of all seats by a safety belt use law (ALL_SEAT) changes quite dramatically. When dummy variables for the states are used, this latter variable appears not very significant (and with a negative coefficient), but in the models without dummy variables for the states, the variable ALL_SEAT has significance levels comparable to the variables LAW and PRIMARY, although its estimated coefficient (of a positive sign) and its associated odds ratio are not quite as large.

It appears that the variable ALL_SEATS (which takes value 1 for the states with a safety belt use law covering all seats in the months when such law was in effect, and 0 otherwise), acts as a proxy for the indicator variables of the group of states with a law covering all seats (the dummy variables). This conjecture is corroborated by the fact that when the observations from the state of California are excluded from the analysis, then the significance of the variable ALL_SEAT is drastically reduced, even without the dummy variables in the model. (California is a state with a safety belt use law covering all seats and it contributes a large majority of observations among the states with a law covering all seats.)

In view of the fact that the main variables of interest (in particular, safety belt use law indicator and primary enforcement indicator) are little affected regardless of whether adjustment for state differences is through the dummy variables, the social and economic covariates, or both, results for the models involving dummy variables are not presented.

Separate logistic regression analyses of safety belt use were performed for drivers and for passengers. Shown first are the results of estimation of the model for drivers.

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-5.0577	0.0870	3379.8065	0.0001	.	0.006
MONTH_YR	1	0.00838	0.000319	690.1207	0.0001	0.181271	1.008
DAY	1	0.5456	0.0130	1765.8528	0.0001	0.148801	1.726
TRUCK	1	-0.7411	0.0158	2206.6445	0.0001	-0.179451	0.477
AGE	1	0.0120	0.000316	1442.6715	0.0001	0.126957	1.012
FEMALE	1	0.4295	0.0129	1099.8691	0.0001	0.106031	1.536
VEH_AGE	1	-0.0924	0.00129	5144.7137	0.0001	-0.285447	0.912
LAW	1	0.6197	0.0286	469.7944	0.0001	0.164654	1.858
PRIMARY	1	0.3654	0.0177	426.8240	0.0001	0.077430	1.441
ALL_SEAT	1	0.3153	0.0188	281.5600	0.0001	0.054724	1.371
ALL_VEH	1	0.0553	0.0207	7.1668	0.0074	0.015192	1.057
FINE	1	0.00801	0.000755	112.5838	0.0001	0.060805	1.008
INCOME_P	1	0.1933	0.0455	18.0414	0.0001	0.031231	1.213
EDU_HS	1	0.0186	0.00147	161.0643	0.0001	0.067121	1.019
URB_POP	1	-0.00327	0.000906	13.0185	0.0003	-0.023766	0.997
HW_SPEND	1	0.0208	0.00649	10.3033	0.0013	0.011258	1.021
CRIME_RT	1	0.000629	0.000074	72.7031	0.0001	0.041614	1.001

The analogous results for passengers are as follows.

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-4.5463	0.1456	974.4216	0.0001	.	0.011
MONTH_YR	1	0.00877	0.000362	587.6802	0.0001	0.189700	1.009
DAY	1	0.4242	0.0220	372.9473	0.0001	0.115411	1.528
URBAN	1	0.0504	0.0213	5.6203	0.0178	0.013079	1.052
TRUCK	1	-0.8221	0.0273	906.6001	0.0001	-0.189230	0.440
AGE	1	0.0196	0.000476	1699.9093	0.0001	0.237345	1.020
FEMALE	1	0.3304	0.0182	329.5965	0.0001	0.101629	1.392
VEH_AGE	1	-0.1033	0.00217	2267.9233	0.0001	-0.318001	0.902
REAR	1	-1.0395	0.0292	1264.6449	0.0001	-0.228396	0.354
LAW	1	0.6490	0.0393	272.2247	0.0001	0.172179	1.914
PRIMARY	1	0.3571	0.0291	150.9822	0.0001	0.076519	1.429
ALL_SEAT	1	0.3189	0.0309	106.6844	0.0001	0.056976	1.376
FINE	1	0.00874	0.00122	51.5919	0.0001	0.066623	1.009
EDU_HS	1	0.0260	0.00206	159.1961	0.0001	0.093820	1.026
HW_SPEND	1	0.0415	0.0107	15.0438	0.0001	0.022168	1.042
CRIME_RT	1	0.000439	0.00009	23.6458	0.0001	0.029641	1.000

The effect of the independent variables on the dependent variable (safety belt use) is measured by the odds ratio, which gives the ratio of the odds of using the safety belts per unit increase in the independent variable. For a zero-one variable, such as the indicator of the presence of a safety belt use law, the odds ratio is the ratio of the odds of using the safety belt when the law is in force to the same odds when there is no law.

The above results for drivers show more than an 85 percent increase in the odds of using the safety belt when a law is enacted, and more than 44 percent increase associated with primary enforcement of the law. The analogous figures for passengers are 91 percent and 43 percent. This finding, based on historical data, provides strong evidence that primary enforcement significantly increases safety belt use.

One also finds that coverage of all seats by a safety belt use law is more significant for passengers than for drivers (relative to the variables indicating the presence and the primary enforcement of a safety belt use law). This result is not surprising, since the provision relating to all-seat coverage does not directly affect drivers, who are always covered by a safety belt use law. In fact, the data indicate about 37 percent increase in the odds of wearing the belts when the law covers all seats. However, as mentioned earlier, part of this effect may be due to the influence of the California data, which is a state with high safety belt use rates.

A further conclusion that follows from the analysis of the logistic regression model is that the level of penalty influences the belt use (about 0.8 percent increase in the odds per $1 increase in fine). The analysis confirms the fact that safety belts are less frequently used by occupants of pickup trucks and vans than occupants of passenger cars (more than a 50% decrease in the odds associated with the TRUCK variable). The use of safety belts is more likely during the day than at night (about 72 percent increase in the odds during the day for drivers and about 53 percent increase for passengers). There is clear evidence that women are more likely to use safety belts than men (53 percent increase in the odds for women drivers and 40 percent increase for women passengers). Age also contributes quite a lot to whether safety belts are used or not (1.2 percent increase in the odds per 1 year increase in age).

A rather interesting result is that the vehicle age proves to be by far the most significant variable in the logistic regression models considered. The odds decrease by about 10 percent for each year increase in vehicle age. It is likely that the significance of vehicle age to safety belt use is a manifestation of the significance of the social and economic status of vehicle occupants to safety belt use. The result can be interpreted as saying that persons with higher income level, and perhaps the associated higher educational level and social status, are more likely to wear safety belts.

For passengers, seating position turned out to be significant with respect to safety belt use, with the odds of wearing the belt by rear seat occupants decreased by almost 65 percent. Among the social and economic state level covariates, educational attainment and crime rate are the two most significant variables, both positively associated with safety belt use.

If the variable indicating alcohol involvement (DRINKING) is incorporated into the model, then the following results are obtained for drivers.

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-3.9504	0.1135	1211.7518	0.0001	.	0.019
MONTH_YR	1	0.00847	0.000401	446.7272	0.0001	0.180591	1.009
DAY	1	0.2632	0.0167	249.2019	0.0001	0.070628	1.301
TRUCK	1	-0.6933	0.0192	1304.7358	0.0001	-0.168642	0.500
AGE	1	0.00832	0.000391	453.5336	0.0001	0.085342	1.008
FEMALE	1	0.3062	0.0159	369.6680	0.0001	0.073989	1.358
VEH_AGE	1	-0.0897	0.00157	3275.1705	0.0001	-0.278572	0.914
DRINKING	1	-1.0279	0.0175	3463.2956	0.0001	-0.282644	0.358
LAW	1	0.6172	0.0363	289.6430	0.0001	0.164817	1.854
PRIMARY	1	0.3246	0.0223	211.2838	0.0001	0.066417	1.383
ALL_SEAT	1	0.3726	0.0226	272.4823	0.0001	0.064838	1.452
ALL_VEH	1	0.0571	0.0263	4.7066	0.0300	0.015692	1.059
FINE	1	0.00640	0.000899	50.7036	0.0001	0.049545	1.006
INCOME_P	1	0.2222	0.0576	14.8616	0.0001	0.035997	1.249
UNEMP_RT	1	-0.0103	0.00469	4.8312	0.0279	-0.011104	0.990
EDU_HS	1	0.0143	0.00176	66.2441	0.0001	0.052461	1.014
URB_POP	1	-0.00487	0.00110	19.6520	0.0001	-0.036620	0.995
HW_SPEND	1	0.0357	0.00827	18.6716	0.0001	0.018916	1.036
CRIME_RT	1	0.000901	0.000087	107.4089	0.0001	0.060460	1.001

These results are presented to show that drinking is an even more significant variable than vehicle age in a logistic regression model of safety belt use. The odds of wearing a safety belt for drinking drivers are reduced by 64 percent. The results for passengers are analogous, but much less reliable due to the extremely high proportion of missing observations. They are not presented here.

Separate logistic regression analyses were also performed for each state, and the results were compared to the findings reported in Sections 4 and 5. Given below are the odds ratios for wearing safety belts associated with the LAW variable (and PRIMARY or FINE variable, if applicable) with p-values giving the significance of the variable in the model. The states where a significant effect of the law is found are listed first (only states included in the analysis of Sections 4 and 5).

Alabama (secondary)	1.088	(p=0.7173)
fine:	1.025	(p=0.0028)
Arizona (secondary)	1.721	(p=0.0154)
California (secondary)	1.222	(p=0.1322)
upgrade to primary:	1.565	(p=0.0001)
Colorado (secondary)	2.479	(p=0.0001)
Connecticut (primary)	7.160	(p=0.0001)
fine:	0.976	(p=0.1081)
Florida (secondary)	2.265	(p=0.0001)
fine:	1.006	(p=0.2890)
Georgia (secondary)	1.797	(p=0.0145)
Illinois (primary)	2.466	(p=0.0151)
changed to secondary:	1.071	(p=0.6206)
Indiana (secondary)	2.671	(p=0.0001)
Iowa (primary)	2.653	(p=0.0044)
fine:	1.016	(p=0.2473)
Kansas (secondary)	3.666	(p=0.0001)
fine:	1.079	(p=0.0061)
Louisiana (secondary)	3.511	(p=0.0046)
fine:	0.992	(p=0.6096)

Maryland (secondary)	3.219	(p=0.0001)
Massachusetts (secondary)	1.889	(p=0.0358)
Michigan (secondary)	5.873	(p=0.0001)
fine:	0.982	(p=0.0454)
Minnesota (secondary)	2.317	(p=0.0008)
fine:	1.016	(p=0.2540)
Missouri (secondary)	2.730	(p=0.0001)
fine:	1.059	(p=0.0349)
New Jersey (secondary)	9.976	(p=0.0001)
New Mexico (primary)	6.435	(p=0.0001)
New York (primary)	9.363	(p=0.0001)
North Carolina (primary)	3.700	(p=0.0001)
fine:	1.037	(p=0.0001)
Ohio (secondary)	3.935	(p=0.0001)
fine:	0.998	(p=0.8588)
Oklahoma (secondary)	4.028	(p=0.0001)
Oregon (primary)	3.435	(p=0.0001)
South Carolina (secondary)	2.740	(p=0.0001)
Tennessee (secondary)	1.516	(p=0.0897)
fine:	1.015	(p=0.0452)
Texas (primary)	6.804	(P=0.0001)
Fine:	1.025	(P=0.0001)
Virginia (secondary)	2.515	(p=0.0001)
Washington (secondary)	1.440	(p=0.0861)
fine:	1.017	(p=0.0032)
West Virginia (secondary)	1.791	(p=0.0039)
Wisconsin (secondary)	4.787	(p=0.0001)

The list of states where the effect of safety belt use law variable was not significant is as follows.

Arkansas (secondary)	1.252	(p=0.4672)
Kentucky (secondary)	1.250	(p=0.2198)
Mississippi (primary)	0.464	(p=0.1080)
changed to secondary:	1.255	(p=0.3197)
Pennsylvania (secondary)	1.012	(p=0.9434)
fine:	1.025	(p=0.1458)

Four states (Arizona, Iowa, Kentucky, Massachusetts) where an effect of a safety belt use law has not been detected based on the analysis of monthly use rates, are now among the states with a significant law effect. All primary enforcement states are among the states with a significant effect of the law. A look at the odds ratios and the p-values associated with the coefficient of the variable LAW confirms that primary enforcement states stand out in terms of the strength of the effect of the law. Six of these states have the odds ratios greater than 3 and the p-values less than 0.001. The only primary enforcement states where the effect of the law is not clearly very strong are Illinois and Mississippi. These exceptions were discussed earlier, and the same comments apply to this analysis.

8. Conclusions

The key findings of this study are that enactment of a safety belt use law results in substantially increased safety belt use rates and that primary enforcement of the law leads to additional increases in the use rates. These findings are based on a comprehensive statistical analysis of a large database encompassing all states and the entire period since the first safety belt use laws were enacted. The database contains information on motorists fatally injured in traffic accidents, but can be used to obtain results for individuals involved in potentially fatal crashes.

The percentage increase in safety belt use rate among individuals involved in potentially fatal crashes is estimated to be 28.6 percent, assuming 45 percent effectiveness of safety belts in preventing fatal injuries. This translates into 12.6 percent decrease in fatalities due to safety belt use laws. Based on the numbers of fatalities among adult occupants of passenger cars, vans, and light and medium trucks in 1993 (a total of 20,772, of which 19,683 occurred in states with safety belt use laws), it can be estimated that 2,838 have been saved because safety belt use laws were in force, while 137 lives could have been saved had the remaining states enacted a safety belt use law. These estimates are based on the average effects and they do not take into account state differences in the effects of safety belt use laws. They are provided for illustrative purposes only.

Similarly, the increase in safety belt use for persons involved in potentially fatal crashes due to primary enforcement of a safety belt use law was estimated to be 13.2 percent or, based on the effectiveness figure as above, the reduction in fatalities is expected to be 5.9 percent due to the primary enforcement. (This is in addition to the reductions due to the law itself.) The number of motor vehicle occupants covered by this study who were killed in traffic accidents in states with primary enforcement laws was 5,854 in 1993. Thus, the results of this study indicate that 367 lives were saved in these states because of the primary enforcement of the law. For states with secondary enforcement laws, the potential benefits of primary enforcement are 880 lives that could have been saved.

The implications of these results are that upgrades of state safety belt use laws to primary enforcement are a matter of great significance in improving highway traffic safety, and state legislatures in states without primary enforcement laws should be urged to take action on this matter.

This study also shows that fine levels bear on the level of compliance with safety belt use laws. Regression models considered here indicate that each $1 increase in fines is associated with a 0.74 percent increase in safety belt use among motorists involved in potentially fatal crashes. For example, the states with $25 fines for violation of a safety belt use law would appear to have, on the average, 11.1 percent higher safety belt use than the states with $10 fines, if all other factors were the same in the states considered.

In summary, the study shows that the enforcement aspects of a safety belt use law (enforcement option and penalty) affect safety belt use rates very strongly, while much less of such effect seems to be associated with the breadth of coverage (vehicles covered and seats covered).

Apart from the laws, safety belt use is shown in this study to be affected by educational levels, as demonstrated through the significance of the state-level variable 'percentage of high school-educated population', and the individual-level variable 'vehicle age', which can be thought of as a proxy for income level and the associated educational attainment.

It is also shown that certain individual-level variables are more determinative of safety belt use than any of the state-level variables. Thus, older individuals are more likely to use safety belts than younger individuals; women are more likely to use safety belts than men; drinking persons are less likely to use safety belts than those not using alcohol; truck occupants are less likely to use safety belts than passenger car occupants; and safety belts are less likely to be worn at night. Among passengers, occupants of rear seats are less likely to use safety belts than occupants of front seats.

The findings pertaining to the above-mentioned individual-level factors are based on the analysis of a logistic regression model of safety belt use among fatally injured individuals. While the estimates of the magnitude of the effects cannot be immediately generalized to the population of all motor vehicle occupants without further study, it can be asserted that the same type of effects occur more generally. This assertion is based on the established relationship between safety belt use rates in observational surveys and safety belt use rates in the Fatal Accident Reporting System.

9. References

Campbell, B.J., The association between enforcement and seat belt use. Journal of Safety Research, 19, 159-163, 1988.

Campbell, B.J., Campbell, F.A., Seat belt law experience in four foreign countries compared to the United States. AAA Foundation for Traffic Safety, Falls Church, VA, December 1986.

Campbell, B.J., Stewart, J.R., Campbell, F.A., Changes in death and injury associated with safety belt laws 1985-1987. University of North Carolina Highway Safety Research Center, Chapel Hill, NC, December 1988.

Escobedo, L.G., Chorba, T.L., Remington, P.L., Anda, R.F., Sanderson, L., Zaidi, A.A., The influence of safety belt laws on self-reported safety belt use in the United States. Accident Analysis and Prevention, 24(6), 643-653, 1992.

Hoxie, P. And Skinner, D., Effects of mandatory seatbelt use laws on highway fatalities in 1985. DOT-HS-807-083. National Highway Traffic Safety Administration, Washington, DC, April 1987.

Hoxie, P. and Skinner, D., Effects of mandatory seatbelt use laws on highway fatalities update - April 1988. Project Memorandum DOT-TSC-HS870-PM-88-5. National Highway Traffic Safety Administration, Washington, DC, April 1988.

Hunter, W.W., Reinfurt, D.W., Cyr, C.S., Stewart, J.R., Hirsch, M.G., Little, C.M., Stutts, J.C., Analysis of occupant restraint issues from state accident data. University of North Carolina Highway Research Center, Chapel Hill, NC, September 1990.

Illinois State Police, News release from State Police Public Affairs Section. Springfield, IL, June 1985.

Klein, T.M., Walz, M.C., The Relationship between observed safety belt use rates and police-reported safety belt use rates in the Fatal Accident Reporting System. National Center for Statistics and Analysis, National Highway Traffic Safety Administration, Washington, DC, September 1992.

National Highway Traffic Safety Administration, Final regulatory impact analysis, Amendment to FMVSS no. 208, Passenger car front seat occupant protection. Washington, DC, July 1984.

National Highway Traffic Safety Administration, Effectiveness of safety belt use laws: a multinational examination. DOT HS 807 018, Washington, DC, October 1986.

Ulmer, R.G., Preusser, G.W., Preusser, D.F., Evaluation of California's safety belt law change to primary enforcement. National Highway Traffic Safety Administration, Washington, DC, December 1993.

Williams, A.F., Lund, A.K., Preusser, D.F., Blomberg, R.D., Results of a seat belt use law enforcement and publicity campaign in Elmira, New York. Accident Analysis and Prevention, 19(4), 243-249, 1987.

Williams, A.F., Wells, J.K., Lund, A.K., Shoulder belt use in four states with belt use laws. Accident Analysis and Prevention, 19(4), 251-260, 1987.

Appendix 1. State safety belt use laws -summary of legislative history and key provisions

ALABAMA 1985 - failed to pass, 1986 - failed, 1987 - failed, 1989 - failed, 1990 - failed
1991 - enacted: signed 7/18/91, effective 7/18/91
* secondary enforcement
* fine $25 (after 1/1/92)
* covers front seats
* covers motor vehicles designed to carry no more than 10 persons
* exceptions: vehicles MY before 1965, rural letter carriers, news/mail deliveries, trailers, medical excuses, vehicles operated in reverse

1994 - attempt to upgrade failed

ALASKA 1985 - carried over, 1986 - failed to pass, 1987 - carried over, 1988 - failed, 1989 - failed
1990 - enacted: signed 6/14/90, effective 9/12/90
* secondary enforcement
* fine $15 maximum
* covers all seats
* covers motor vehicles equipped with safety belts
* exceptions: school bus passengers unless bus is required to be equipped with safety belts, mail and newspaper deliveries, medical excuses, emergency vehicles

ARIZONA 1983 - failed to pass, 1984 - failed, 1985 - failed, 1986 - failed, 1987 - failed (incl. referendum bill), 1988 - failed, 1989 - failed
1990 - enacted: signed 5/23/90, effective 1/1/91
* secondary enforcement
* fine $10 first offense, $25 subsequent offenses
* covers front seats
* covers motor vehicles designed to carry 10 or fewer passengers and required to be equipped with safety belts
* exceptions: vehicles MY before 1972, medical excuses, letter carriers
* public information and education activities by office of highway safety (using federal funds)

ARKANSAS 1983 - failed to pass, 1984 - failed, 1985 - failed, 1987 - failed, 1989 - failed
1991 - enacted: signed 3/14/91, effective 7/5/91
* secondary enforcement
* fine $25
* covers front seats
* covers motor vehicles required to be equipped with safety belts except buses and other public conveyances
* exceptions: cars manufactured before 7/1/68, vehicles manufactured

before 1/1/72, medical excuses, letter carriers
(Note: individual jurisdictions had safety belt use ordinances earlier)

CALIFORNIA 1984 - failed to pass
1985 - enacted: signed 10/1/85, effective 1/1/86
(amendments 9/24/88, 9/5/90)
* secondary enforcement
* fine $22 first offense, $55 subsequent offenses
* covers all seats
* covers passenger motor vehicles designed to carry no more than 10 persons and trucks of less than 6000 lbs unladen weight
* exceptions: passengers in back seat of taxicabs, limousines or emergency vehicles, medical excuses rural letter carriers, peace officers

1992 - upgrade: effective 1/1/93
* primary enforcement
* exempts taxicab drivers on city streets
* requires notice on safety belt importance on all used cars sold by dealers

COLORADO 1985 - failed to pass, 1986 - failed
1987 - enacted: signed 5/7/87, effective 7/1/87
(amendment 4/23/89)
* secondary enforcement
* fine $10 + surcharge $1
* covers front seats
* covers motor vehicles required to be equipped with safety belts (including passenger car, van, taxi, small truck)
* exceptions: peace officers, medical excuses, delivery vehicles, rural letter carriers, ambulance team except driver, buses, farm tractors
* public information and education program by division of highway safety
* allows reductions in insurance premiums for use of safety belts

1994 - upgrade: effective 1/1/95
* fine $15

CONNECTICUT 1983 - bill to require student drivers to wear belts - failed
1985 - enacted: signed 6/27/85, effective 1/1/86
* primary enforcement
* fine $15, no points
* covers front seats
* covers passenger motor vehicles (passenger car, station wagon, camper, truck with a load capacity of 1500 lbs or less, vanpool)

* exceptions: medical excuses, emergency vehicles except fire fighters, rural letter carriers, newspaper deliveries, public or livery conveyance, vehicles with air bags
* educational program by office of highway safety and department of motor vehicles

1987 - attempt to repeal - failed

1991 - upgrade: signed 6/5/91
* fine $37

1992 - amendment: signed 3/2/92
* removes exemption for vehicles with air bags

DELAWARE 1984 - failed (but established task force to study safety belts), 1985 - carried over, 1986 - failed, 1987 - carried over, 1988 - failed, 1989 - failed (incl. referendum bill), 1990 - failed

1991 - enacted: signed 5/22/91, effective 1/1/92
* secondary enforcement
* fine $20, no points
* covers front seats
* covers motor vehicles required to be equipped with safety belts
* exceptions: farm tractors, medical excuses, letter carriers

DISTRICT OF COLUMBIA 1985 - enacted: signed 10/22/85, effective 12/12/85
* secondary enforcement
* fine $15 maximum (after 6/12/86), no points
* covers driver and front seat outboard passenger
* covers motor vehicles with seating capacity of 8 passengers of less
* exceptions: farm vehicles, vehicles manufactured before 7/1/66, medical excuses
* public education campaign by the Mayor

FLORIDA 1985 - failed to pass

1986 - enacted: signed 6/2/86, effective 7/1/86
* secondary enforcement
* fine $20 (after 1/1/87)
* covers front seats
* covers motor vehicles except buses, farm tractors, trucks of unladen weight more than 5000 lbs
* exceptions: medical excuses, newspaper delivery
* public education campaign by law enforcement agencies, safety councils and schools

1992 - attempt to upgrade to primary - failed, 1993 - attempt to upgrade to primary - failed, 1994 - attempt to upgrade - failed

GEORGIA 1985 - carried over, 1986 - failed to pass, 1987 - carried over
1988 - enacted: signed 2/19/88, effective 9/1/88
(amended 3/30/90)
* secondary enforcement
* fine $15 maximum (when also charged with certain other violations)
* covers front seats
* covers passenger cars required to be equipped with safety belts designed to carry 10 passengers or less
* exceptions: persons who make frequent stops for deliveries if speed between stops is less than 15 mph, medical excuses, MY before 1965, vehicles operated in reverse, rural letter carriers, emergency vehicles, vehicles equipped for off road operation, trucks
1990 - amendment: signed 3/30/90 to explicitly exempt pick-up trucks

HAWAII 1983 - bill to require passengers in back of trucks to wear safety belts - failed to pass
1984 - failed
1985 - enacted: signed 6/5/85, effective 12/16/85
* primary enforcement
* fine $15, no points
* covers front seats
* covers motor vehicles required to be equipped with safety belts
* exceptions: medical excuses, emergency vehicles, buses, passengers when all safety belts are in use by other passengers, rental and commercial vehicles
* educational program on value of safety belts by State Department of Transportation and police
1986 - amendment to exempt taxi drivers when carrying passengers
1987 - upgrade to remove exception for rental and commercial vehicles
1988 - upgrade: effective 6/6/88
* fine $20
1994 - attempt to upgrade - failed

IDAHO 1986 - enacted: signed 4/4/86, effective 7/1/86
* secondary enforcement
* fine $5, no points
* covers front seats
* covers motor vehicles required to be equipped with safety belts with weight under 8000 lbs
* exceptions: medical excuses, emergency vehicles, passengers when all safety belts are in use by other passengers
* educational program by State Department of Transportation
1988 - amendment to exempt mail carriers

ILLINOIS 1985 - enacted: signed 1/8/85, effective 7/1/85
* primary enforcement
* fine $25
* covers front seats
* covers motor vehicles required to be equipped with safety belts
* exceptions: persons frequently leaving vehicle for deliveries if speed between stops is no more than 15 mph, medical excuses, rural letter carriers, vehicles operating in reverse, vehicles manufactured before 1/1/65

1985 - law exempting handicapped persons from complying with safety belt use law
1986 - attempt to repeal - failed
1987 - amendment: signed 9/8/87, effective 1/1/88
* secondary enforcement

(Note: Chicago had a safety belt use ordinance since Dec. 1984)

INDIANA 1985 - enacted: signed 4/17/85, effective 7/1/87
(amended 4/23/91)
* secondary enforcement
* fine $25, no points
* covers front seats
* covers passenger motor vehicles required to be equipped with safety belts (including buses but excluding trucks, tractors and recreational vehicles)
* exceptions: medical excuses, rural letter carriers, newspaper delivery, commercial vehicle making frequent stops, vehicle operated in reverse, vehicle manufactured before 1/1/65
* educational programs by bureau of motor vehicles and department of highways

1986 - attempt to repeal - failed, 1993 - attempt to upgrade to primary - failed

IOWA 1985 - carried over
1986 - enacted: signed 2/20/86, effective 7/1/86
(amended 1987)
* primary enforcement
* fine $10 + court costs $11.50 (after 1/1/87), no points
* covers front seats
* covers motor vehicles required to be equipped with safety belts
* exceptions: MY earlier than 1966, persons required to alight vehicle frequently if speed between stops is less than 25 mph, bus passengers, rural letter carriers, medical excuses, emergency vehicles except driver
* educational programs to be established by the departments of public safety and education

1987 - attempts to repeal and downgrade - failed, 1989 - attempt to repeal - failed

KANSAS 1985 - failed to pass
1986 - enacted: signed 5/1/86, effective 7/1/86
(amended 1989)
* secondary enforcement
* fine $10 (after 7/1/87)
* covers front seats
* covers passenger cars manufactured with safety belts designed for carrying 10 passengers of less (incl. van)
* exceptions: trailers, trucks over 12000 lbs, medical excuses, postal carrier, newspaper deliveries
* educational program by state secretary of transportation
1993 - attempt to upgrade to primary - failed

KENTUCKY 1986 - failed to pass, 1990 - failed, 1992 - failed
1994 - enacted: signed 3/9/94, effective 7/13/94
* secondary enforcement
* fine $25
* covers all seats
* covers motor vehicles designed to carry no more than 10 passengers
* exceptions: farm trucks with weight greater than 1 ton, vehicles manufactured before 1/1/66, medical excuses, letter carriers

(Note: local ordinances requiring wearing seat belts were enacted in Lexington in Jan. 1990, Louisville Feb. 1991)

LOUISIANA 1985 - enacted: signed 7/10/85, effective 7/1/86
* secondary enforcement
* fine $25 (after 8/1/86)
* covers front seats
* covers passenger cars, vans, and trucks having gross weight 6000 lbs or less (incl. pickups) manufactured after 1/1/81
* exceptions: medical excuses, rural letter carriers, vehicles operated in reverse, passengers when a safety belts is not provided in their seat
* educational programs to encourage compliance by department of public safety and correction
1986 - attempt to repeal - failed, 1992 - attempt to upgrade to primary - failed
1993 - attempt to upgrade to primary - failed

MAINE 1983 - failed to pass, 1985 - failed, but enacted law requiring inspection of safety belts on vehicles MY 1980 and later, 1986 - failed, 1987 - failed, but enacted a law requiring safety belt use by students and instructors during training, 1991 - failed
1993 - passed, but vetoed by governor

MARYLAND 1985 - failed to pass
1986 - enacted: signed 5/13/86, effective 7/1/86
(amended 7/1/87, 7/1/89, 4/24/91)
* secondary enforcement
* fine $25, no points
* covers driver and front seat outboard passenger
* covers passenger cars, multipurpose vehicles, trucks with capacity 3/4 ton or less and gross weight 7000 lbs or less
* exceptions: medical excuses, letter carriers, historic vehicles
* educational program by state police
1993 - attempt to upgrade to primary - failed

MASSACHUSETTS 1983 - introduced
1984 - failed to pass
1985 - enacted: signed 10/22/85, effective 1/1/86
* secondary enforcement
* fine $15, no points
* covers all seats
* covers motor vehicles required to be equipped with safety belts manufactured after 7/1/66 except buses
* exceptions: passengers if all safety belts are in use by other passengers, rural letter carriers, persons making frequent stops if speed between stops is less than 15 mph, police officers
* public information and education program by highway safety bureau
1985 - repealed by referendum in Nov. 85, not effective after 12/4/85
1987 - law requiring safety belt systems inspection
1988 - re-introduced - failed, 1989 - re-introduced - failed,
1990 - re-introduced, 1992 - failed
1994 - enacted: overriding governor's veto, effective 2/1/94
* secondary enforcement
* fine $25
* covers all seats
* covers passenger cars, vans, and trucks less than 18000 lbs
* exceptions: motor vehicles manufactured before 7/1/66, medical excuses, rural mail carriers, drivers of taxis, liveries, and buses, emergency vehicles
* public information and education program by highway safety bureau

MICHIGAN 1983 - introduced, 1884 - introduced
1985 - enacted: signed 3/8/85, effective 7/1/85
(amended 4/5/85, 1990, 5/20/91)

* secondary enforcement
* fine $25 (after 1/1/86), no points (7/1/85 - 1/1/86 fine $10)
* covers front seats
* covers motor vehicles required to be equipped with safety belts manufactured after 1/1/65 except buses
* exceptions: medical excuses, rural letter carriers, commercial or postal vehicles that make frequent stops
* program to encourage compliance by secretary of state

1992 - attempt to upgrade to primary - failed, 1993 - attempt to upgrade to primary - failed, 1994 - attempt to upgrade to primary

MINNESOTA

1983 - carried over
1984 - failed to pass
1985 - carried over
1986 - enacted: signed 2/24/86, effective 8/1/86
* secondary enforcement
* no fine, no points
* covers front seats
* covers passenger cars, pickup trucks, vans, recreational vehicles
* exceptions: passengers if all seats with belts are occupied, vehicle operated in reverse, medical excuses, persons making frequent stops if speed between stops is less than 25 mph, rural postal carriers, pickup trucks in farm work, vehicles manufactured before 1/1/65

1987 - upgrade bill carried over
1988 - upgrade enacted: effective 5/1/88
* fine $10

1991 - upgrade enacted: effective 5/27/91
* fine $25

1993 - attempt to upgrade to primary - failed, 1994 - attempt to upgrade to primary - failed

MISSISSIPPI

1985 - failed to pass, 1986 - failed, 1987 - failed, 1988 - failed, 1989 - failed (incl. referendum)
1990 - enacted: signed 3/20/90, effective 3/20/90
* primary enforcement
* no fine
* covers front seats
* covers motor vehicles designed to carry 10 passengers or less except all-terrain vehicles and trailers
* exceptions: farm use vehicles, medical excuses, rural letter carriers, utility meter readers
* educational programs by department of public safety, signs along highways to be erected by highway department

1994 - amendment: signed 3/7/94, effective 7/1/94
* secondary enforcement
* fine $25, no points

MISSOURI 1984 - failed to pass
1985 - enacted: signed 3/5/85, effective 9/28/85
* secondary enforcement
* fine $10 (after 7/1/87), no points
* covers front seats
* covers motor vehicle designed to carry 10 passengers or less except trucks
* exceptions: letter carriers, medical excuses, vehicles manufactured before 1/1/68
* public information program by department of public safety
1986 - attempt to repeal - failed, 1987 - attempt to repeal - failed
1988 - amendment May 1988 to remove a sunset provision and eliminate court costs for offenders of safety belt use law
1989 - attempt to repeal - failed, 1994 - attempt to upgrade - failed

MONTANA 1985 - failed to pass
1987 - enacted: signed 4/9/87, effective 10/1/87
* secondary enforcement
* fine $20 (after 1/1/88), no points
* covers all seats
* covers motor vehicles
* exceptions: medical excuses, vehicles that make frequent stops, passengers when all seats with safety belts are occupied, special mobile equipment
* public information and education program by highway traffic safety division
1988 - upheld by referendum Nov. 1988

NEBRASKA 1985 - enacted: signed 6/5/85, effective 9/6/85
* secondary enforcement
* fine $25, no points
* covers front seats
* covers motor vehicles with safety belts installed by manufacturer
* exceptions: passengers if all safety belts in front seats are used by other passengers, medical excuses, rural letter carriers
1986 - repealed by referendum Nov. 1986
1992 - re-enacted: passed 4/21/92 (no governor's approval), effective 1/1/93
* secondary enforcement
* fine $25, no points

* covers front seats
* covers motor vehicles required to be equipped with safety belts except buses
* exceptions: vehicles MY before 1973, farm use vehicles, medical excuses, members of ambulance or rescue team, rural letter carriers
* public information and education program by department of motor vehicles

(Note: ordinance in the city of Lincoln 5/6/86 requiring use of safety belts)

NEVADA 1985 - law that if the Federal Government gives the state permission to raise state speed limit above 55 mph, then use of safety belts would be required

1987 - enacted: signed 6/15/87, effective 7/1/87
* secondary enforcement
* fine $25
* covers all seats
* covers motor vehicles of unladen weight of less than 6000 lbs
* exceptions: vehicles not required to be equipped with safety belts, passengers if their seat is not equipped with safety belt, rural letter carriers, persons who make frequent stops to leave vehicle if speed between stops is less than 15 mph, passengers in public transportation (taxis, buses, emergency vehicles), medical excuses

NEW HAMPSHIRE 1985 - failed to pass, 1986 - failed to pass, 1989 - failed to pass, 1993 - failed to pass

NEW JERSEY 1984 - law requiring students and instructors to wear safety belts in driving education vehicles

1984 - enacted: signed 12/8/84, effective 3/1/85
* secondary enforcement
* fine $20, no points
* covers front seats
* covers passenger automobiles
* exceptions: vehicles not required to be equipped with safety belts, vehicles manufactured before 7/1/66, rural letter carriers, medical excuses
* booklet on benefits of safety belts by division of motor vehicles, funds will be sought by office of highway safety for educational programs

1992 - attempt to upgrade to primary - failed, 1994 - attempt to upgrade - failed

NEW MEXICO 1985 - enacted: signed 4/2/85, effective 1/1/86
* primary enforcement
* fine $25 - $50 (incl. court costs)
* covers front seats

* covers motor vehicle required to be equipped with safety belts designed to carry 10 passengers or less except trailer, school bus, truck
* exceptions: medical excuses, rural letter carriers, passengers if all seats with safety belts are occupied
* educational program to encourage compliance by the departments of transportation, public education and health and environment

1987 - attempt to repeal - failed, 1987 - attempt to upgrade - failed

1989 - upgrade: approved 4/7/89

* covers motor vehicles required to be equipped with safety belts having gross weight of less than 10000 lbs

1991 - attempt to repeal - failed, 1991 - attempt to upgrade - failed

NEW YORK 1984 - law requiring safety belt use by persons with junior licenses, probationary licenses, or learner's permits

1984 - enacted: signed 7/12/84, effective 12/1/84 (amended 7/16/89, 5/10/91)

* primary enforcement
* fine $50 (after 1/1/85)
* covers front seats
* covers motor vehicles required to be equipped with safety belts
* exceptions: medical excuses, taxis, liveries, tractors, trucks over 18000 lbs, buses, emergency vehicles
* educational campaign by governor's traffic safety committee

1986 - attempt to repeal - failed, 1987 - repeal and referendum bill - carried over 1988 - repeal and referendum bill - failed to pass, 1989 - repeal and referendum bill - carried over, 1990 - repeal and referendum bill - failed 1991 - attempt to repeal - failed

NORTH CAROLINA 1985 - enacted: signed 5/23/85, effective 10/1/85 (amended 7/16/87, 6/28/91)

* primary enforcement
* fine $25 (after 1/1/87), no points
* covers front seats
* covers motor vehicles required to be equipped with safety belts designed for carrying 10 passengers or less except trailers
* exceptions: medical excuses, rural letter carriers, newspaper deliveries, persons frequently leaving vehicle for deliveries if speed between stops is less than 20 mph, property carrying agricultural or commercial use vehicles
* driver education programs by division of motor vehicles and department of public instruction

1987 - attempt to repeal and hold referendum - failed

NORTH DAKOTA 1985 - failed to pass
1987 - failed
1989 - enacted: signed 5/23/89, effective 7/10/89
* secondary enforcement
* fine $20 (after 1/1/91)
* covers front seats
* covers motor vehicles manufactured with safety belts designed for carrying no more than 11 passengers
* exceptions: driver if all safety belts in front seats are in use, rural letter carriers, agricultural use vehicles
1989 - repealed in referendum 12/5/89
1993 - re-enacted effective 8/1/93
1993 - suspended pending referendum
1994 - upheld in referendum, effective 7/14/94
(Note: City of Grand Rapids has safety belt use ordinance)

OHIO 1984 - introduced, 1985 - carried over
1986 - enacted: signed 2/4/86, effective 5/6/86
* secondary enforcement
* fine $20 (driver) + $10 (for passenger if in violation) (after 7/4/86) (fine waived if viewed educational film
on safety belts before court appearance but court cost of $15 may be imposed)
* covers front seats
* covers passenger cars, commercial cars, commercial tractors, and trucks required to be factory equipped with safety belts
* exceptions: postal service, newspaper delivery, medical excuses, occupant when safety belt is not available, occupant protected by air bag
* educational program by department of highway safety
1988 - attempt to repeal - failed
1992 - amended: approved 3/2/92, effective 6/1/92
* removes driver's responsibility for passenger compliance
* removes exception for occupants protected by air bags

OKLAHOMA 1985 - enacted: signed 6/4/85, effective 2/1/87
* secondary enforcement
* fine $10 + court costs $15, no points
* covers front seats
* covers passenger cars (excluding trucks, tractors, pickups, vans, recreational vehicles, farm use vehicles)
* exceptions: medical excuses, postal carriers
* educational program by state department of public safety
1988 - amendment: approved 7/1/88, effective 3/1/89
* removes exclusion of pickup trucks and vans

1990 - repeal and referendum bill - failed to pass, 1992 - attempt to upgrade to primary - failed, 1993 - attempt to upgrade to primary - failed

OREGON 1985 - failed to pass

1987 - enacted: signed 6/26/87, effective 1/1/89
* primary enforcement
* fine $50
* covers all seats
* covers motor vehicles required to be equipped with safety belts or in which safety belts have been installed
* exceptions: privately owned commercial vehicles (but not pickup trucks 8000 lbs or less), passengers when all seating positions are occupied, persons in custody of police, mail and newspaper delivery, persons giving treatment in ambulance, medical excuses

1988 - repealed in referendum Nov. 1988

1990 - re-enacted by initiative for safety belt use law: approved in Nov. 1990 election, effective 12/7/90

PENNSYLVANIA 1984 - introduced, 1985 - pending, 1986 - pending

1987 - introduced and enacted: signed 11/23/87, effective 11/23/87
* secondary enforcement
* fine $10 (after 3/23/88), no points
* covers front seats
* covers passenger car, truck, motor home
* exceptions: vehicle manufactured before 7/1/66, medical excuses, rural letter carriers, persons making frequent stops for deliveries if speed between stops is less than 15 mph
* educational campaign by state department of transportation

1992 - attempt to upgrade to primary - failed

RHODE ISLAND 1983 - failed to pass, 1984 - failed, 1985 - carried over, 1986 - failed, but enacted law requiring students to wear safety belts in driver training vehicles, 1988 - failed, 1989 - carried over, 1990 - failed

1991 - enacted: effective 6/18/91
* secondary enforcement
* no fine, no points
* covers all passengers
* covers motor vehicles required to be equipped with safety belts
* exceptions: vehicles manufactured before 7/1/66, medical excuses, letter carriers
* public information and education program highway safety office

1992 - attempt to upgrade to primary - failed, 1993 - attempt to upgrade to primary - failed, 1994 - attempt to upgrade

SOUTH CAROLINA 1985 - carried over, 1986 - failed, 1987 - carried over, 1988 - failed
1989 - enacted: effective 7/1/89
* secondary enforcement
* fine $10 (driver responsible, maximum total $20), no points
* covers all seats (but rear seats only if shoulder belts installed)
* covers passenger car, truck, van, recreational vehicle required to be equipped with safety belts
* exceptions: vehicles manufactured before 7/1/66, medical excuses, emergency vehicle personnel when attending to patient, public transportation but not taxi, parade vehicles, postal carriers, passengers when all seats with safety belts are occupied, persons making frequent stops for delivery

1993 - attempt to upgrade to primary - failed

SOUTH DAKOTA 1983 - failed to pass, 1985 - failed, 1986 - failed, 1987 - failed, 1988-failed, 1989 - failed, 1990 - failed, 1991 - failed, 1991 - failed, 1992 - failed, 1993 - failed
1994 - enacted: signed 2/25/94, effective 1/1/95
* secondary enforcement
* fine $20
* covers front seats
* covers passenger cars, trucks, vans, recreational vehicles required to be equipped with safety belts
* exceptions: medical excuses, rural mail carrier, newspaper deliveries, farm use vehicles, vehicles manufactured before 1/1/73

1994 - upheld in referendum Nov. 1994

TENNESSEE 1985 - carried over
1986 - enacted: signed 4/21/86, effective 4/21/86 (amended 3/22/89)
* secondary enforcement
* fine $25 (after 1/1/87) (can pay $20 via mail and waive court appearance), no fine for first offense (warning ticket only), no points, no court costs
* covers front seats
* covers motor vehicles required to be equipped with safety belts with gross weight 8500 lbs or less
* exceptions: vehicles of public or livery conveyance, medical excuses, rural letter carriers, dealership employees involved in test driving if dealership test drives at least 50 cars a day within radius of 1 mile, vehicles MY before 1969, vehicles operated in reverse, utility meter readers, newspaper delivery
* educational program by department of safety and department of health

and environment, signs for belt use to be erected

1987 - attempt to repeal - failed, 1992 - attempt to upgrade to primary - failed
1993 - attempt to upgrade to primary - failed, 1994 - attempt to upgrade to primary - failed

1994 - upgrade: signed 3/22/94, effective 3/22/94

* removes exemption from fine for first time offenders

TEXAS 1985 - enacted: signed 6/16/85, effective 9/1/85

* primary enforcement
* fine $25 - $50 (after 12/1/85)
* covers front seats
* covers passenger cars designed to carry 10 passengers or less (including trucks with rated capacity of not more than 1500 lbs) required to be equipped with safety belts
* exceptions: medical excuses, postal carriers
* educational program to encourage seat belt use by state department of transportation

1987 - attempt to repeal - failed

UTAH 1985 - failed to pass

1986 - enacted: signed 3/18/86, effective 4/28/86 (amended 3/9/90, 2/11/91)

* secondary enforcement
* fine $10, no points
* covers front seats
* covers motor vehicles required to be equipped with safety belts
* exceptions: medical excuses, vehicles manufactured before 7/1/66, rural letter carriers, persons making frequent stops for pickup or delivery

1992 - attempt to upgrade to primary - failed, 1994 - attempt to upgrade - failed

VERMONT 1983 - failed to pass, 1984 - failed, 1986 - failed, 1987 - carried over, 1988 - failed, 1989 - carried over, 1990 - failed, 1991 - failed, 1992 - failed

1993 - enacted: effective 1/1/94

* secondary enforcement
* fine $10 (driver responsible)
* covers all seats
* covers motor vehicles required to be equipped with safety belts
* exceptions: medical excuses, rural mail carriers, vehicles making frequent stops if speed between stops is less than 15 mph, farm use vehicles, emergency vehicles personnel when performing their duties, passengers of buses and taxis, occupants when their seat is not equipped with safety belt

VIRGINIA 1983 - failed to pass, 1984 - failed, 1985 - failed, 1986 - failed

1987 - enacted: signed 3/27/87, effective 1/1/88
- * secondary enforcement
- * fine $25, no points, no court cost
- * covers front seats
- * covers motor vehicles equipped or required to be equipped with safety belts
- * exceptions: medical excuses, law enforcement officers, rural letter carriers, newspaper deliveries, drivers of taxicabs
- * educational program by department of motor vehicles and police department

1988 - amended: approved 3/29/88
- * exempts commercial and municipal vehicles making frequent stops for collection or delivery of goods or services, and utility meter readers

1992 - attempt to upgrade to primary - failed

WASHINGTON 1983 - failed to pass, 1984 - failed, 1985 - carried over

1986 - enacted: signed 3/31/86, effective 6/11/86 (amended 1990)
- * secondary enforcement
- * fine minimum $25 (after 1/1/87), fine prescribed by state supreme court adjusting for inflation biannually, customary fine in 1991 was $47, no points
- * covers all seats
- * covers motor vehicles required to be equipped with safety belts including passenger cars, multipurpose passenger vehicles except trailers, buses, trucks
- * exceptions: medical excuses, occupants when all seats with safety belts are occupied, additional exceptions may be made by state patrol for farm and construction vehicles or persons required to make frequent stops

1987 - law enacted specifying conditions when insurance companies may reduce premia because of safety belt use

1993 - attempt to upgrade to primary - failed, 1994 - attempt to upgrade to primary - failed

WEST VIRGINIA 1984 - failed to pass, 1985 - failed, 1986 - failed, 1987 - failed, 1988 - passed, but vetoed by governor, 1989 - failed, 1990 - failed 1991 - failed, 1992 - failed

1993 - enacted: signed 3/23/93, effective 9/1/93
- * secondary enforcement
- * fine $25, no points
- * covers front seats
- * covers motor vehicles required to be equipped with safety belts

designed for transporting 10 passengers or less except trailers
* exceptions: vehicles manufactured before 1/1/67, rural mail carriers, medical excuses
* educational programs to encourage compliance by highway safety program, division of public safety, and municipal law enforcement agencies

WISCONSIN 1985 - carried over, 1986 - failed
1987 - enacted: signed 11/27/87, effective 12/1/87
* secondary enforcement
* fine $10 + fees $20.90, no points
* covers all passengers (except rear seat if equipped with only lap belt)
* covers motor vehicles required to be equipped with safety belts
* exceptions: all-terrain vehicles, snowmobiles, medical excuses, emergency vehicles, taxicabs, truck used for planting or harvesting not being operated on highway, rural letter carriers, newspaper deliveries, persons making frequent stops if speed between stops is less than 10 mph, land survey crews, vehicles manufactured before 1/1/72, antique reproductions
* public information program by state department of transportation

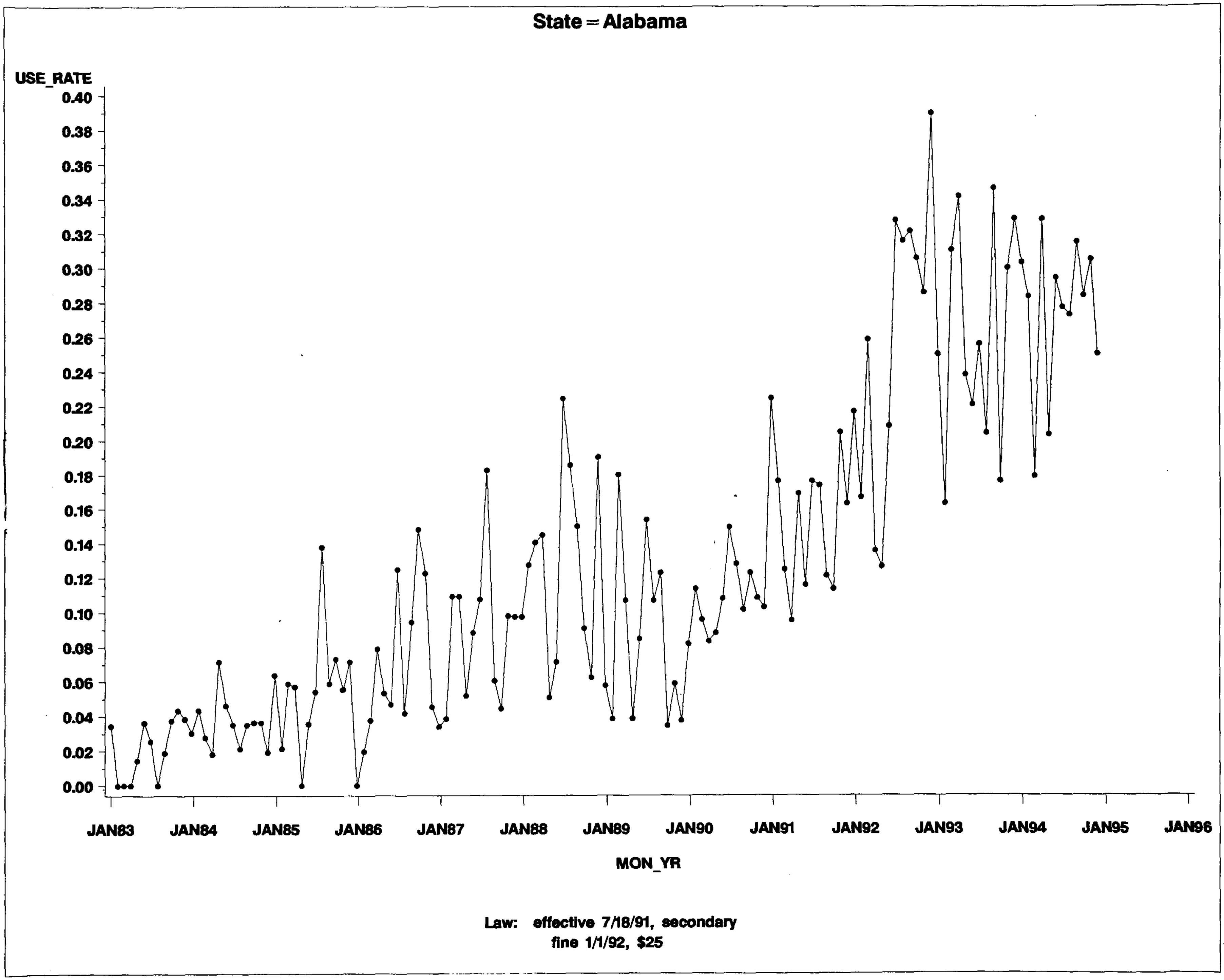
1988 - repeal and referendum bill - failed
1989 - amendment to change sunset provision
1989 - repeal and referendum bill - failed, 1990 - attempt to repeal - failed
1991 - amended: effective 8/8/91
* primary enforcement (accidental change in law, the purpose of bill was to waive court costs for safety belt law offenders, police might not use primary enforcement)

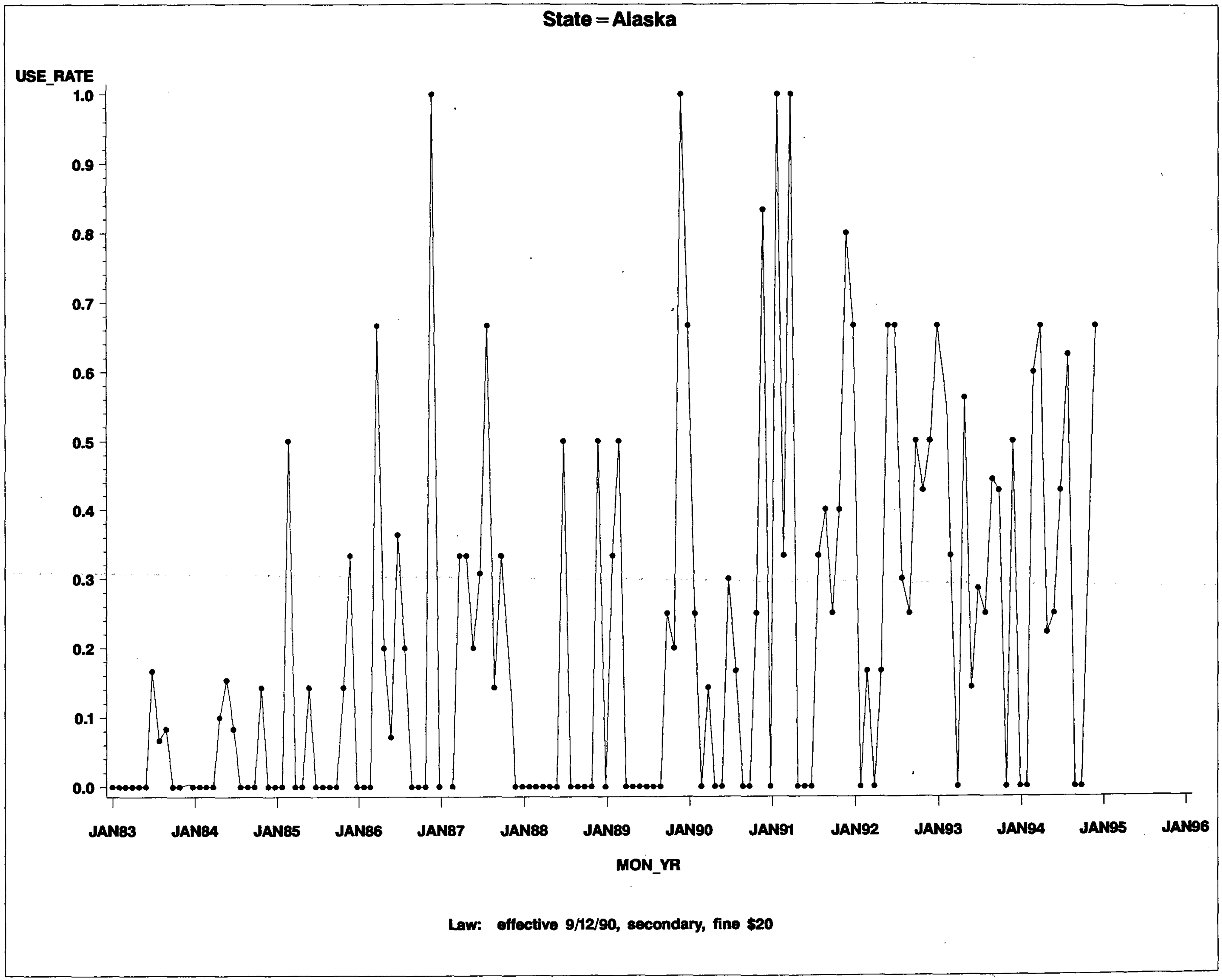
1992 - amended
* secondary enforcement

WYOMING 1985 - failed to pass, 1987 - failed, 1988 - failed
1989 - enacted: signed 3/14/89, effective 6/8/89
(amended 3/13/90, 2/21/91)
* secondary enforcement
* no fine (but $5 reduction in fine for other violation if in compliance)
* covers front seats
* covers motor vehicles required to be equipped with safety belts designed to carry 11 persons or less and primarily used to transport persons (including pickup truck)
* exceptions: emergency vehicles, buses, medical excuses, occupants when all safety belts are in use, postal carriers
* public information program by highway department

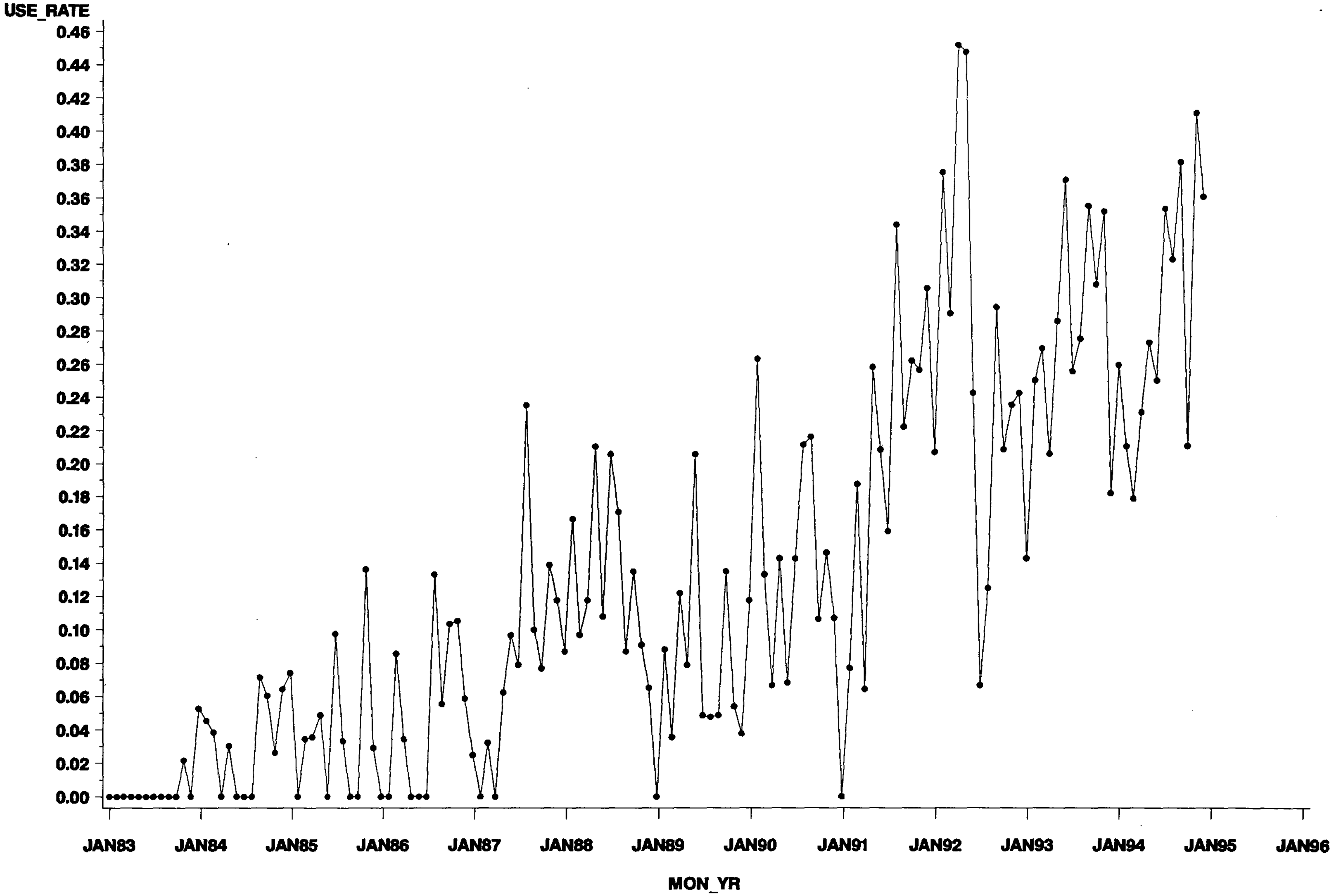
1993 - attempt to upgrade to primary - failed

Appendix 2. Time plots of safety belt use rates among fatally injured motor vehicle occupants (FARS data, 1983-1994, monthly)

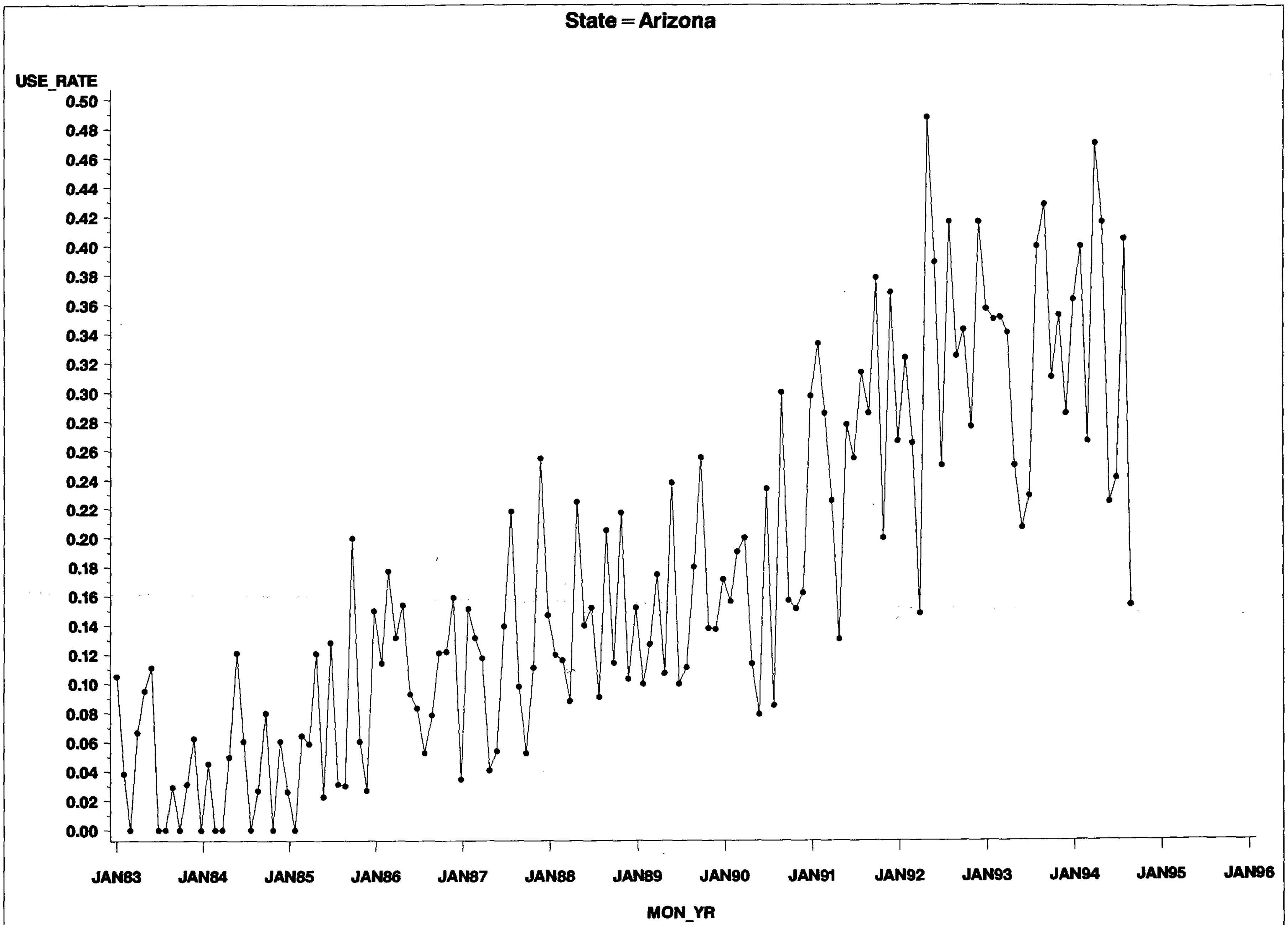

State = Alabama
USE_RATE
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
MON_YR
Law: effective 7/18/91, secondary
fine 1/1/92, $25


State = Alaska
USE_RATE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
MON_YR
Law: effective 9/12/90, secondary, fine $20

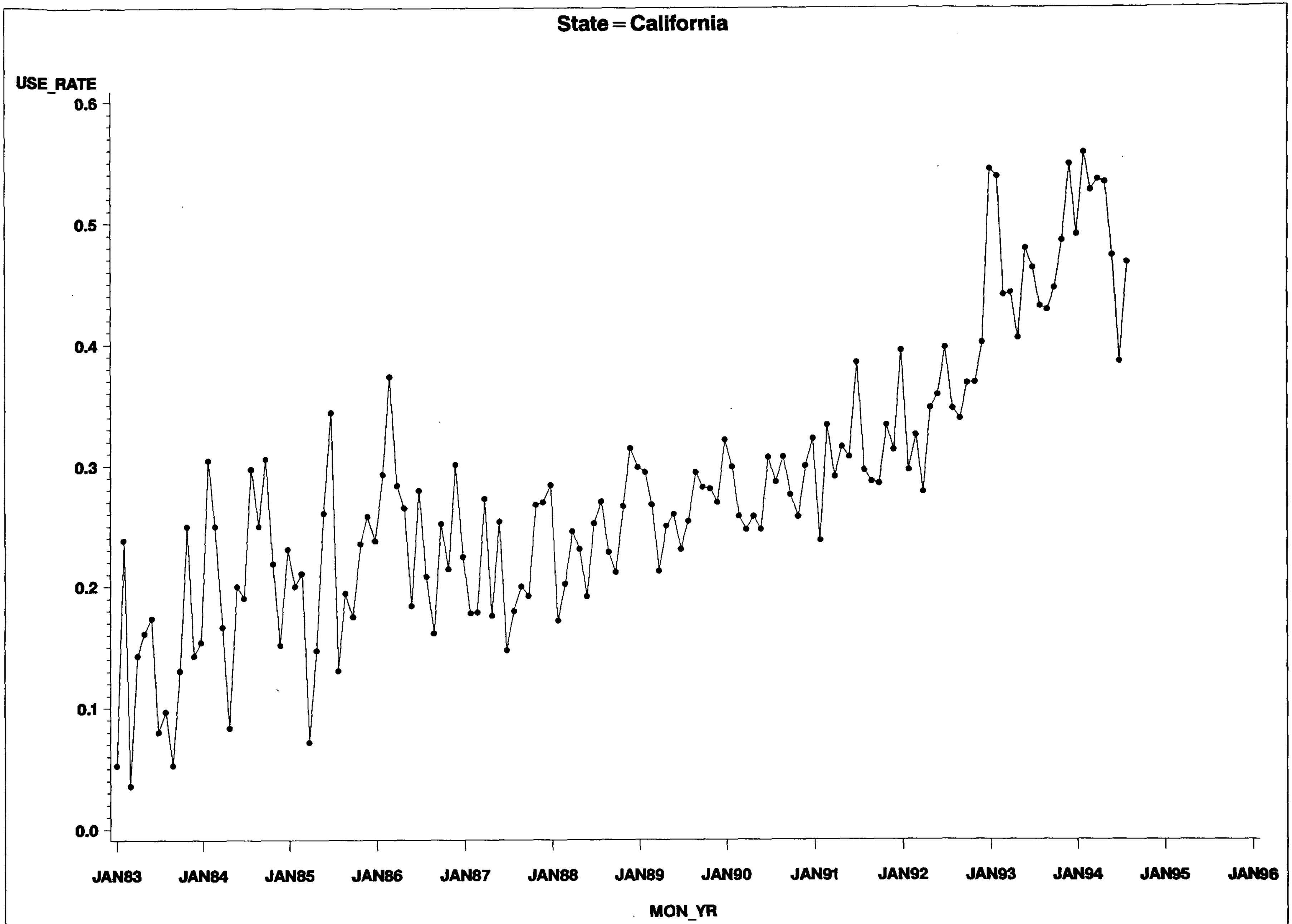
State = Arkansas



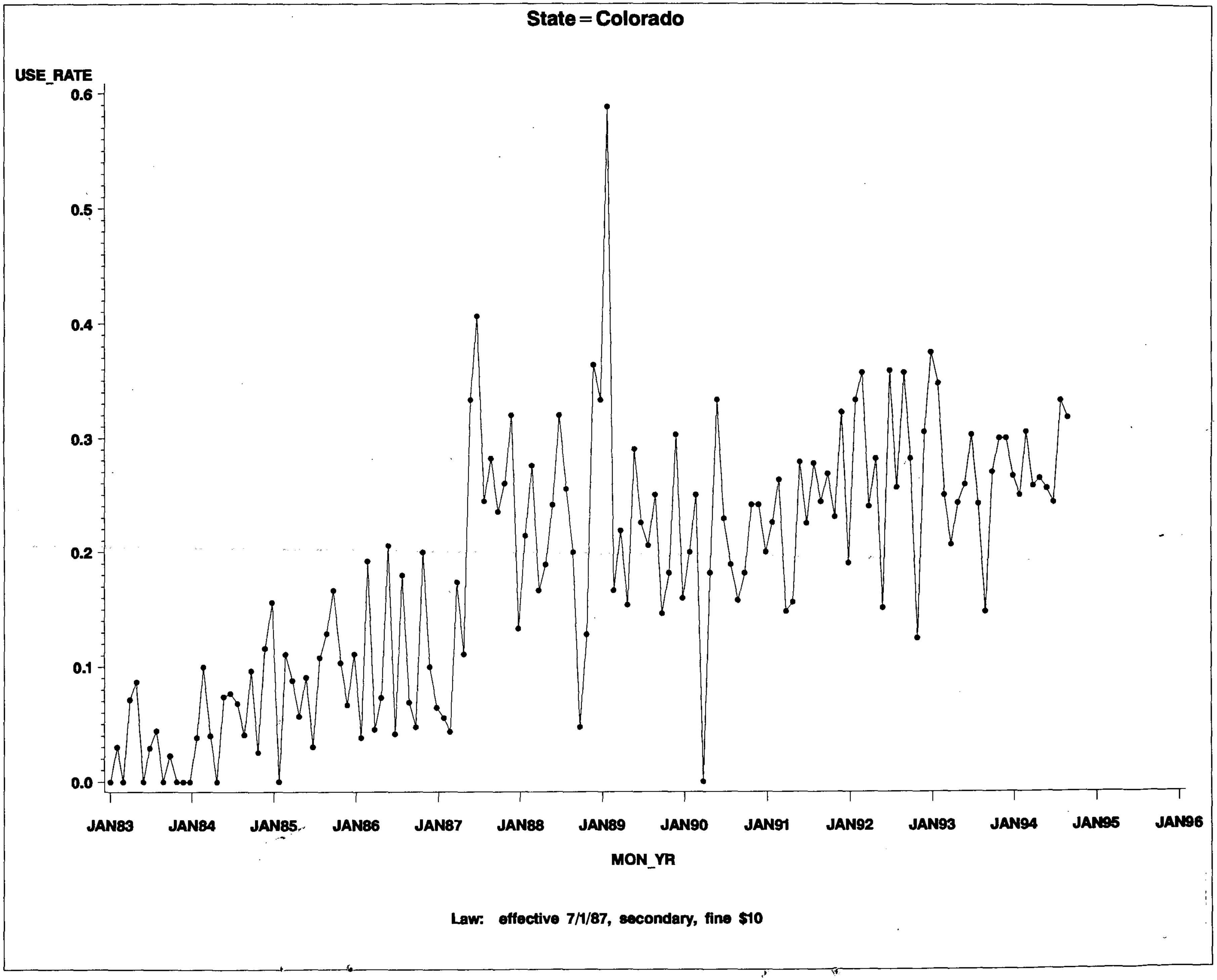
Law: effective 7/5/91, secondary, fine $25

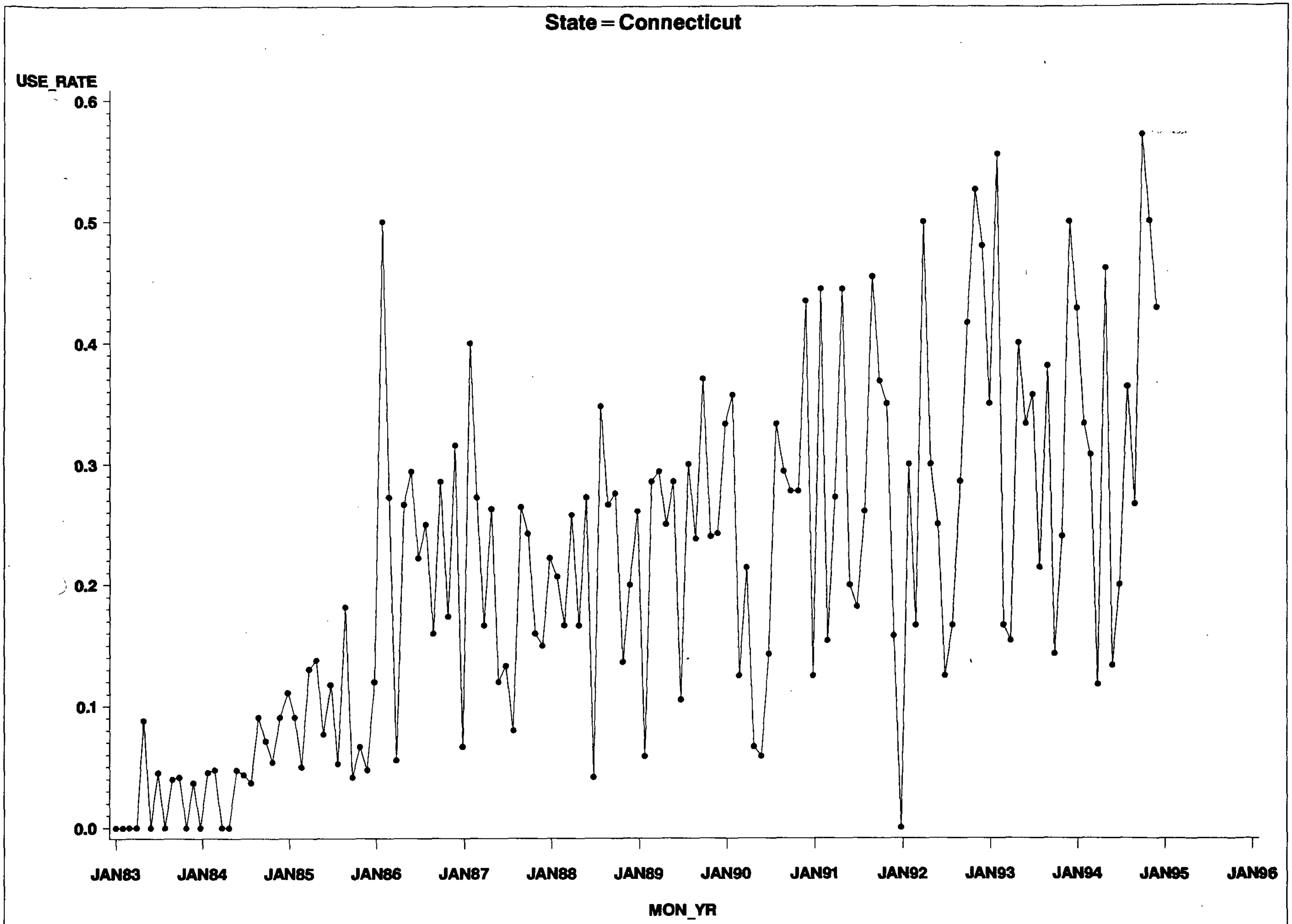


Law: effective 1/1/91, secondary, fine $10



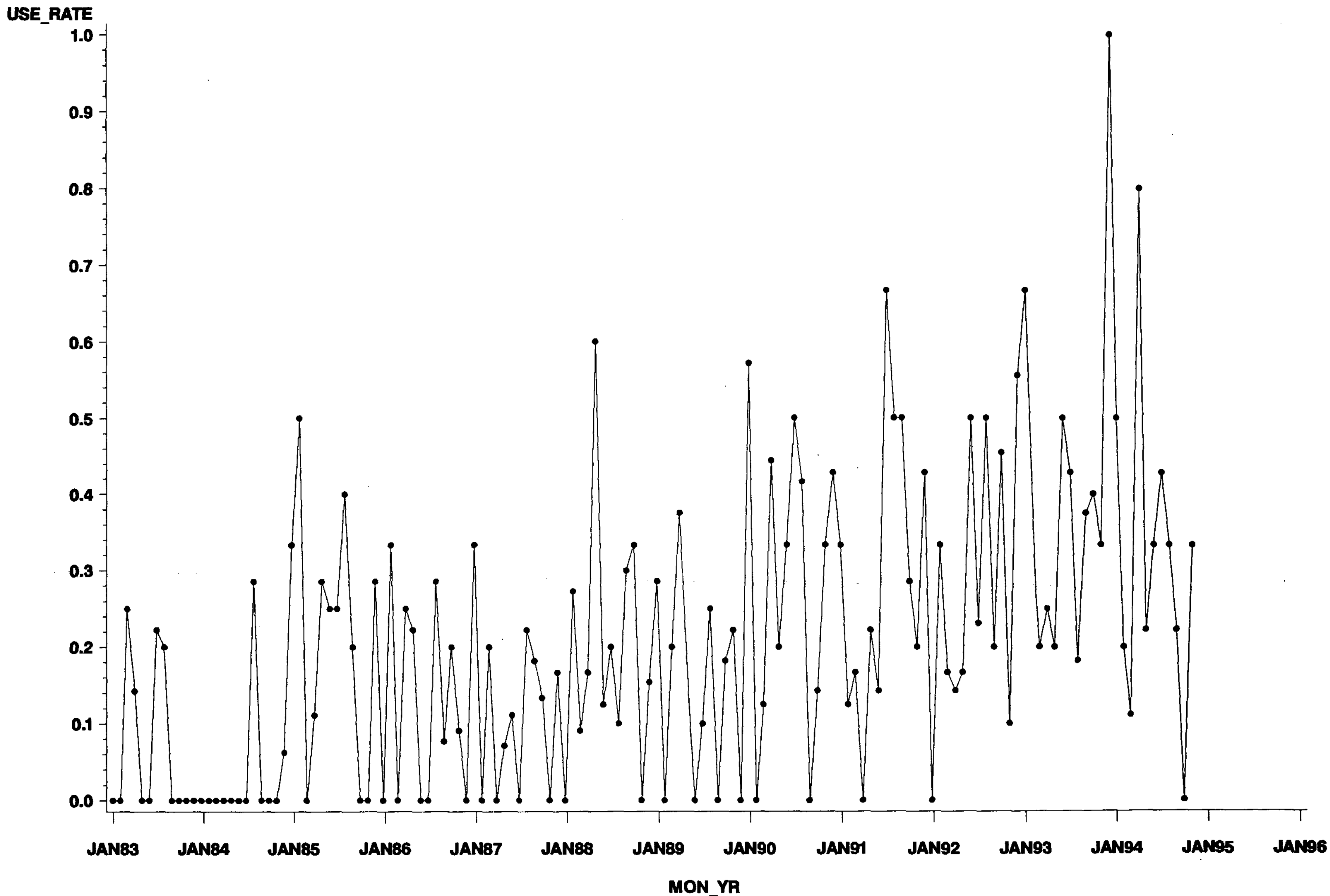
Law: effective 9/12/90, secondary, fine $22 – $55
upgrade 1/1/93, primary


State = Colorado
USE_RATE
0.6
0.5
0.4
0.3
0.2
0.1
0.0
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
MON_YR
Law: effective 7/1/87, secondary, fine $10



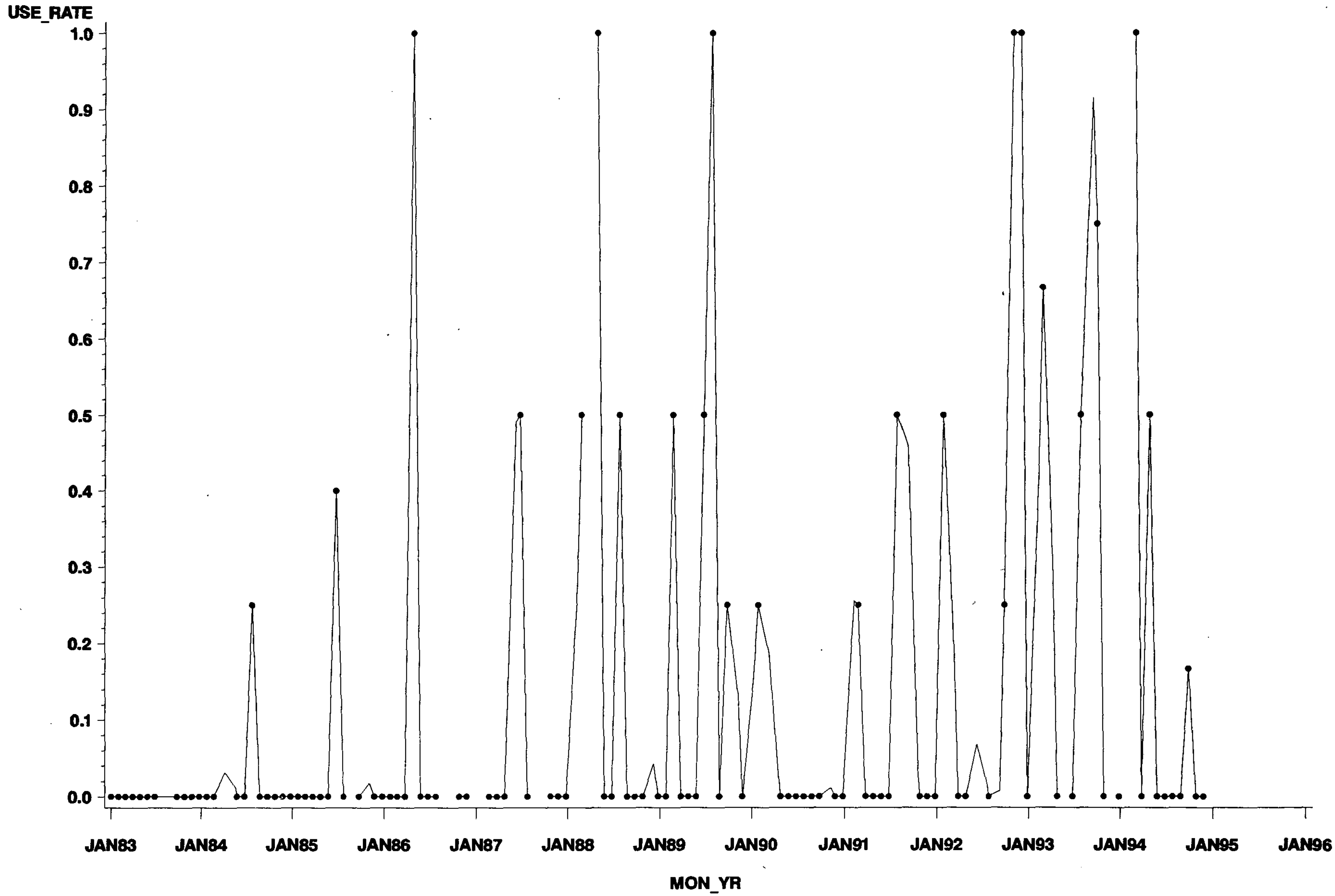
Law: effective 1/1/86, primary, fine $15
upgrade 6/5/91, fine $37

State = Delaware



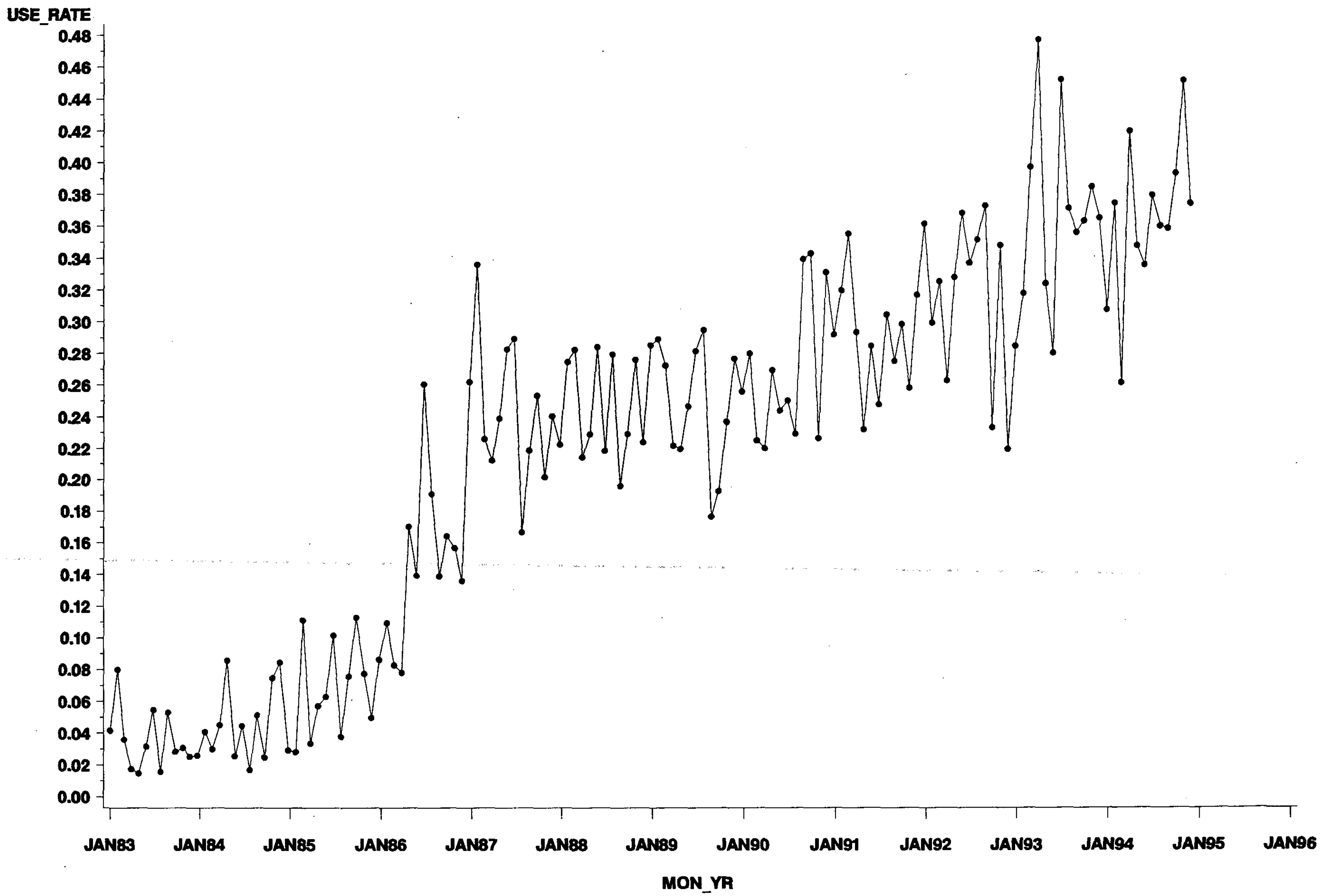
Law: effective 1/1/91, secondary, fine $20

State = Dist of Columbia

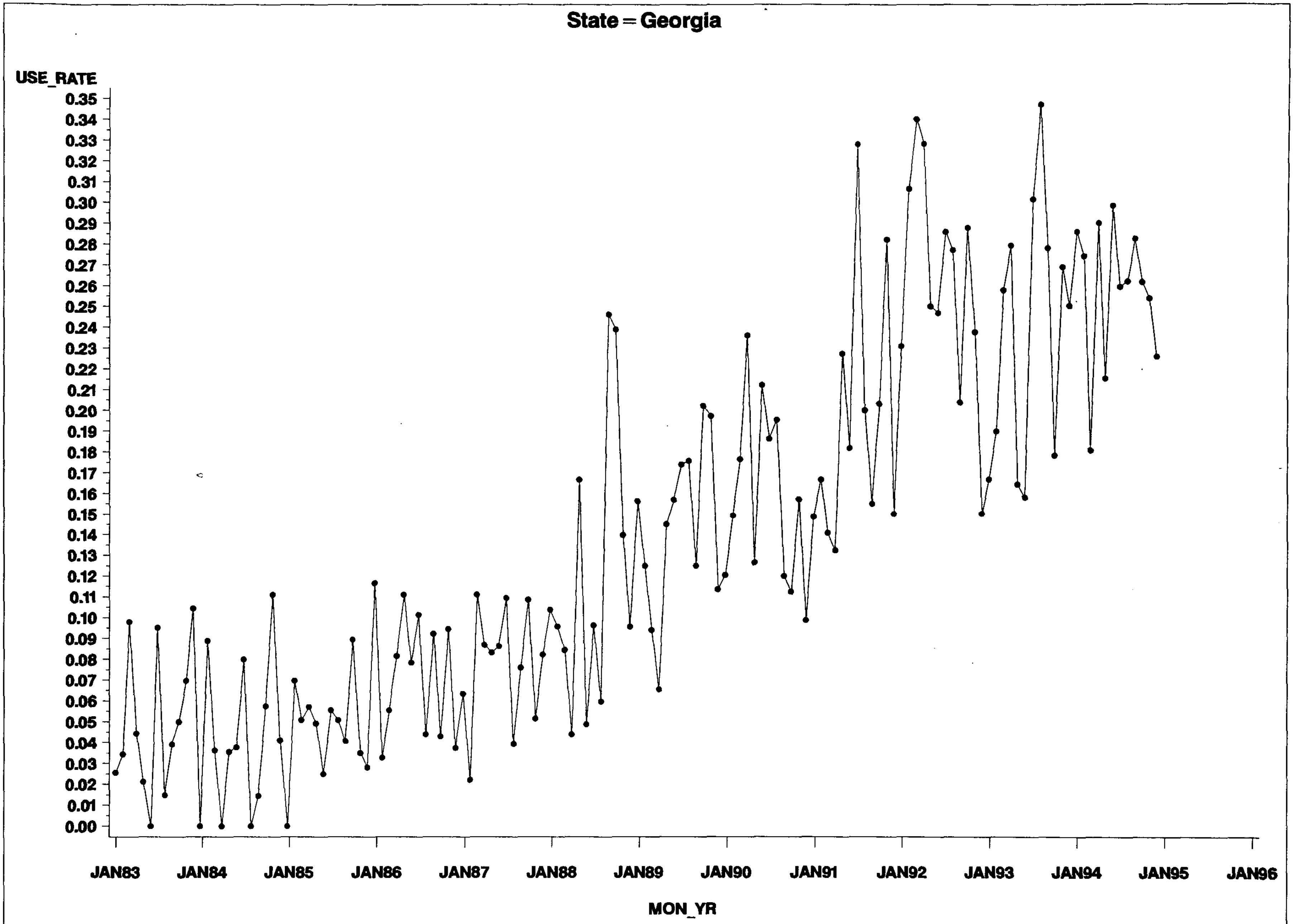


Law: effective 12/12/85, secondary
fine 6/12/86, $15

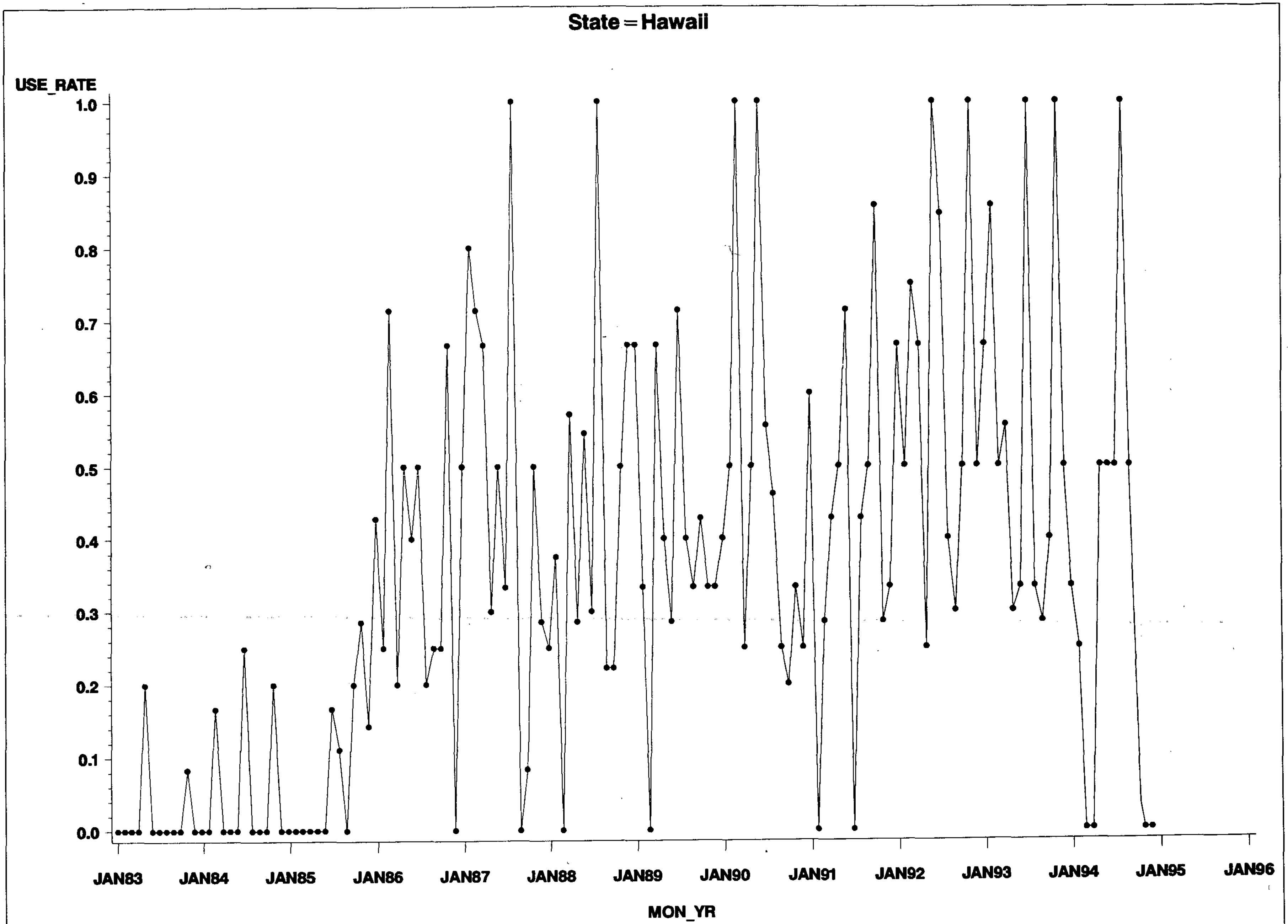
State = Florida



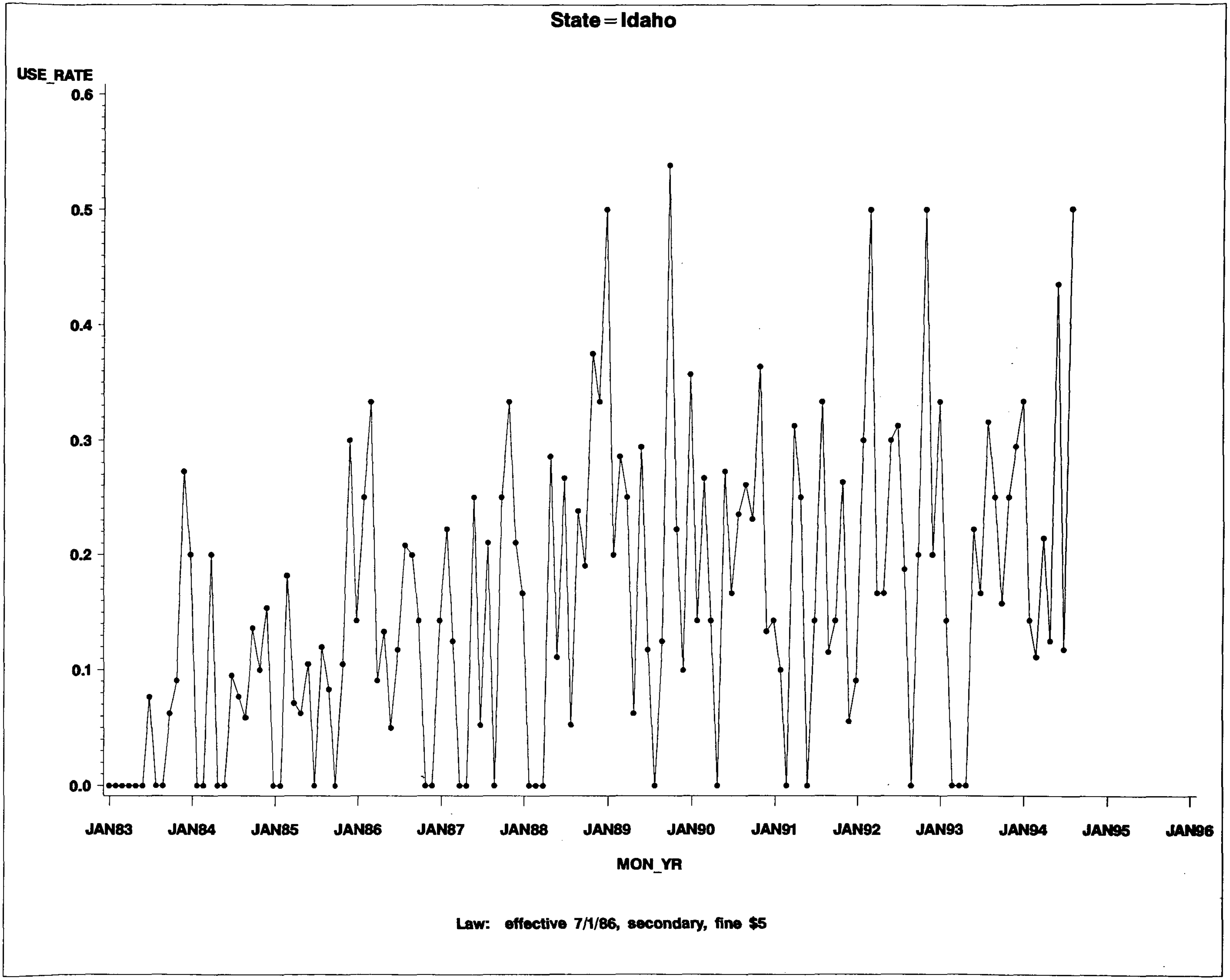
Law: *effective* **7/1/86, secondary**
fine 1/1/87, $20



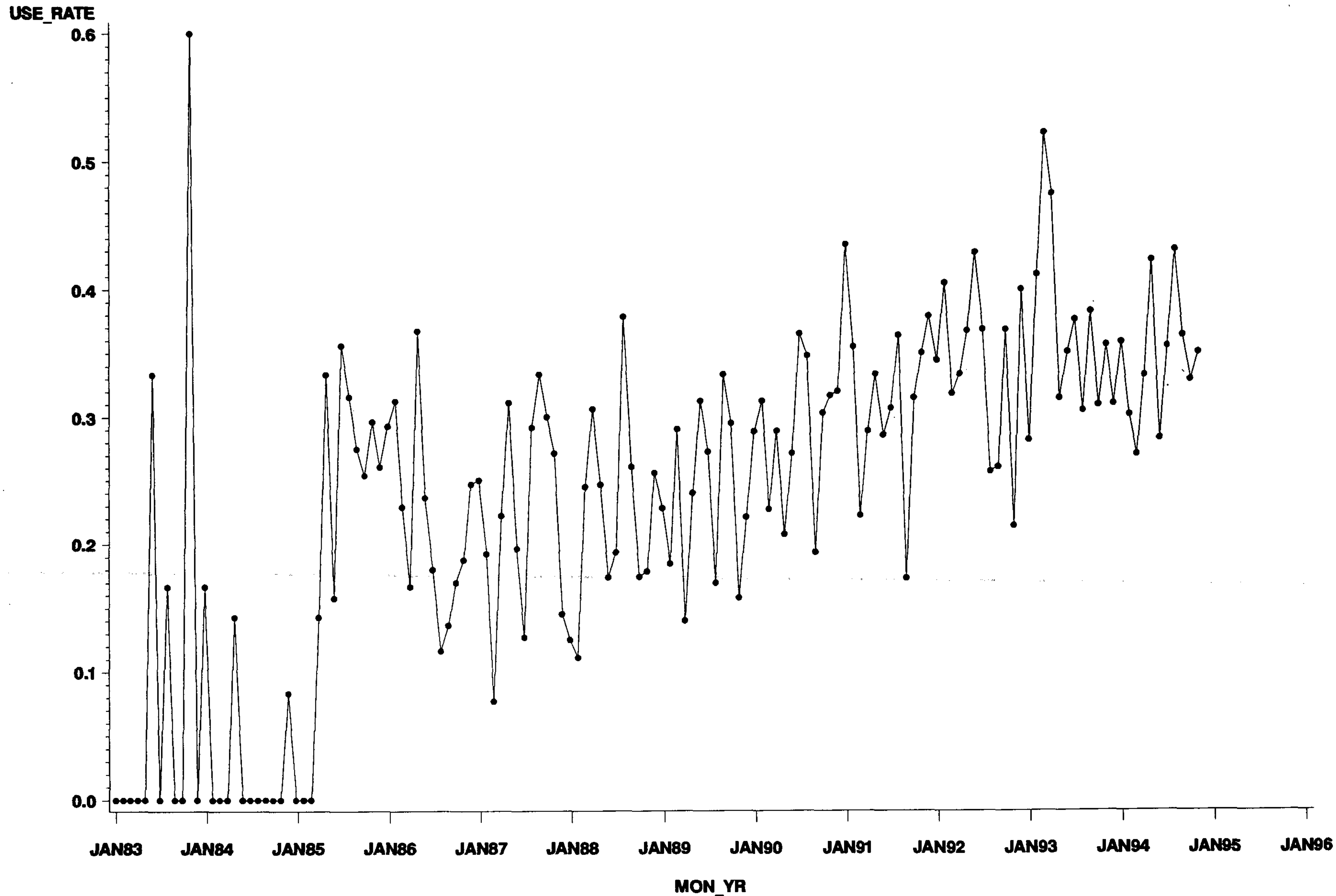
Law: effective 9/1/88, secondary, fine $15
amended 3/30/90, exempts pickups explicitly



Law: effective 12/16/85, secondary, fine $15
upgrade 6/6/88, fine $20

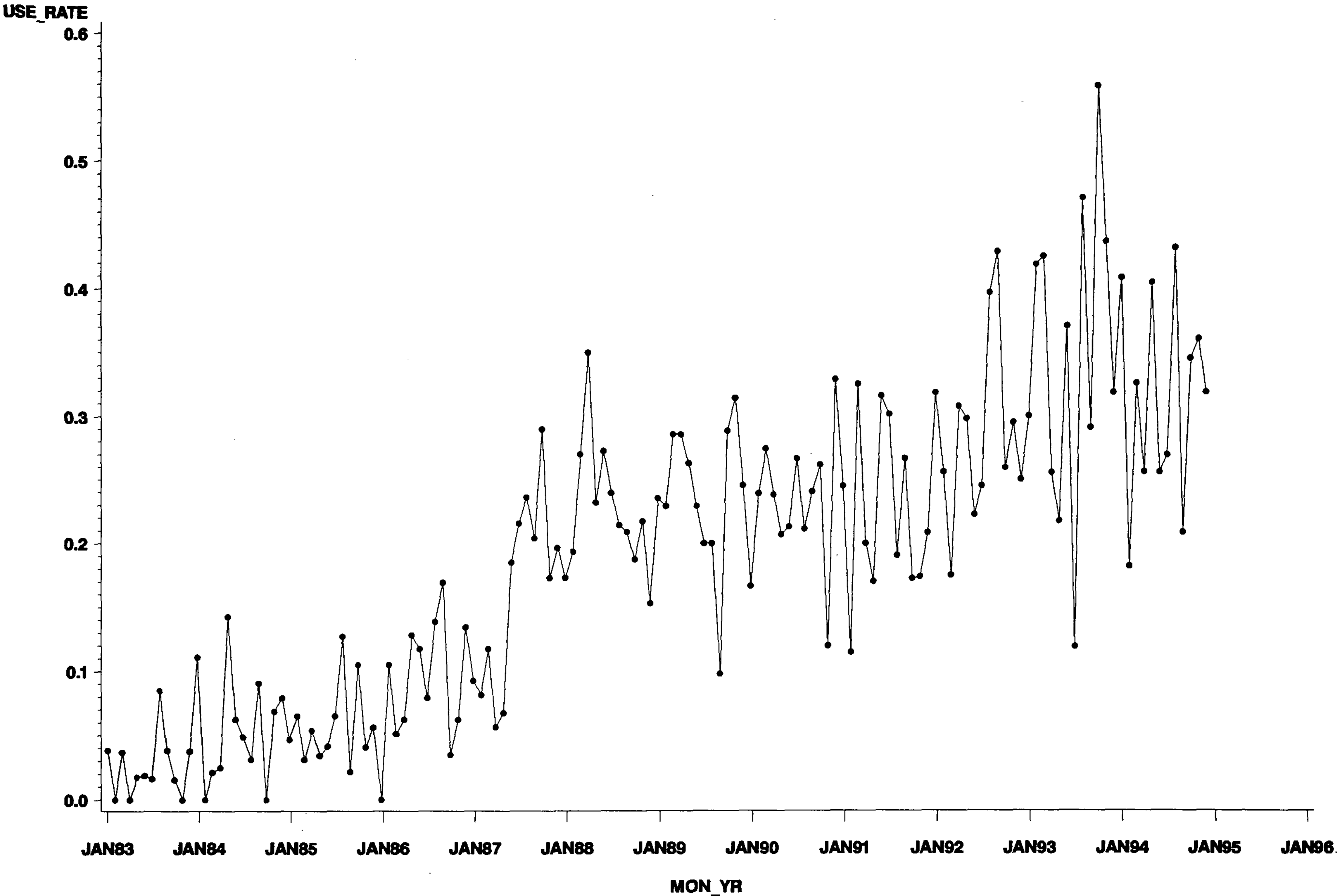

State=Idaho
USE_RATE
0.6
0.5
0.4
0.3
0.2
0.1
0.0
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
MON_YR
Law: effective 7/1/86, secondary, fine $5

State = Illinois



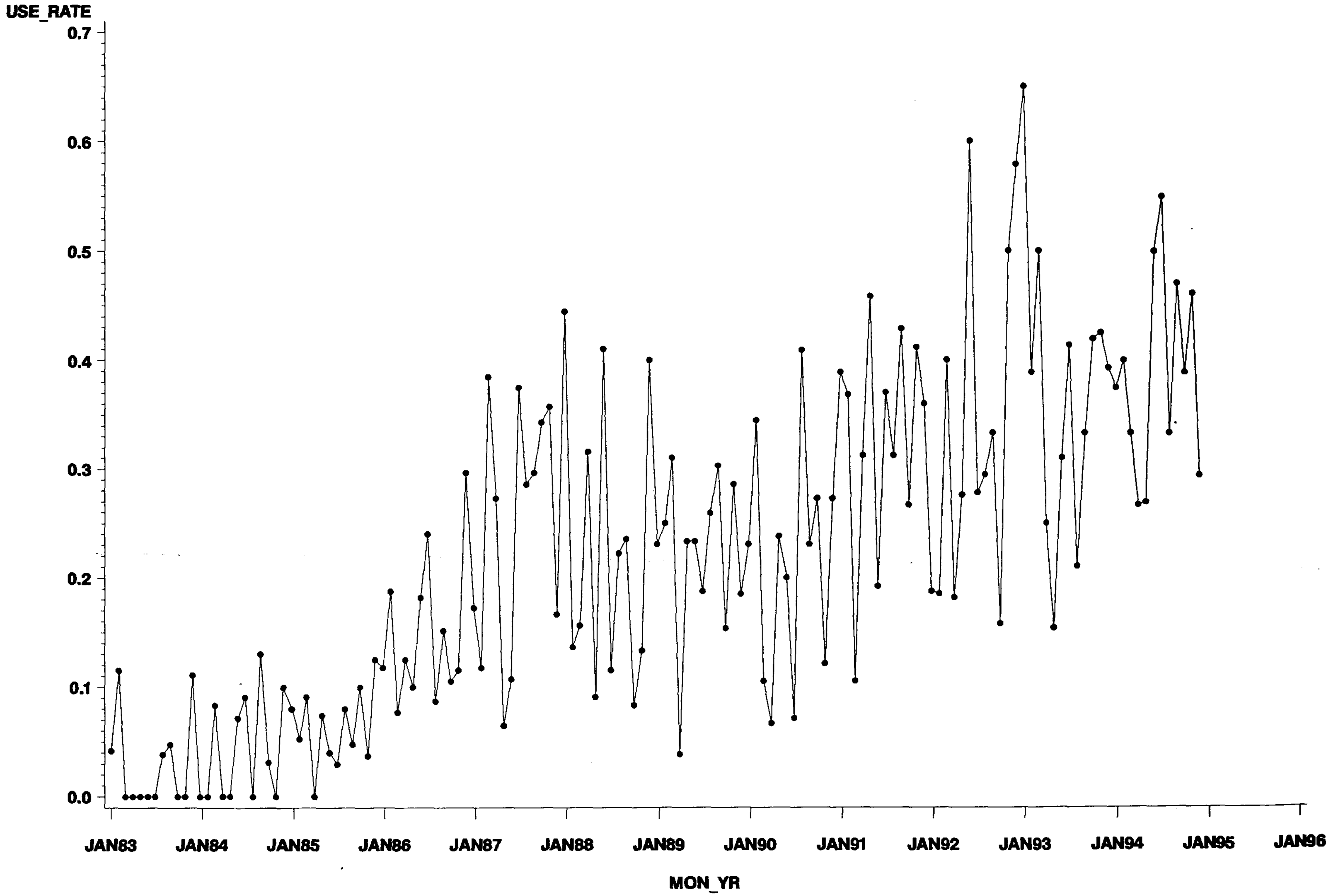
Law: effective 7/1/85, primary, fine $25
change 1/1/88, secondary

State = Indiana

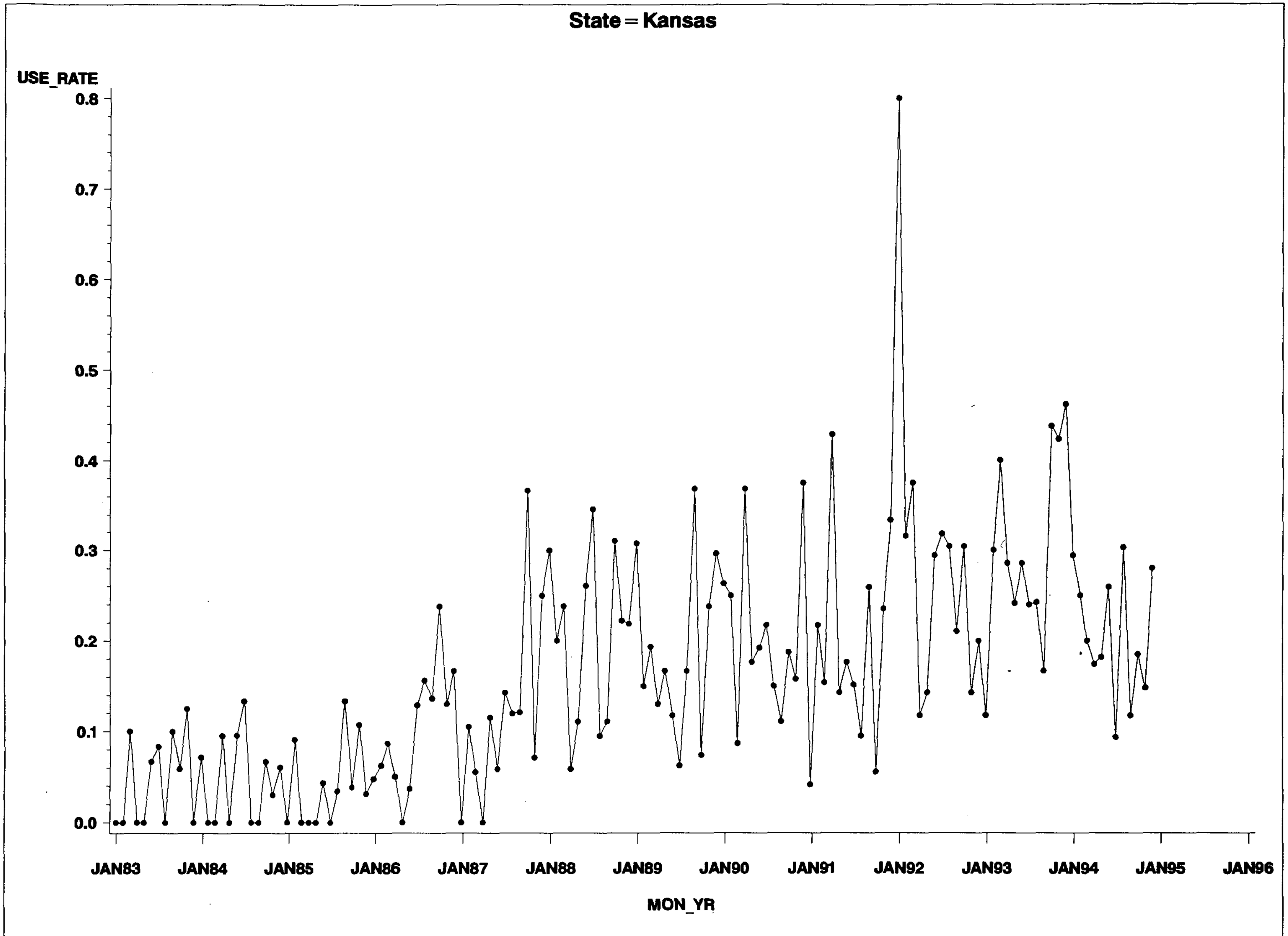


Law: effective 7/1/87, secondary, fine $25

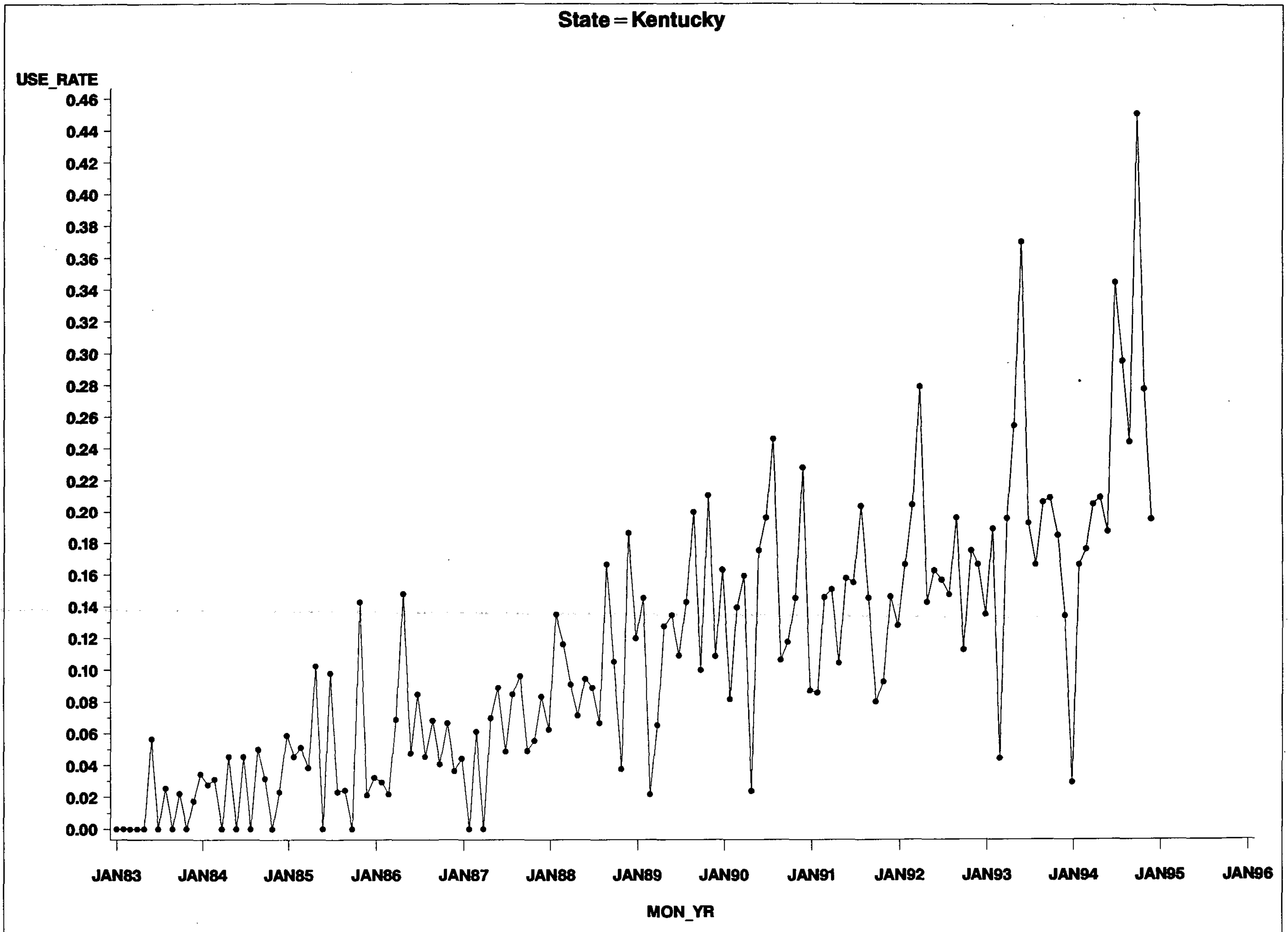
State = Iowa



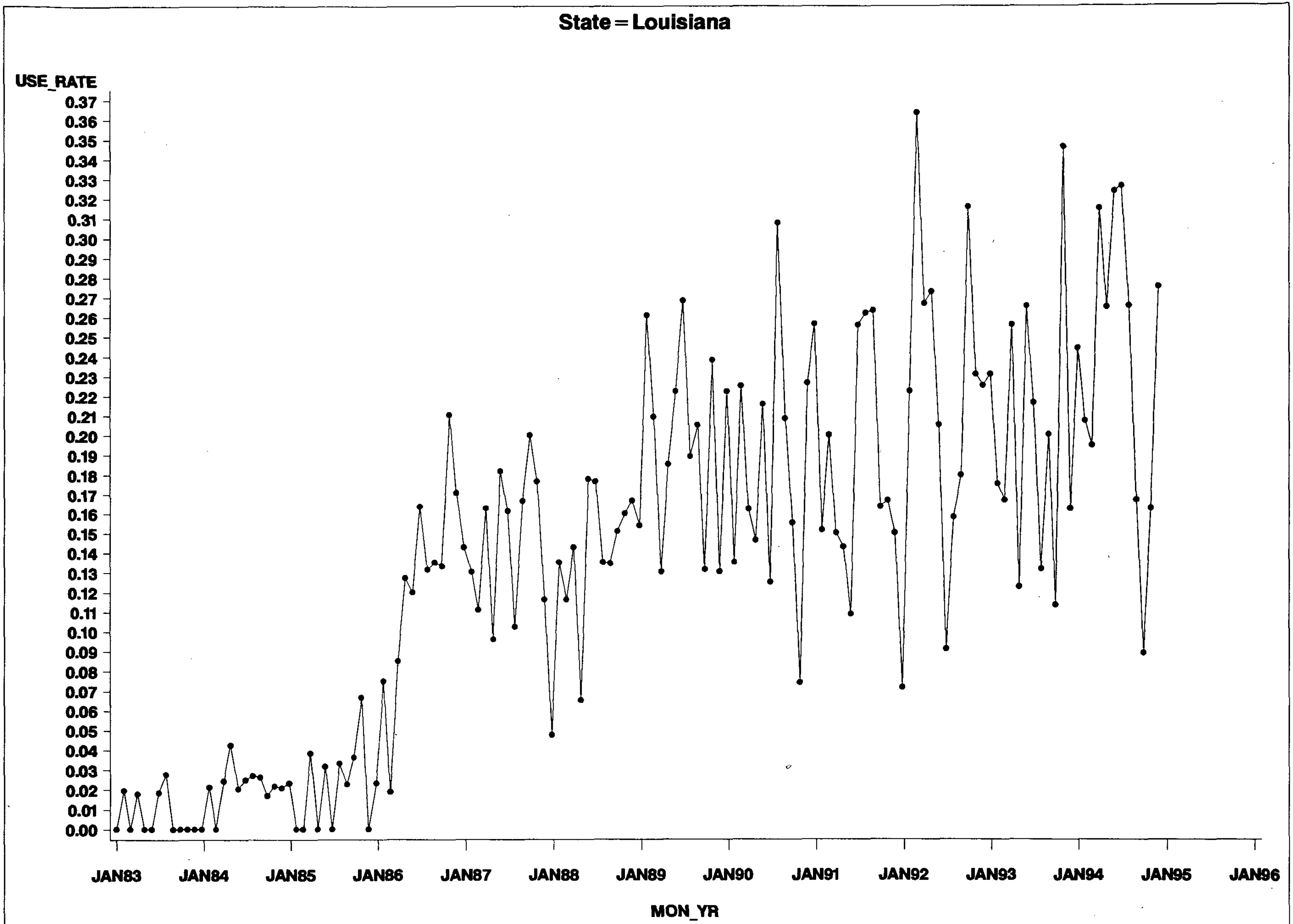
Law: effective 7/1/86, primary
fine 1/1/87, $22.50



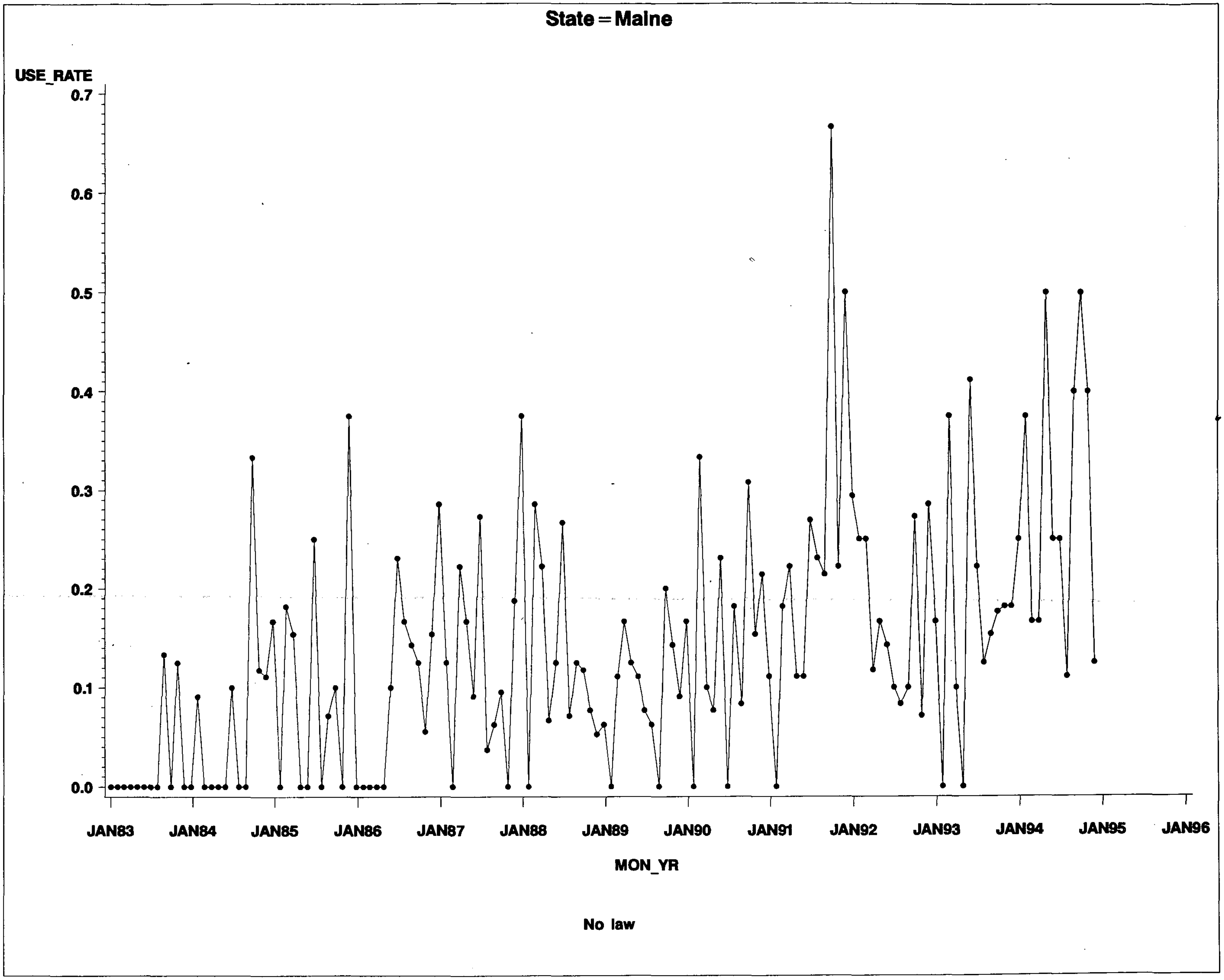
Law: effective 7/1/86, secondary, fine $10



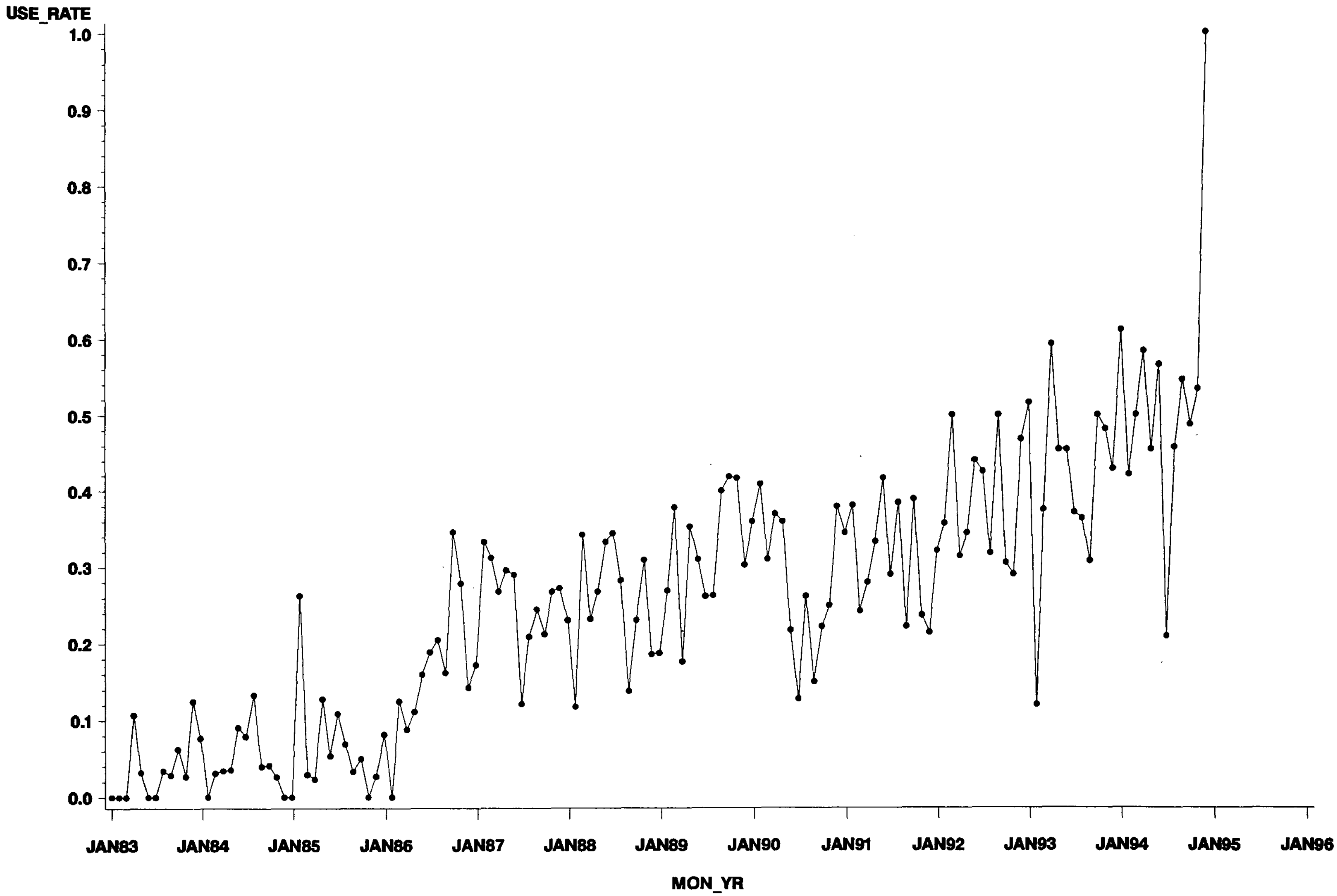
Law: effective 7/13/94, secondary, fine $25



Law: effective 7/1/86, secondary
fine 8/1/86, $25

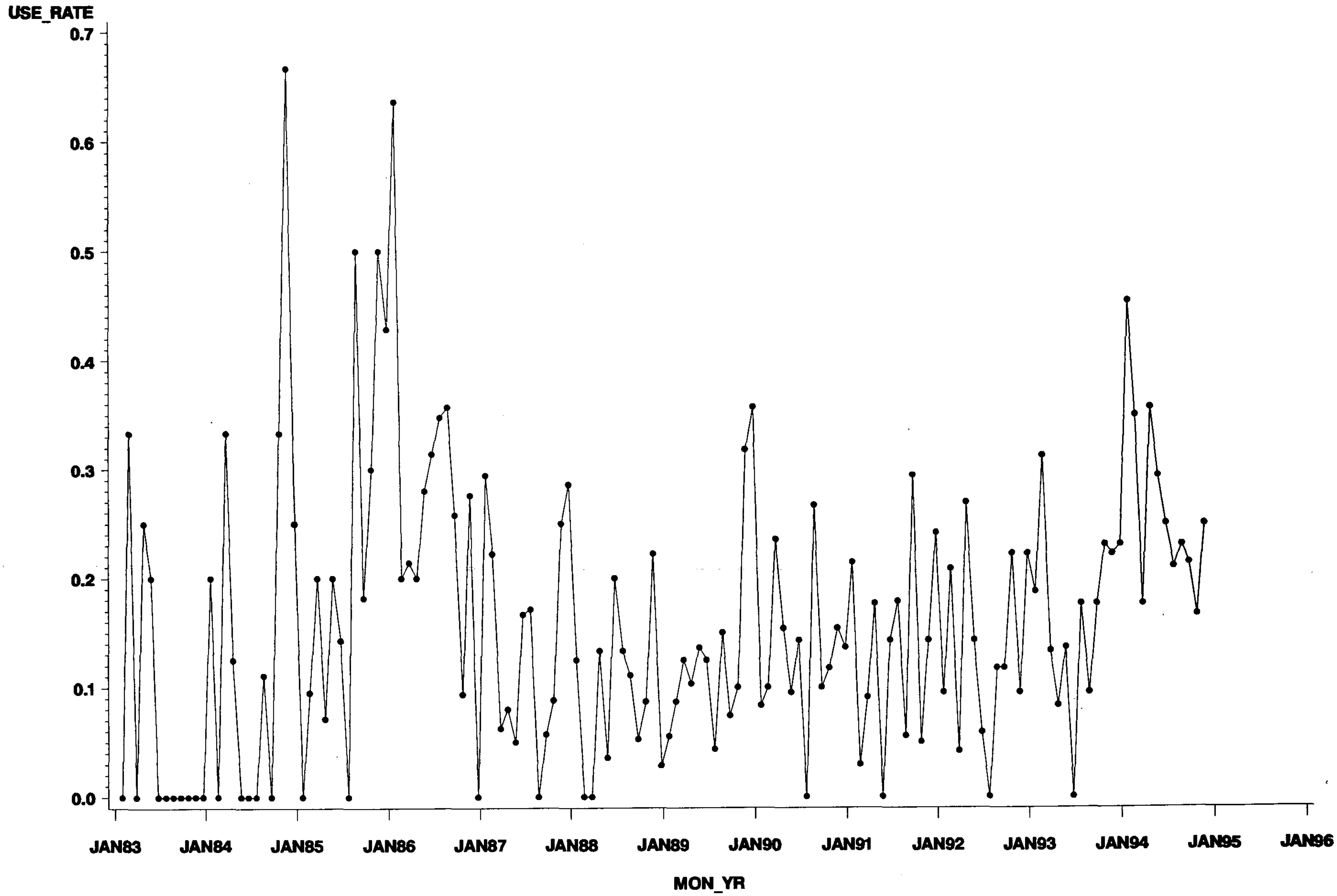

State = Maine
USE_RATE
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
MON_YR
No law

State = Maryland

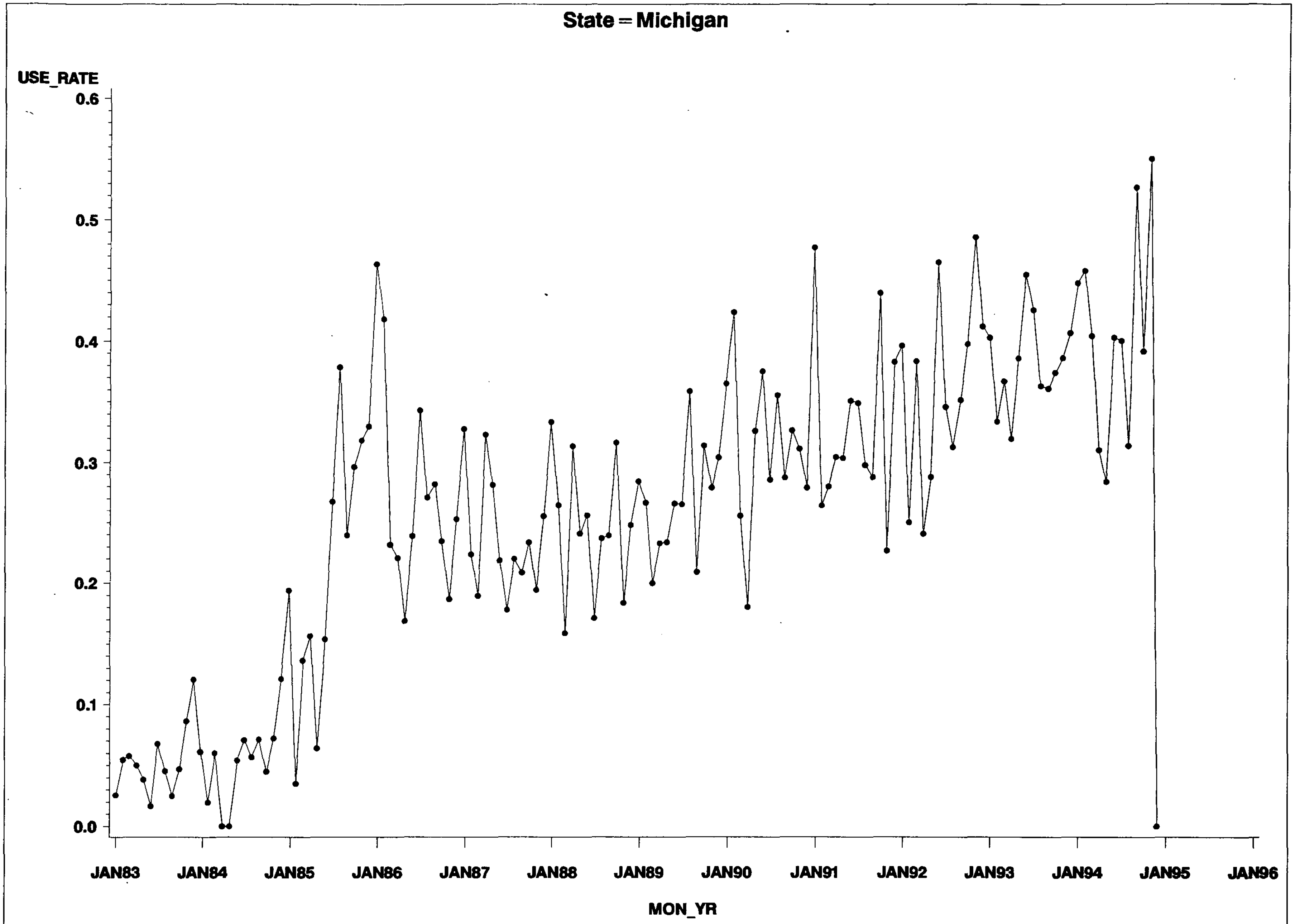


Law: effective 7/1/86, secondary, fine $20

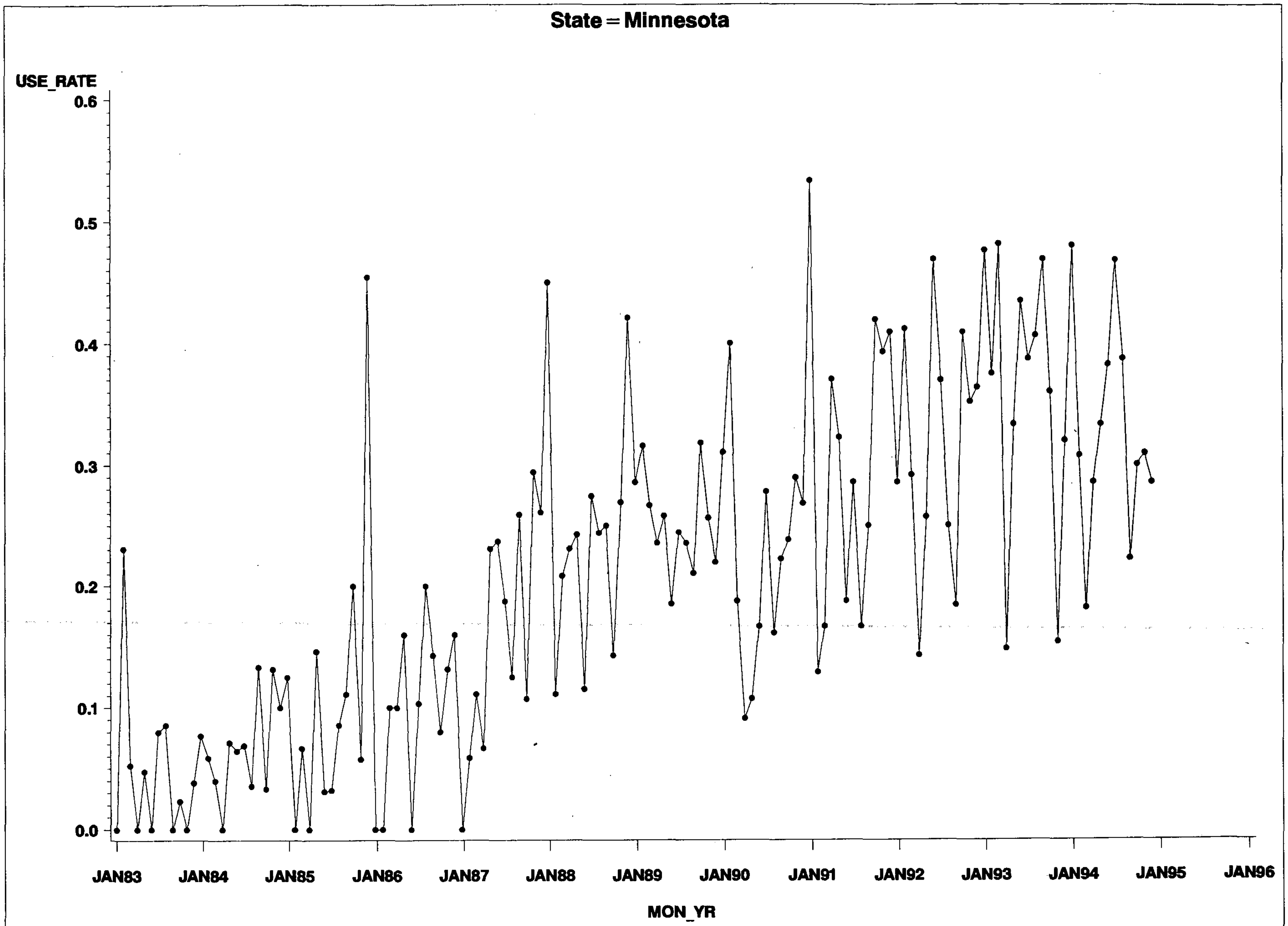
State = Massachusetts



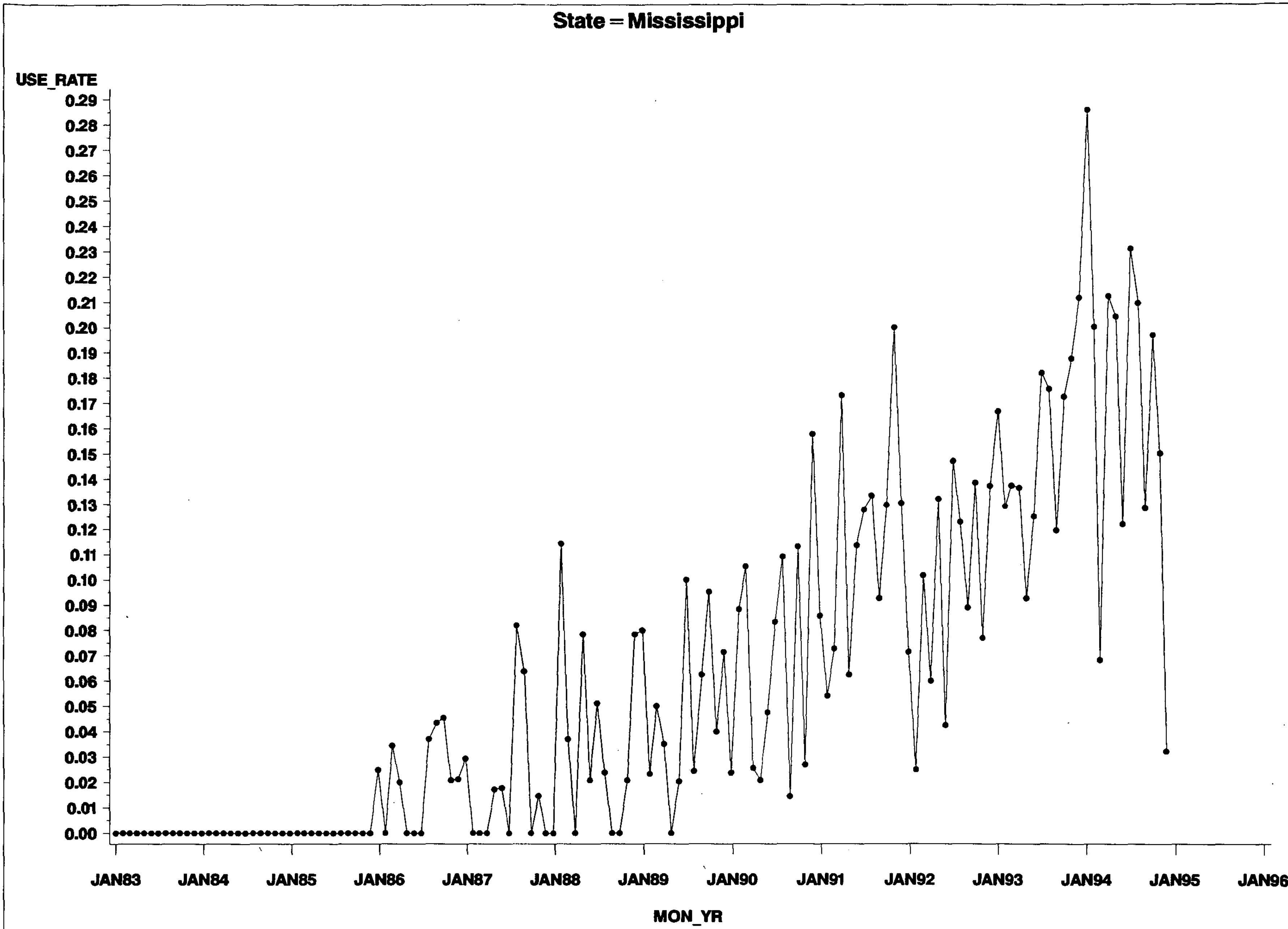
Law: effective 2/1/94, secondary, fine $25



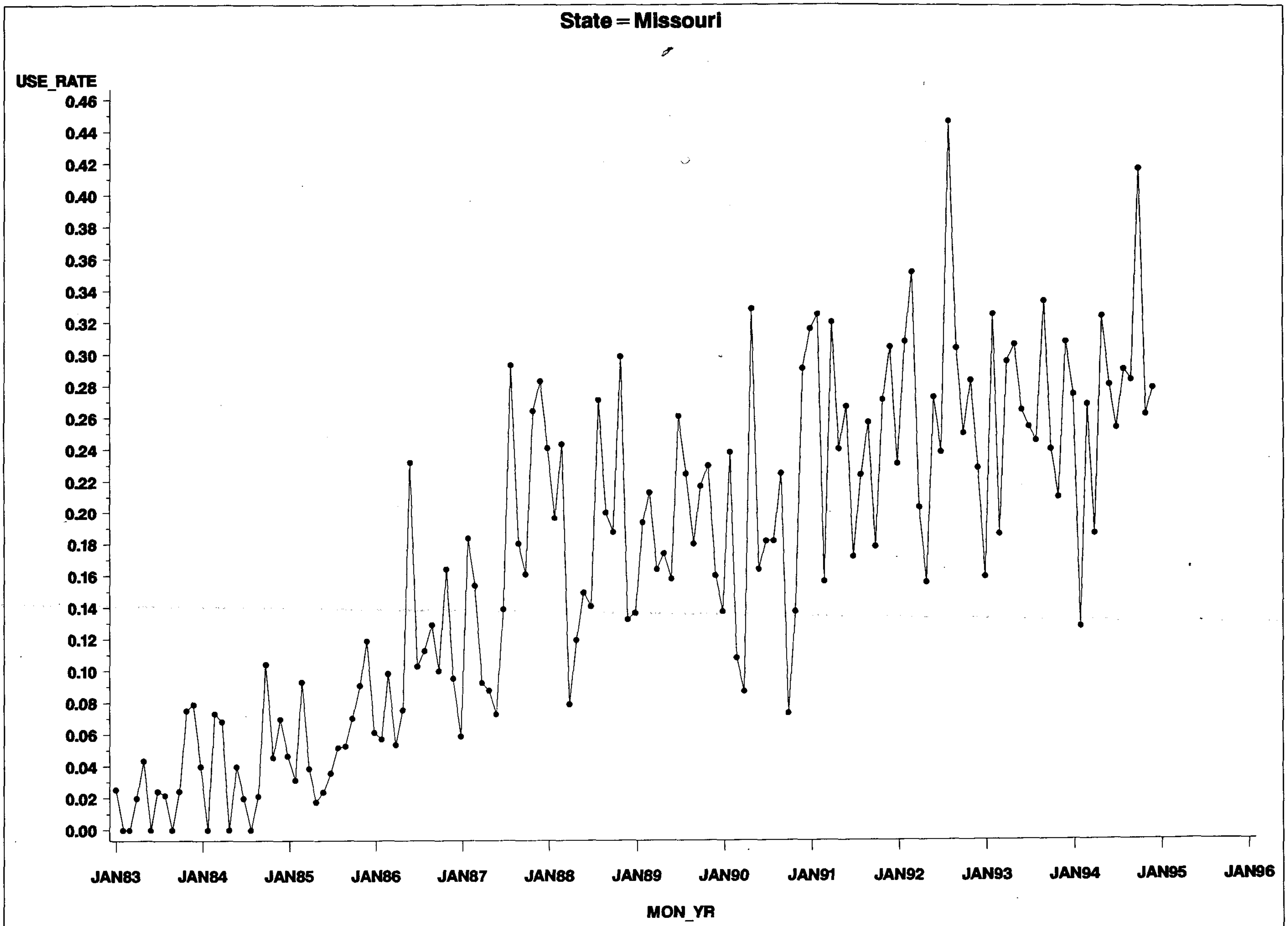
Law: effective 7/1/85, secondary, fine $10
upgrade 1/1/86, fine $25



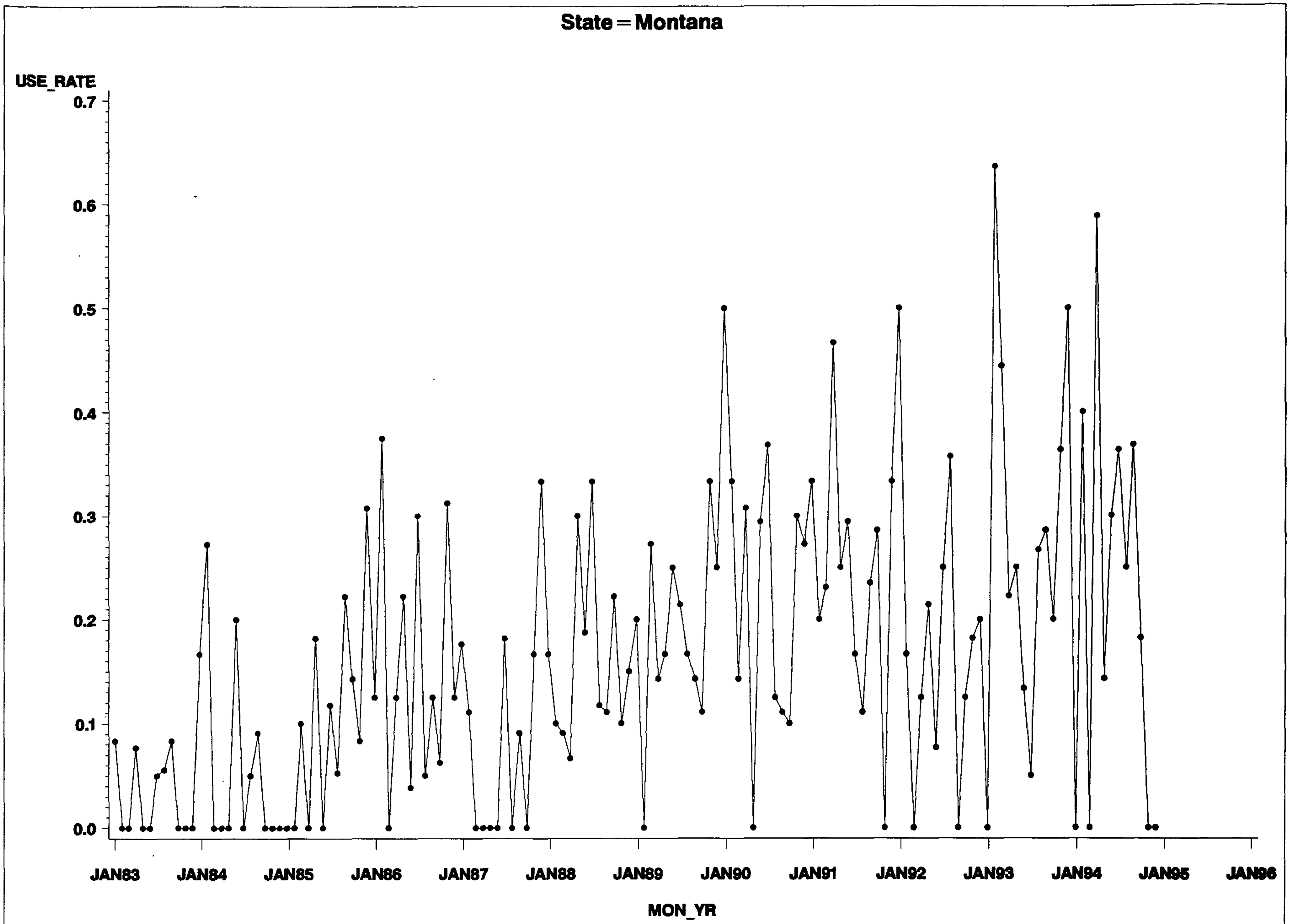
Law: effective 8/1/86, secondary, fine $0
upgrade 5/1/86, fine $10
upgrade 5/27/91, fine $25



Law: effective 3/20/90, primary, fine $0
change 7/1/94 secondary, fine $25

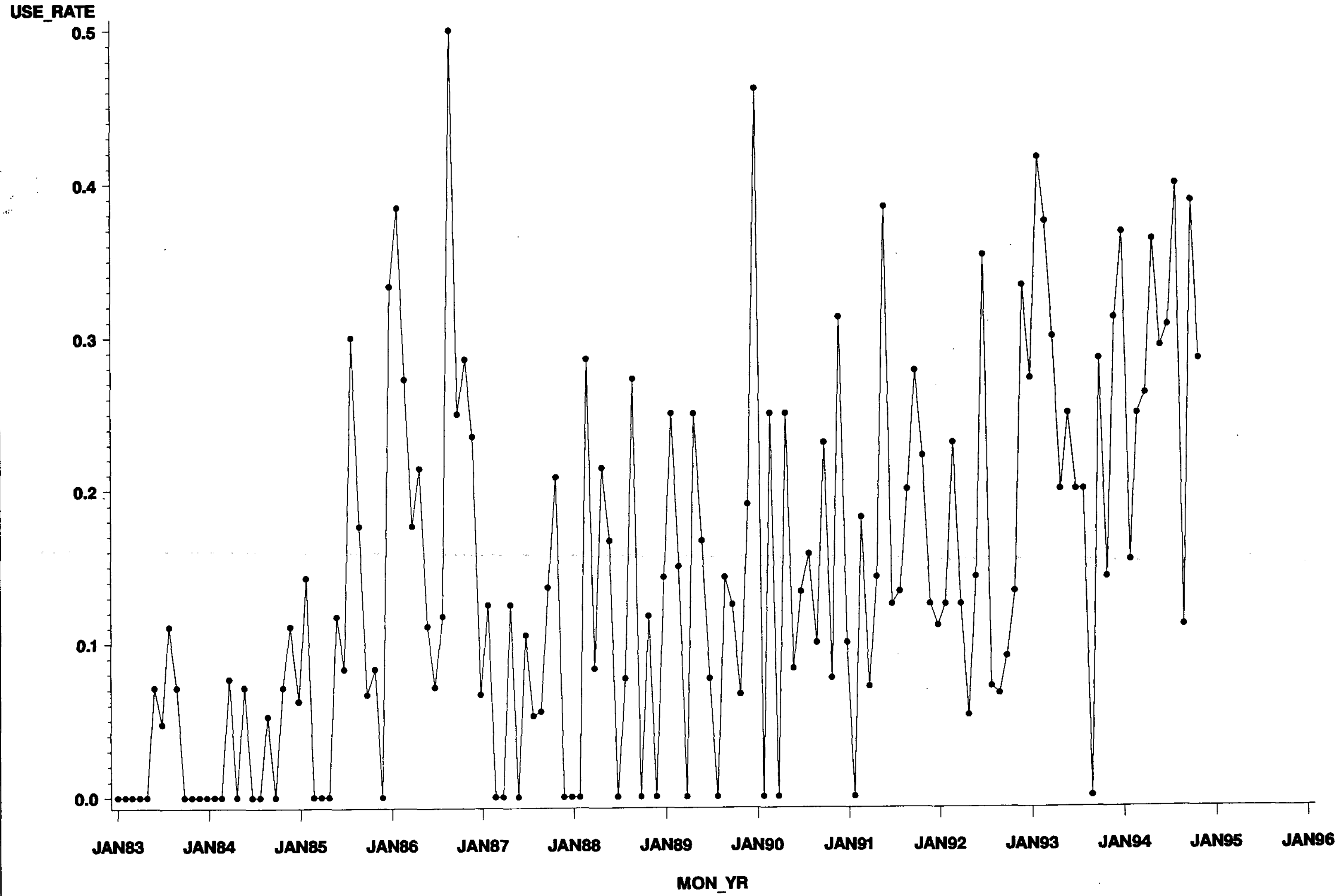


Law: effective 9/28/85, secondary
fine 7/1/87, $10



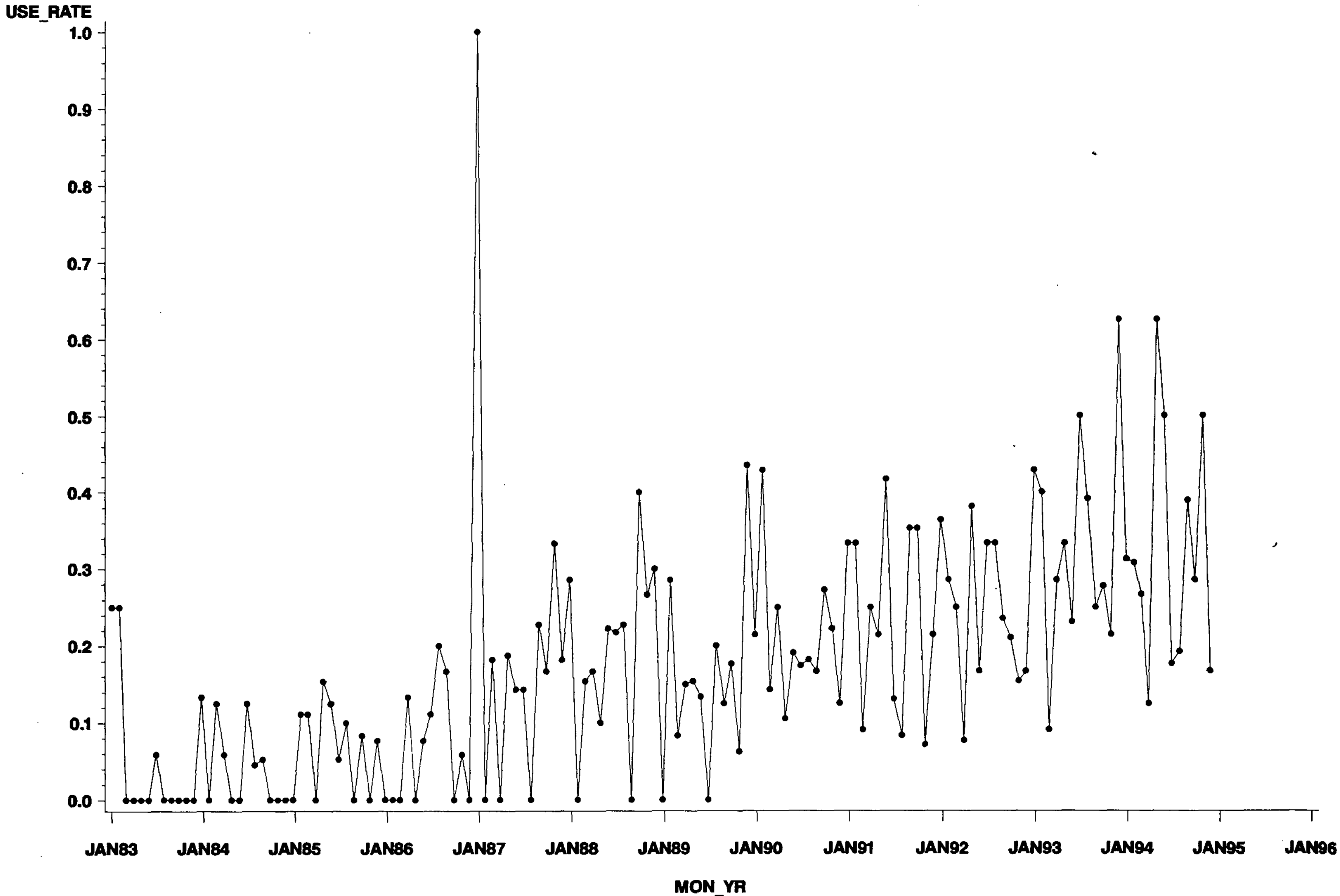
Law: effective 10/1/87, secondary
fine 1/1/88, $20

State = Nebraska



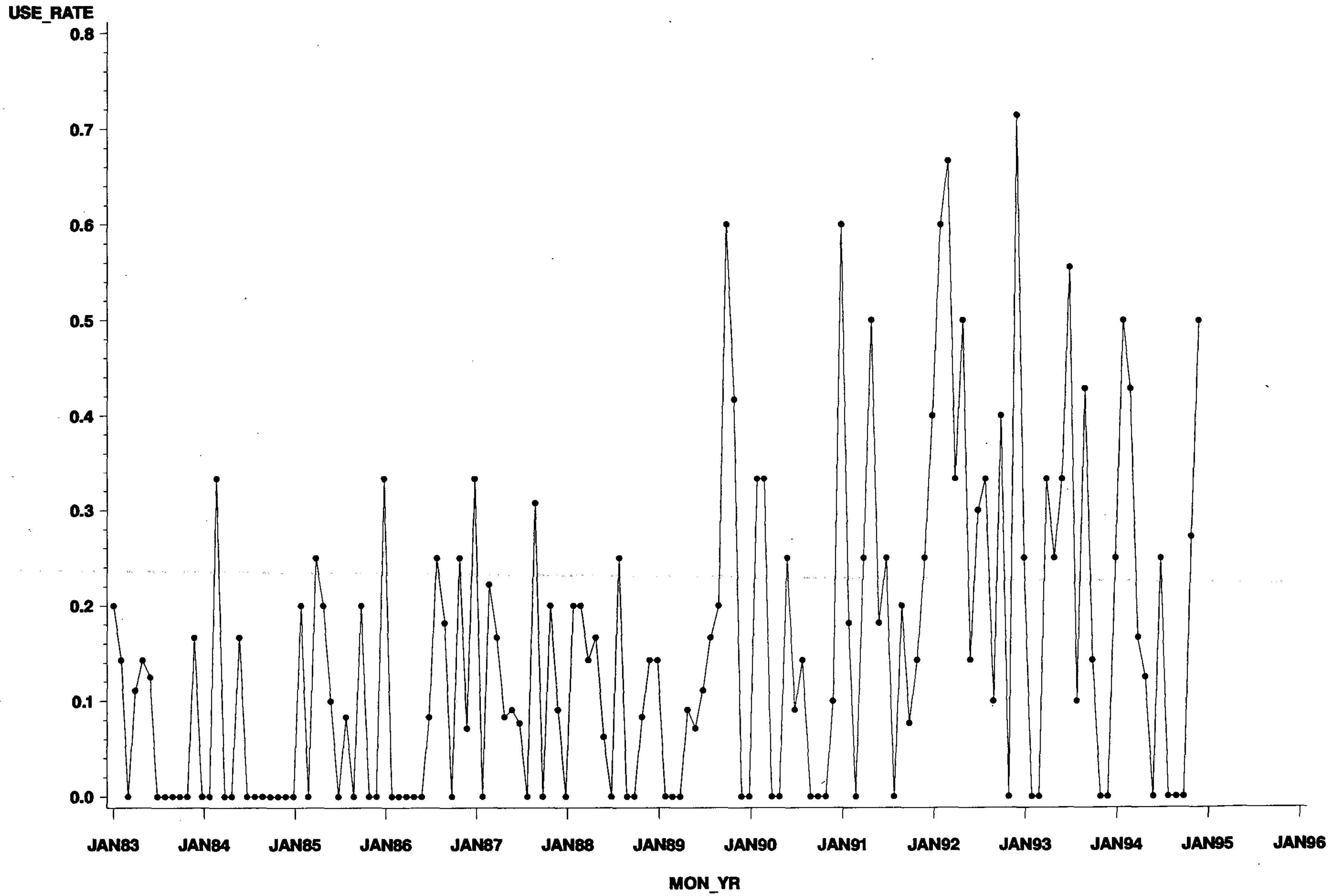
Law: effective 9/6/85, secondary, fine $25
repealed Nov. 86
effective 1/1/93, secondary, fine $25

State = Nevada

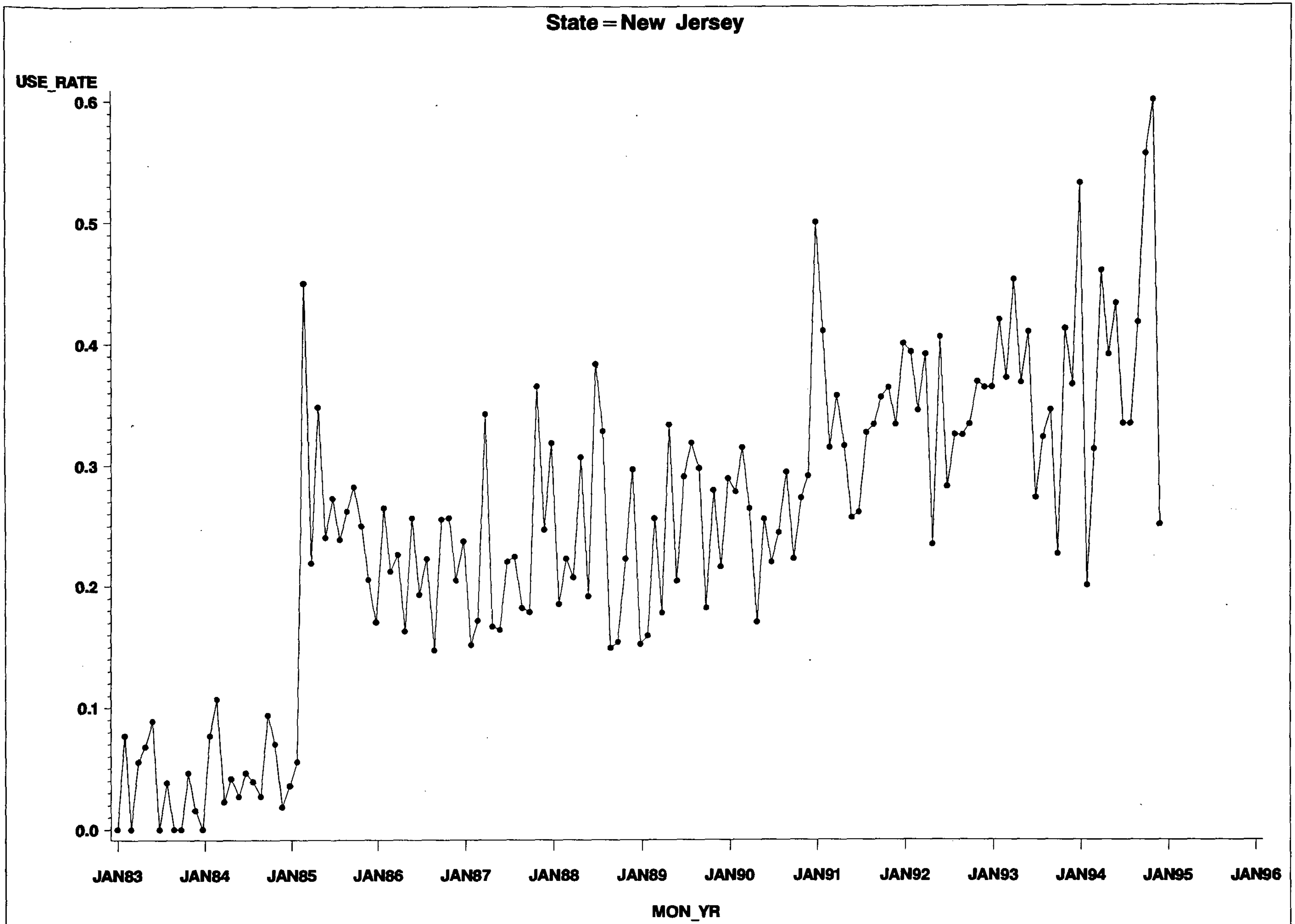


Law: effective 7/1/87, secondary, fine $25

State = New Hampshire

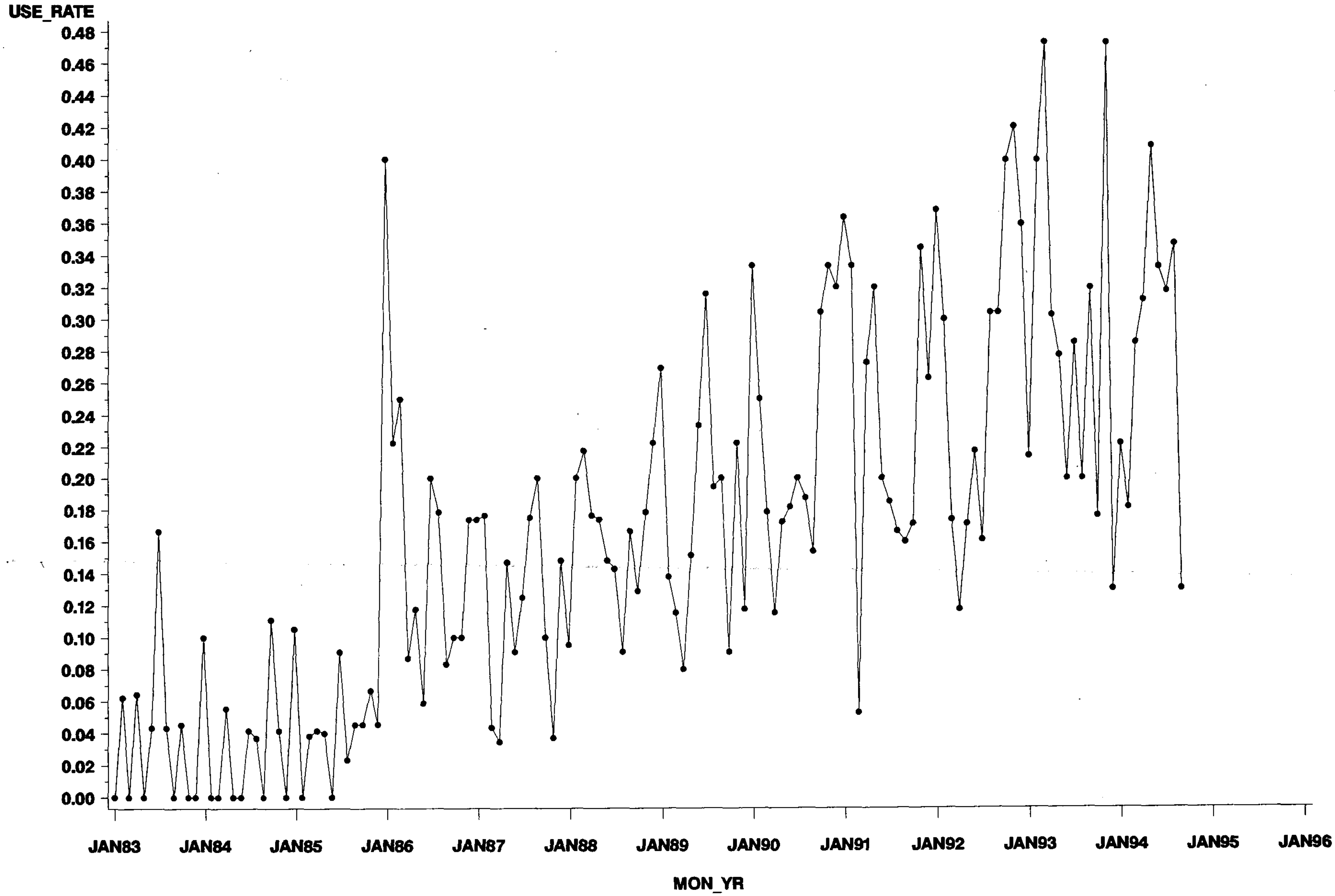


No law

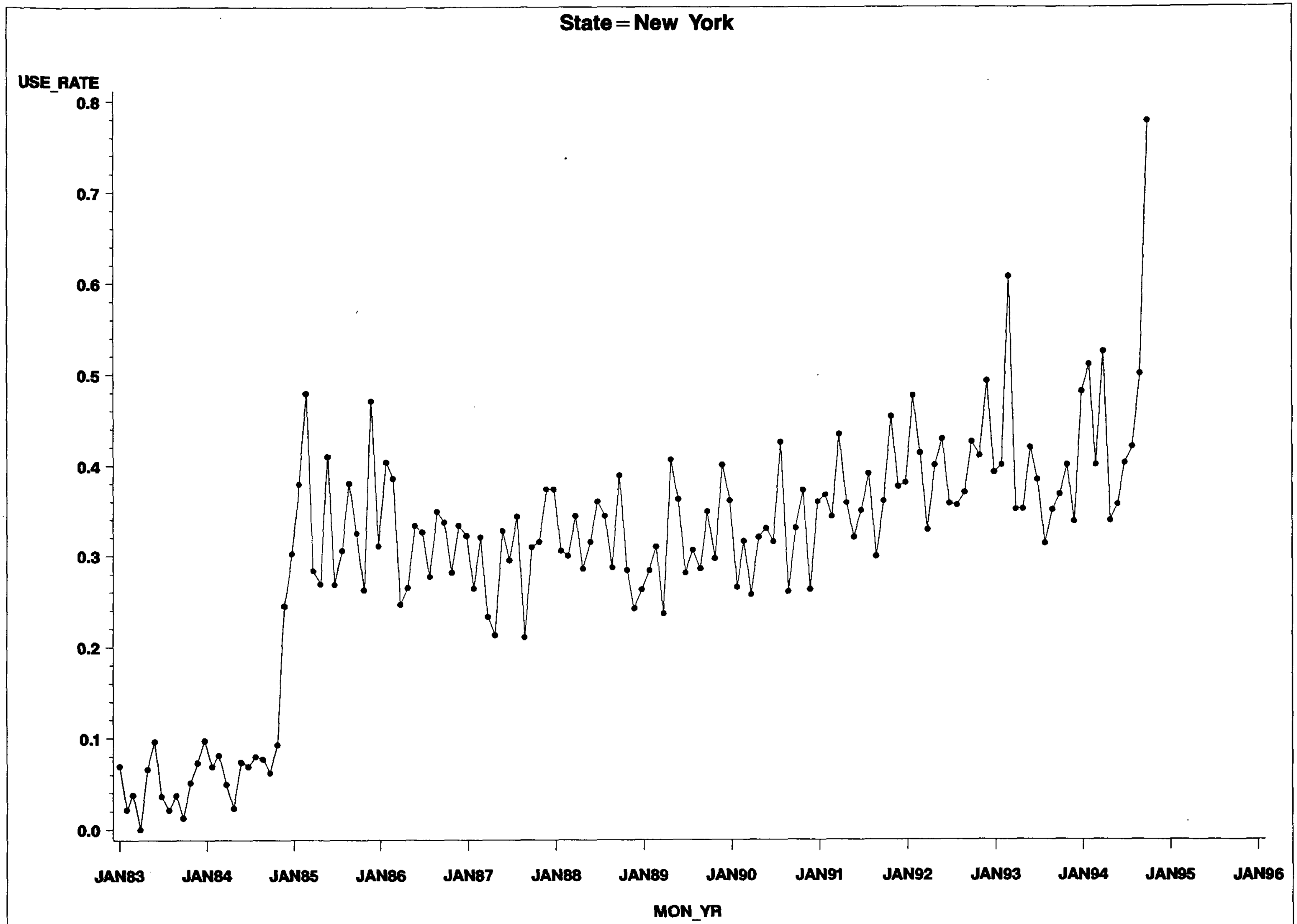


Law: effective 3/1/85, secondary, fine $20

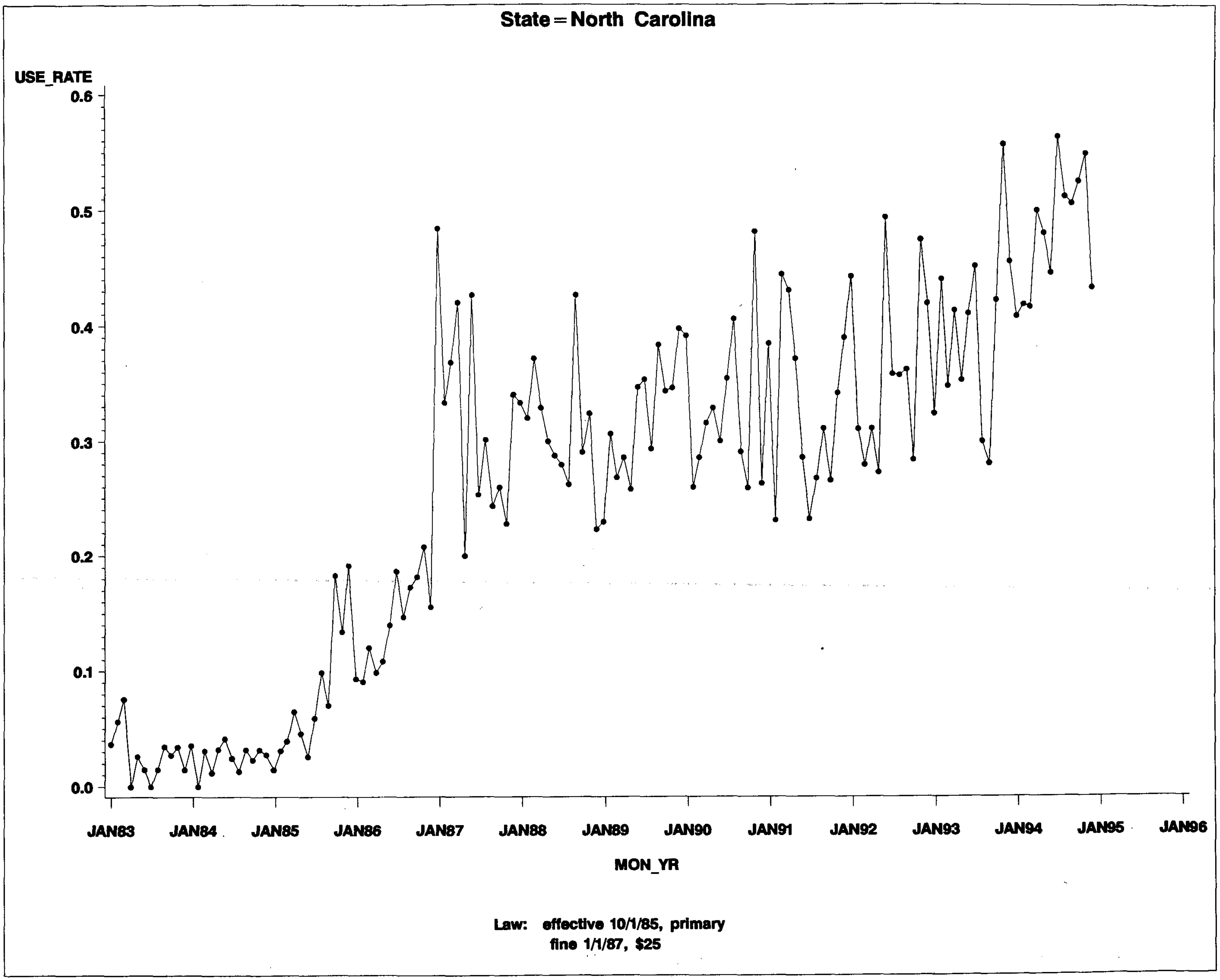
State=New Mexico

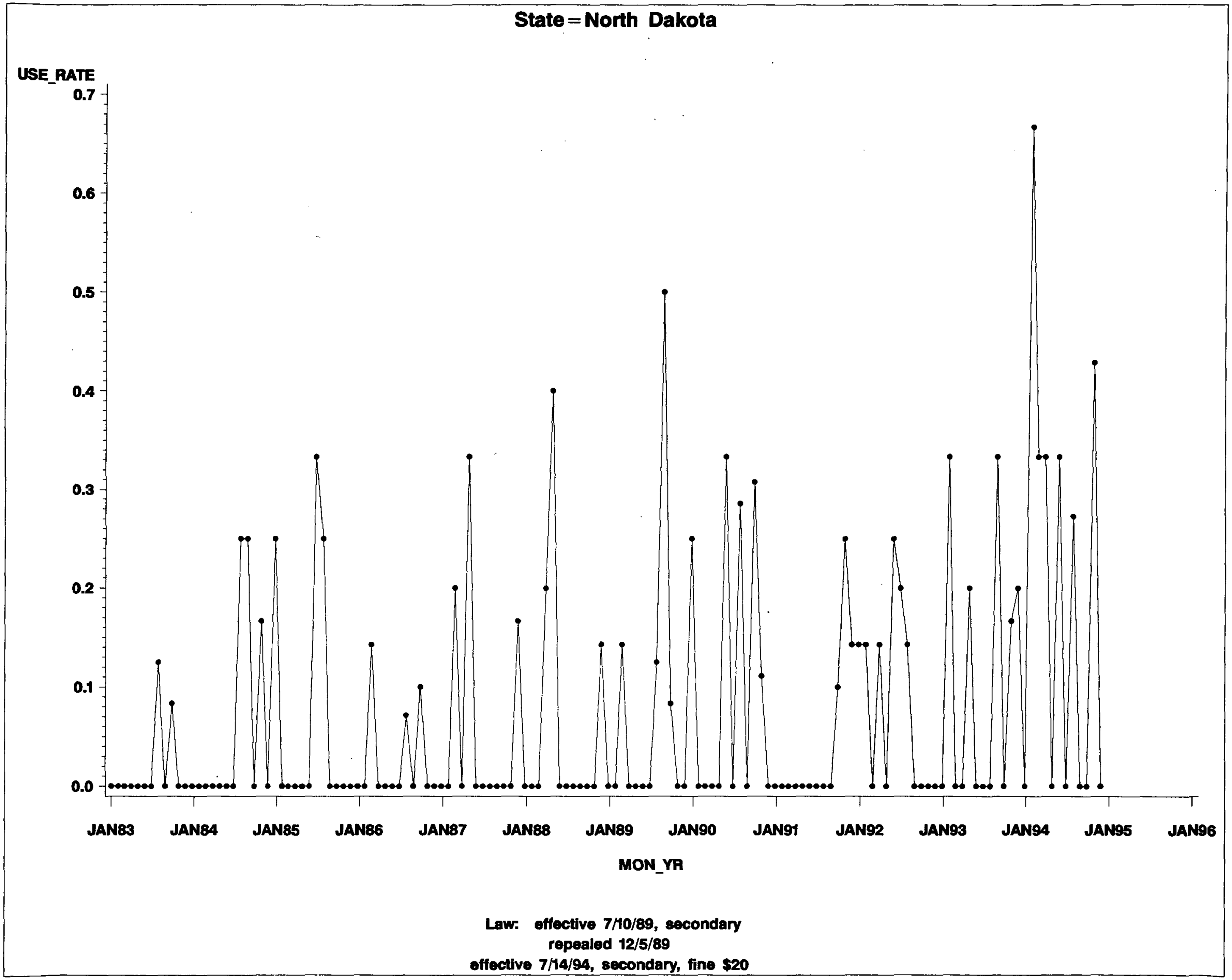


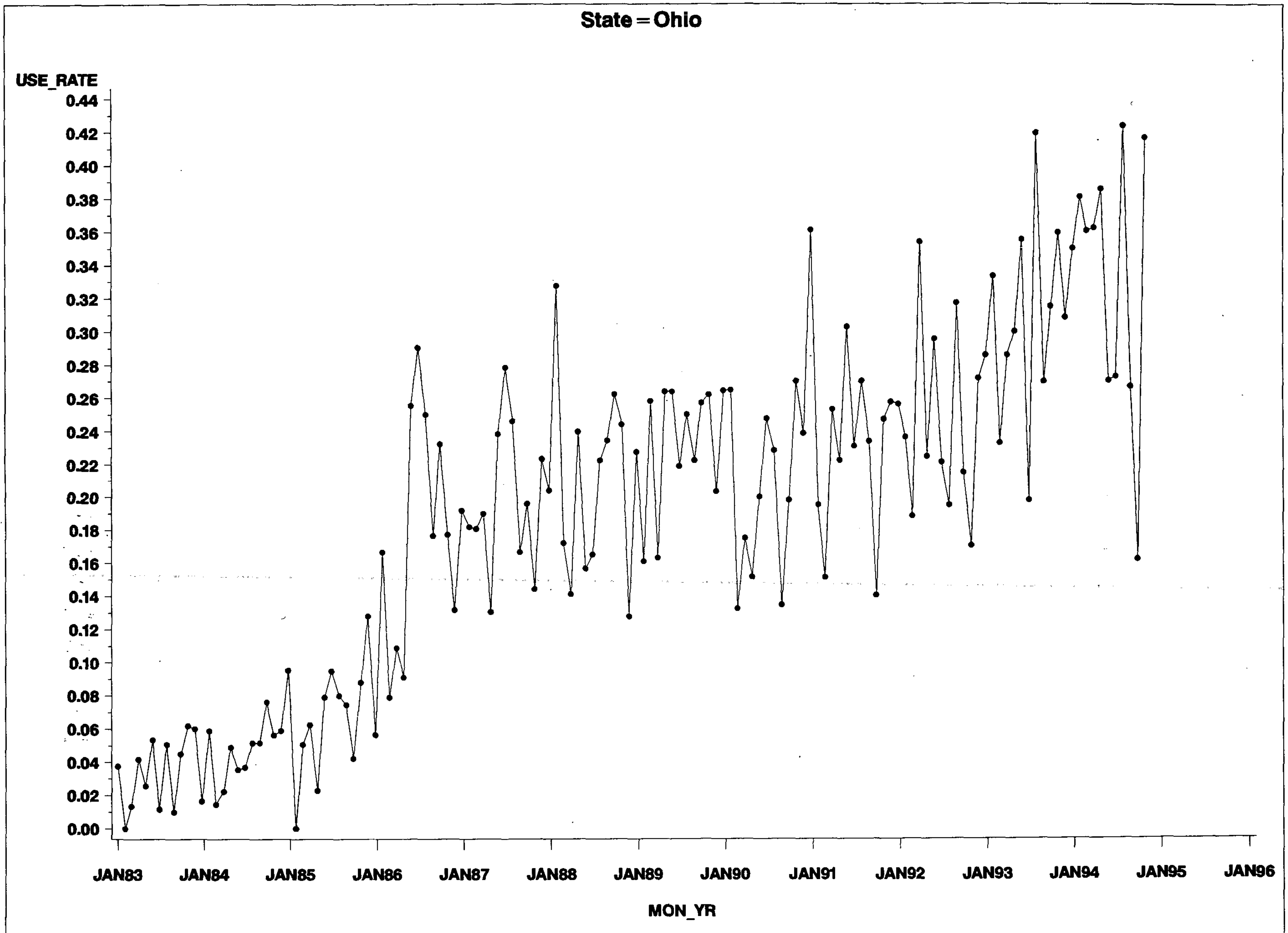
Law: effective 1/1/86, primary, fine $25 – $50



Law: effective 12/1/84, primary
fine 1/1/85, $50

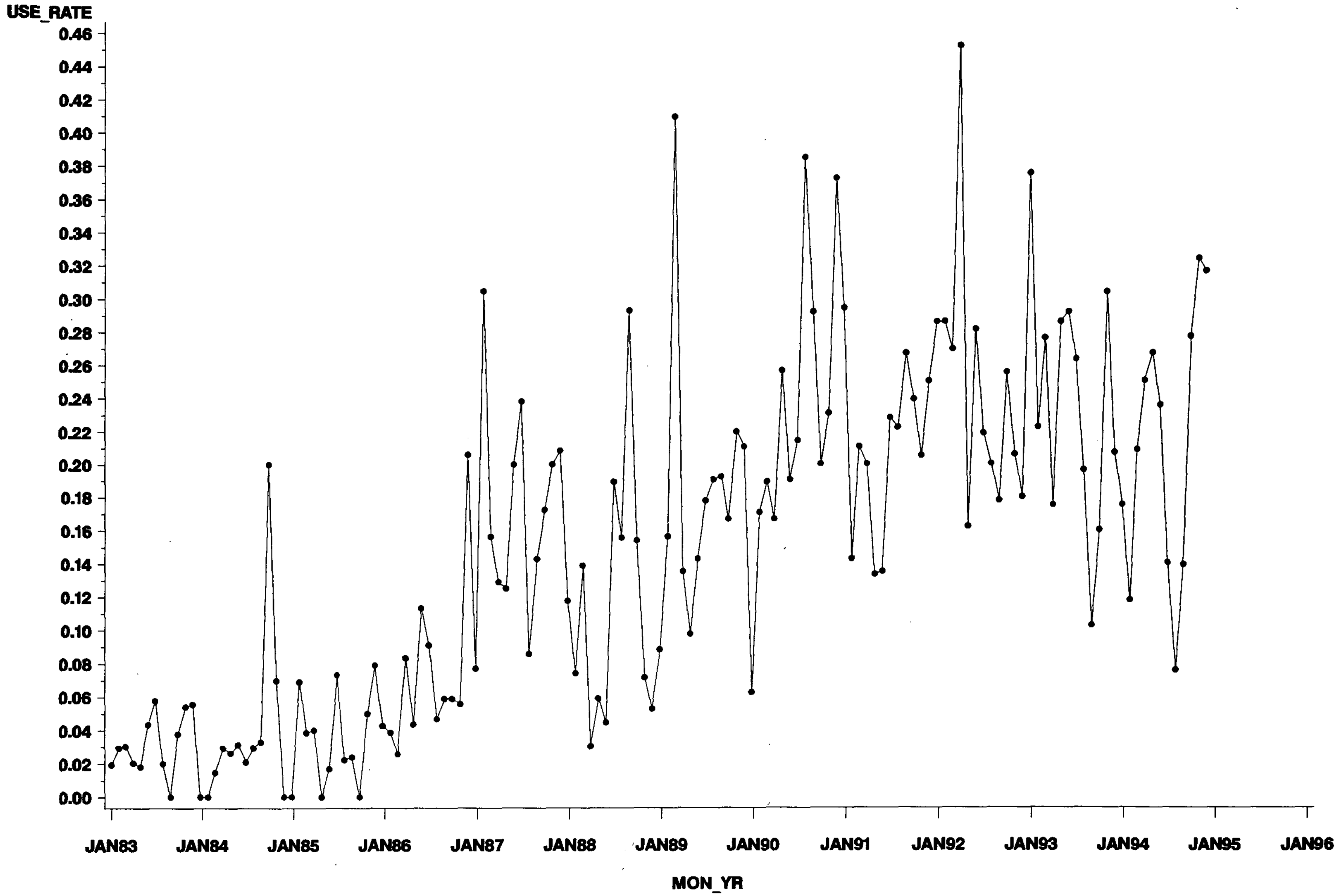

State=North Carolina
USE_RATE
0.6
0.5
0.4
0.3
0.2
0.1
0.0
JAN83 JAN84 JAN85 JAN86 JAN87 JAN88 JAN89 JAN90 JAN91 JAN92 JAN93 JAN94 JAN95 JAN96
MON_YR
Law: effective 10/1/85, primary
fine 1/1/87, $25


State=North Dakota
USE_RATE
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
MON_YR
Law: effective 7/10/89, secondary
repealed 12/5/89
effective 7/14/94, secondary, fine $20

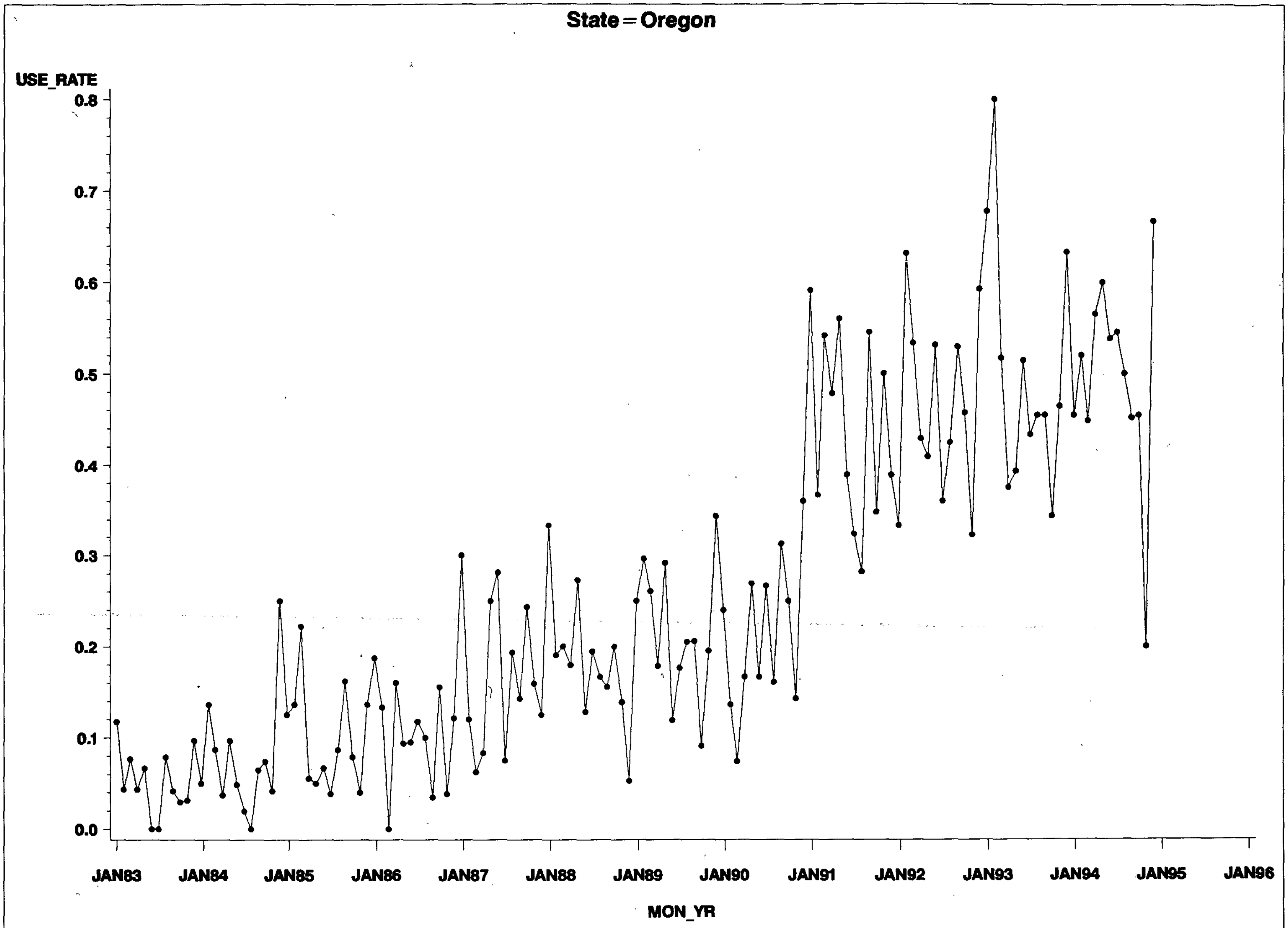


Law: effective 5/6/86, secondary
fine 7/4/86, $20

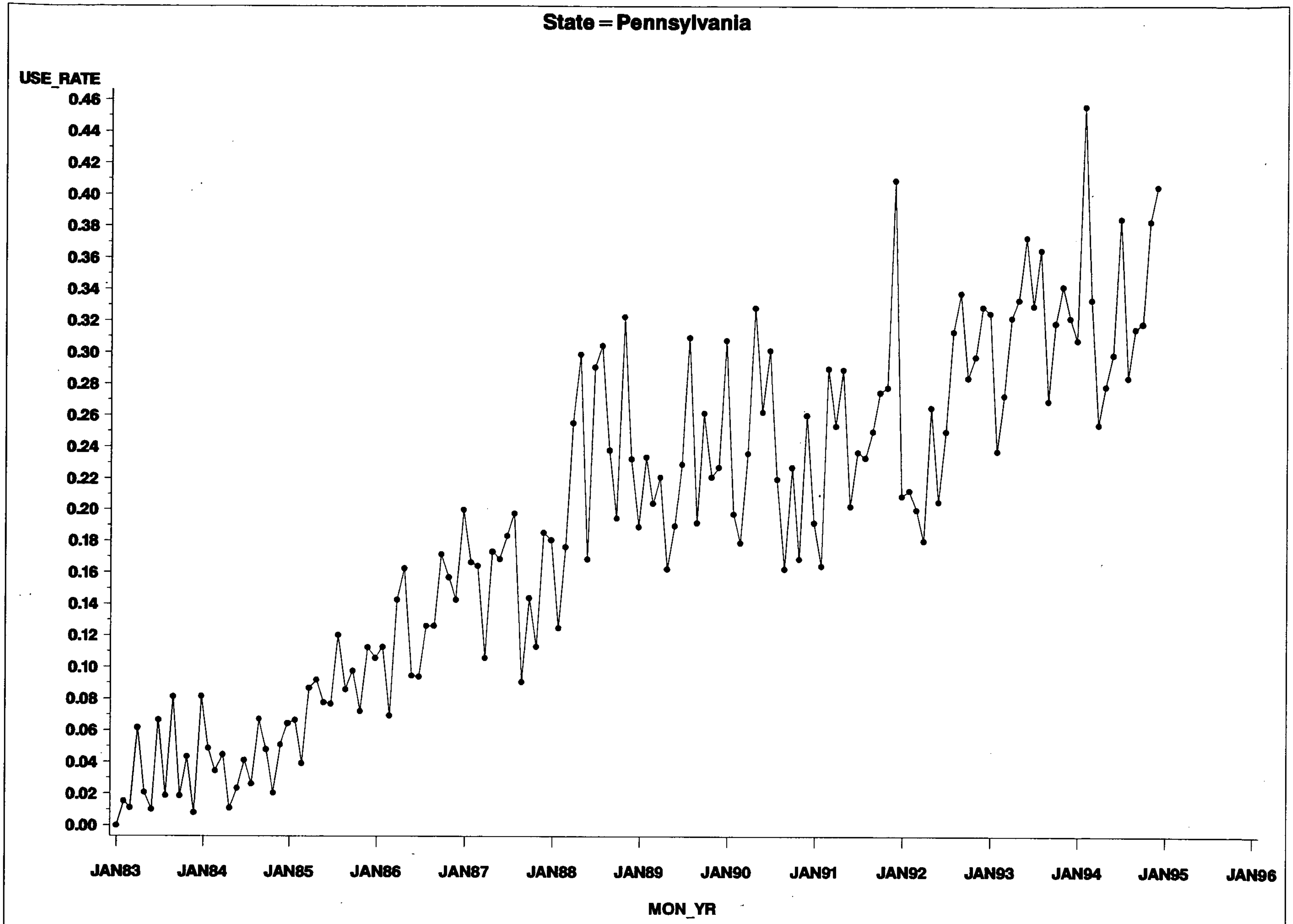
State = Oklahoma



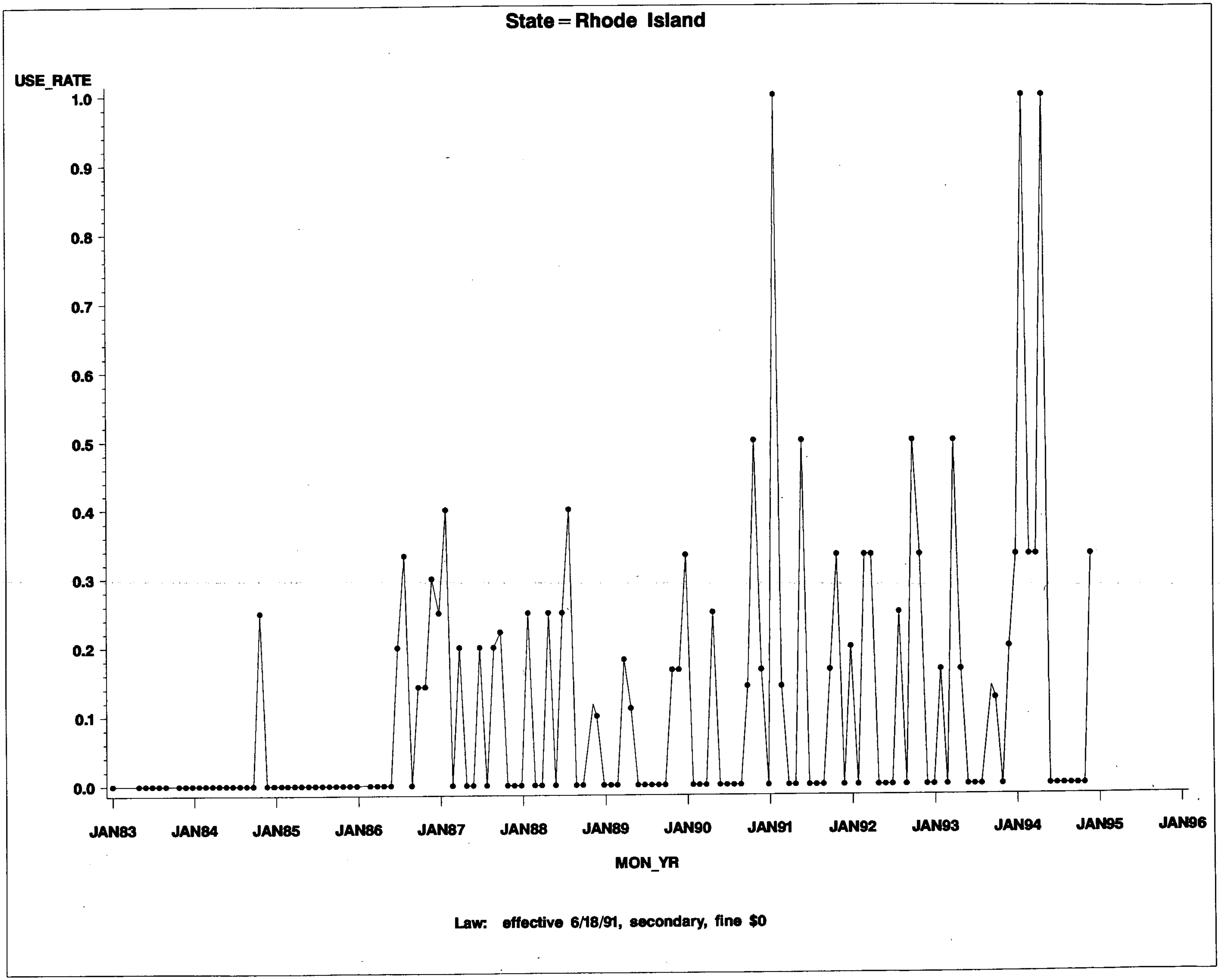
Law: effective 2/1/87, secondary, fine $25
upgrade 3/1/89 removed exclusion of pickups and vans

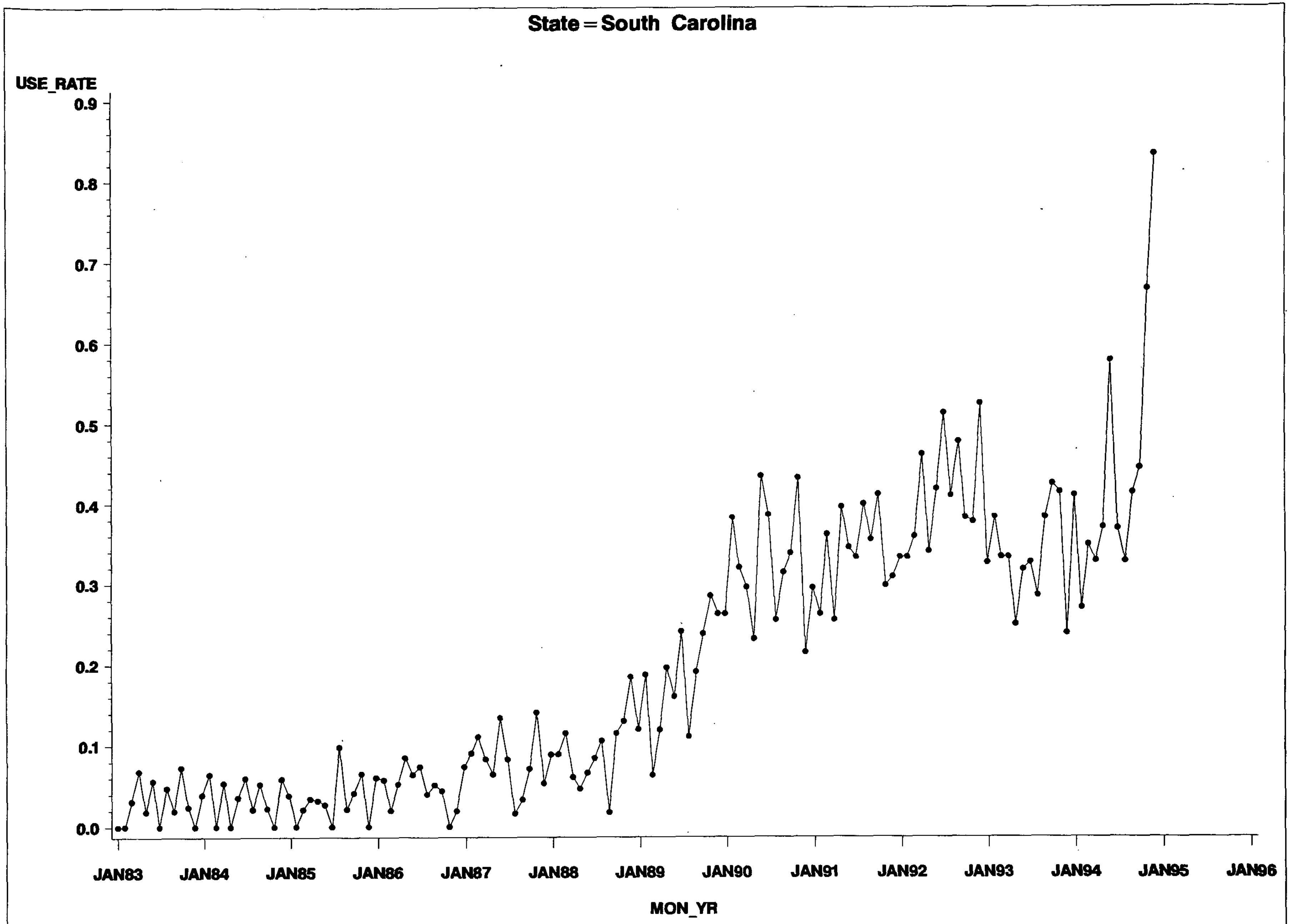


Law: effective 12/7/90, primary, fine $50

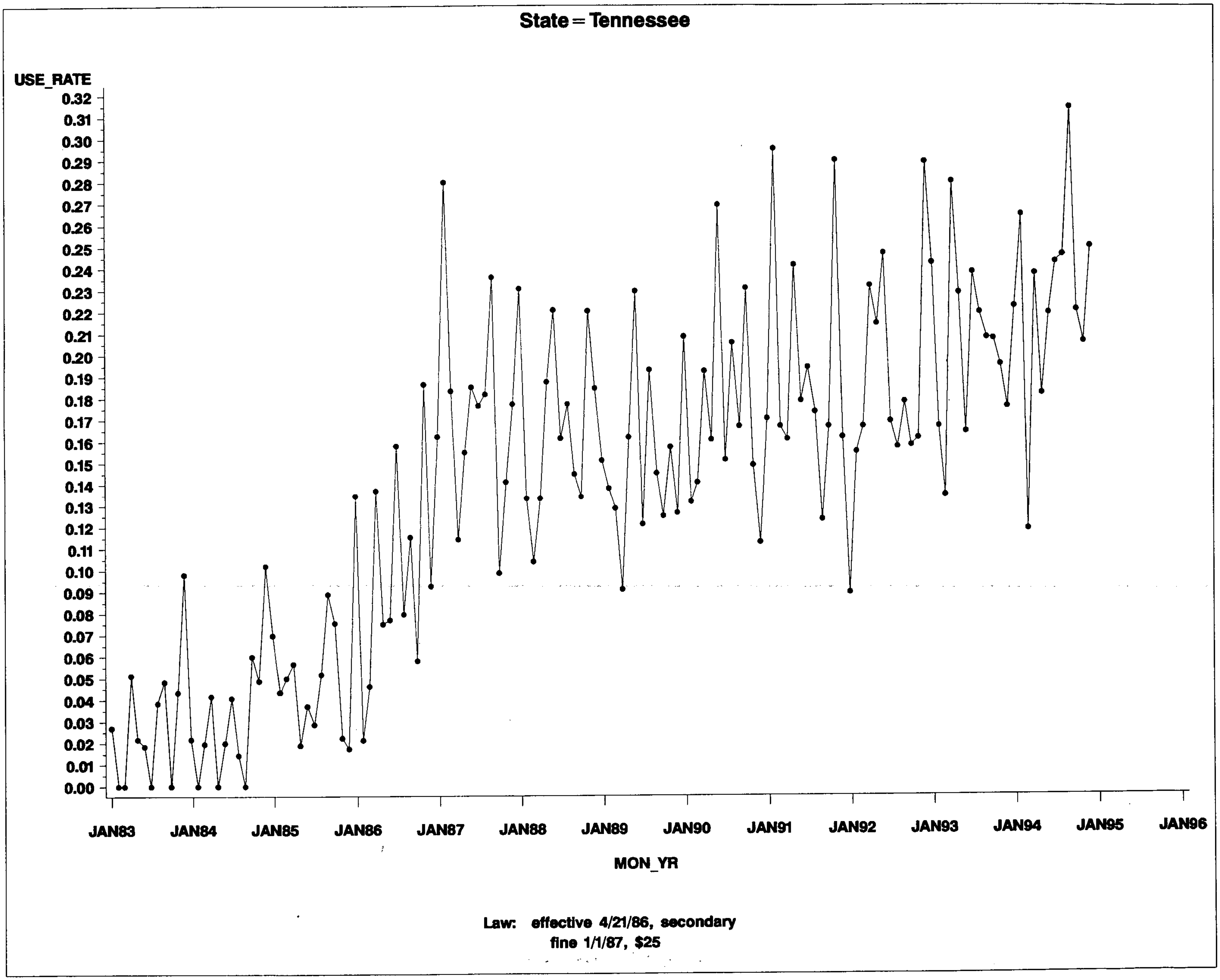


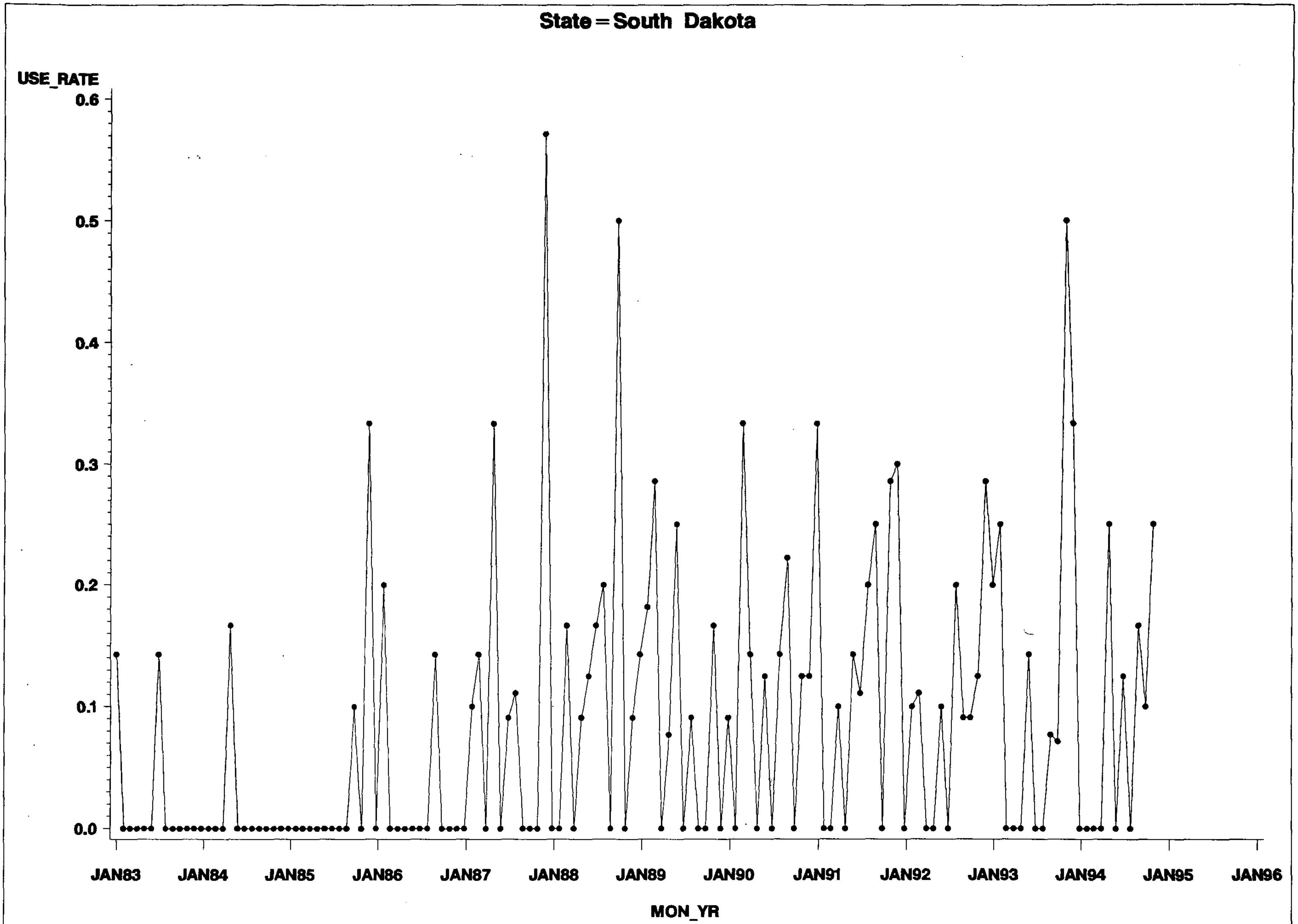
Law: effective 11/23/87, secondary
fine 3/23/88, $10


State=Rhode Island
USE_RATE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
MON_YR
Law: effective 6/18/91, secondary, fine $0

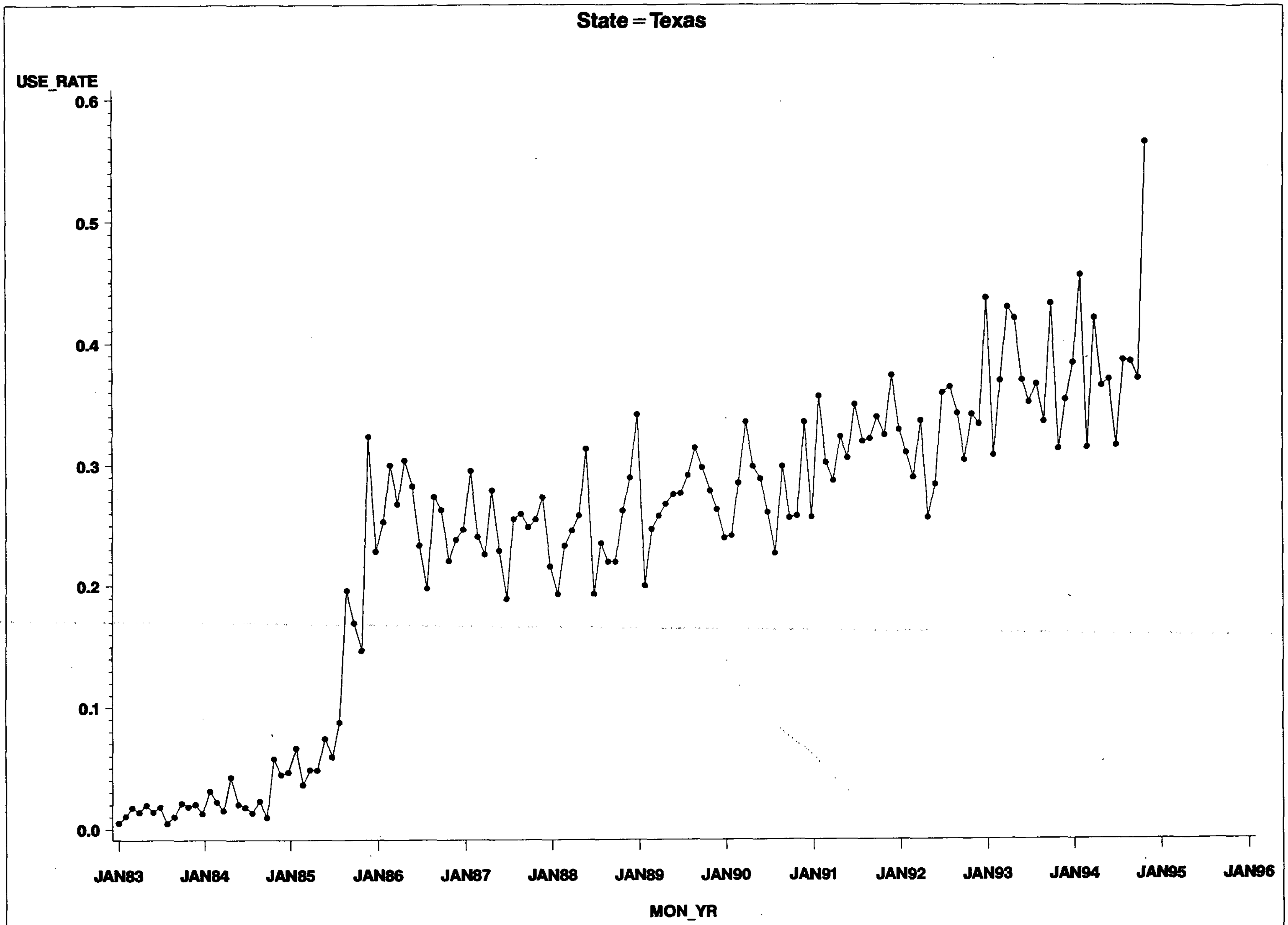


Law: effective 7/1/89, secondary, fine $10


State = Tennessee
USE_RATE
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
MON_YR
Law: effective 4/21/86, secondary
fine 1/1/87, $25

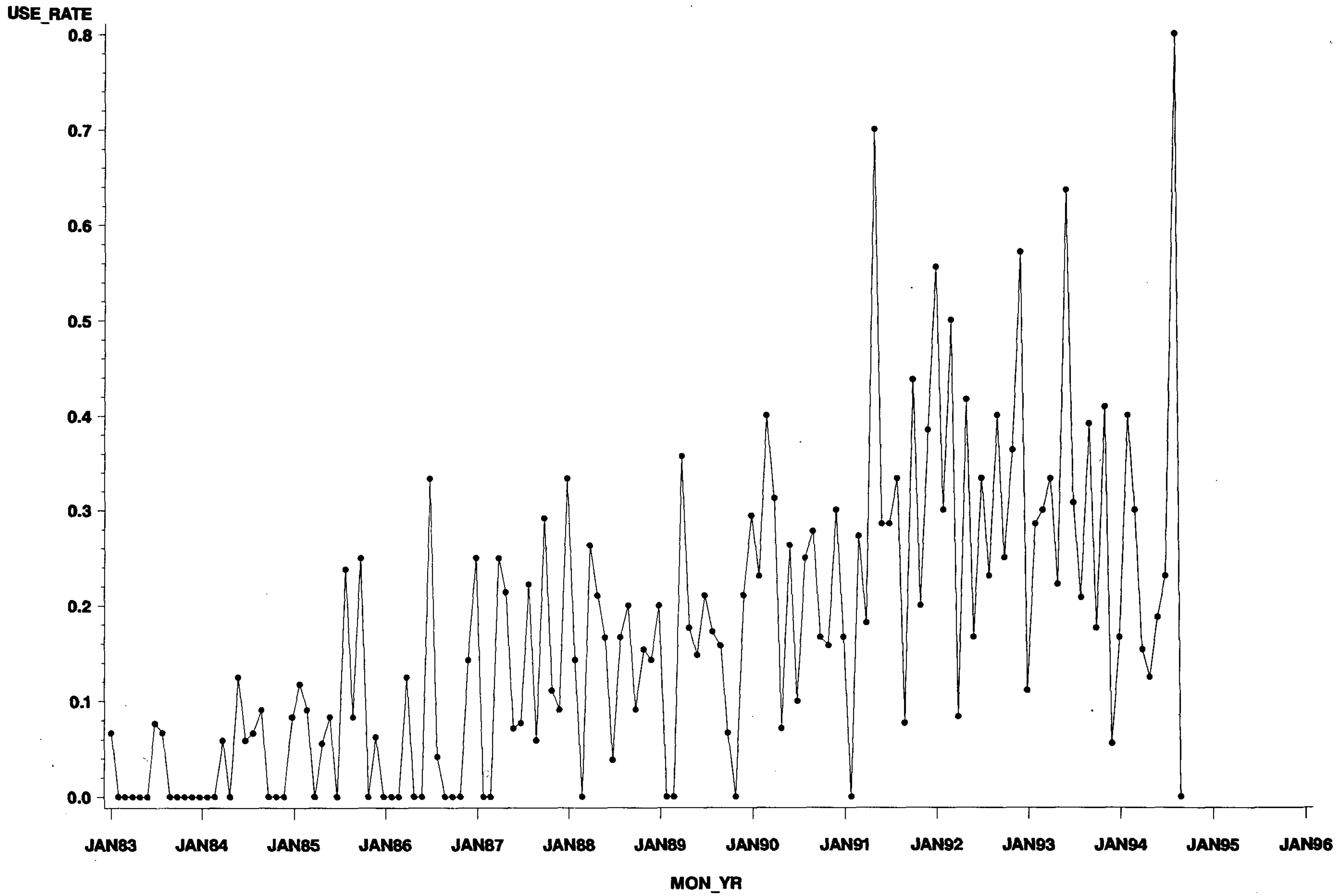


Law: effective 1/1/95, secondary, fine $20



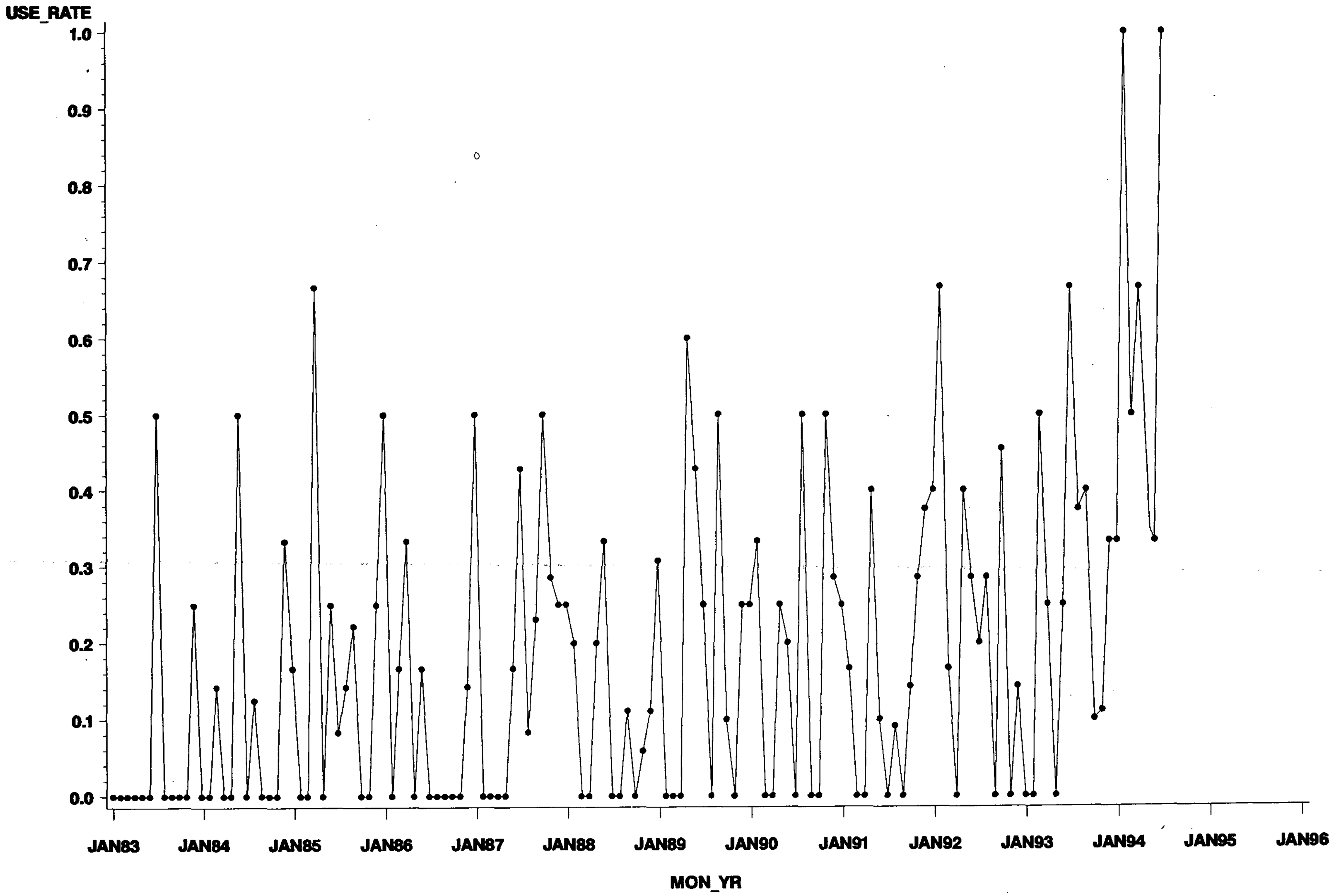
Law: effective 9/1/85, primary
fine 12/1/85, $25 – $50

State = Utah



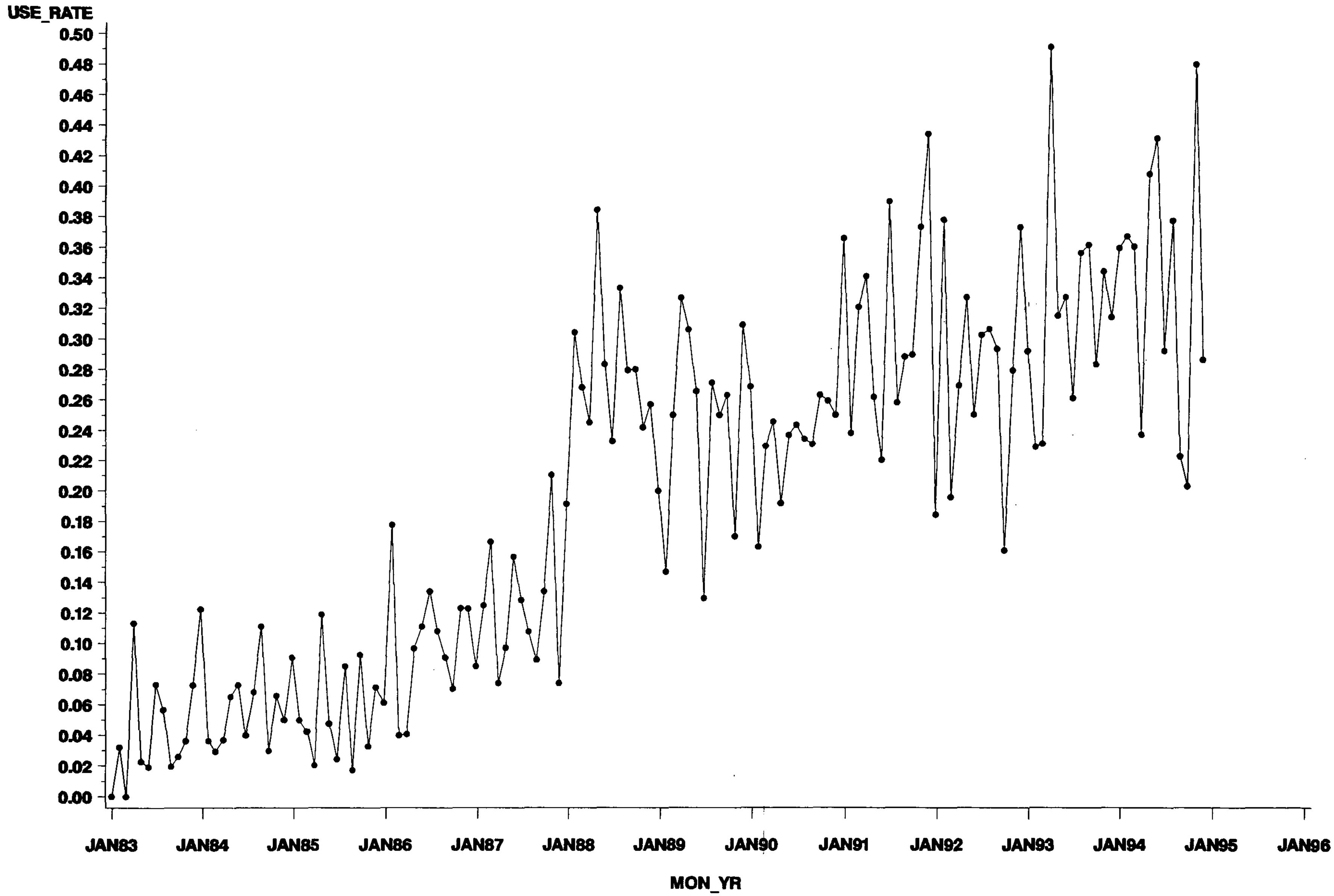
Law: effective 4/28/86, secondary, fine $10

State = Vermont

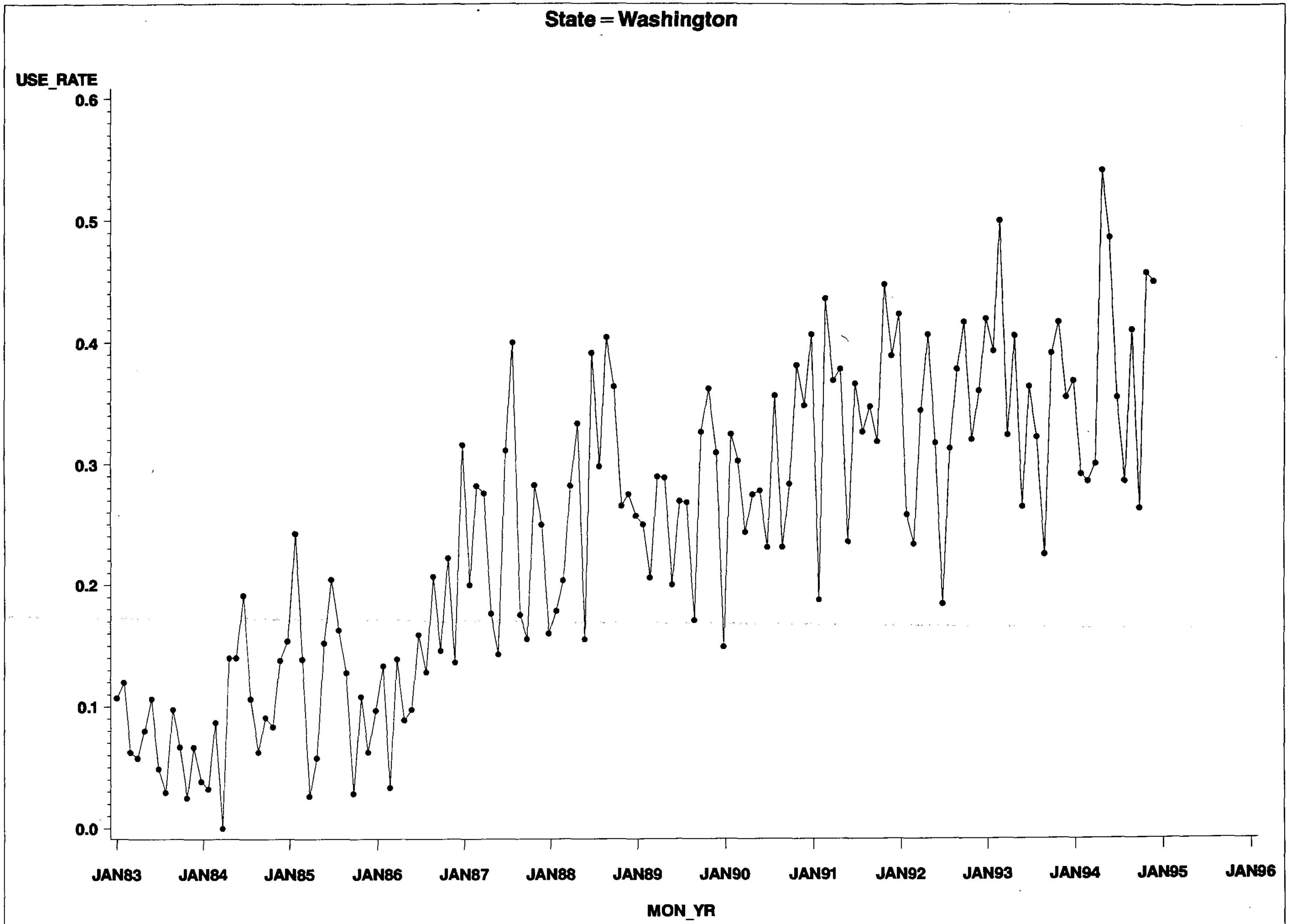


Law: effective 1/1/94, secondary, fine $10

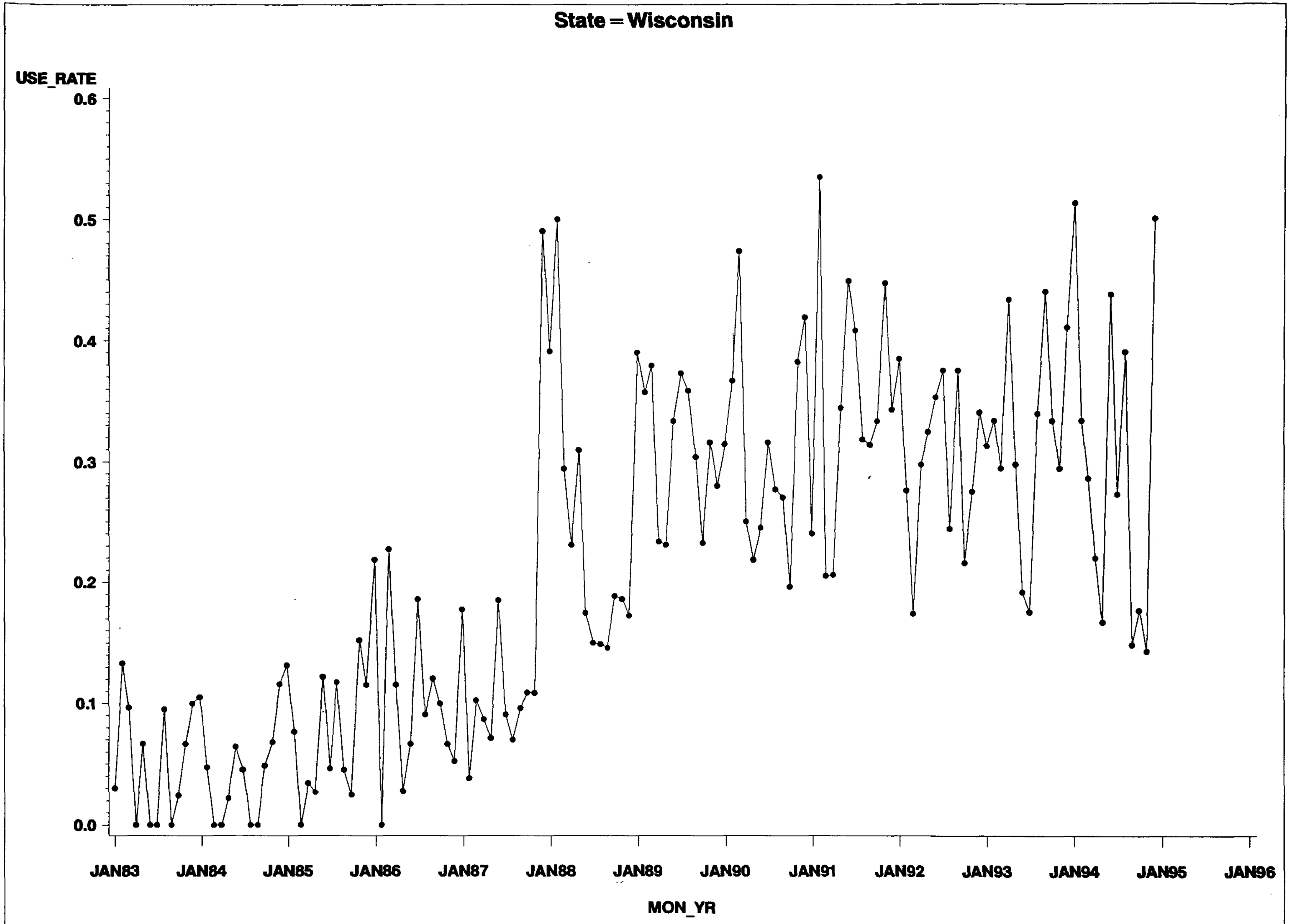
State = Virginia



Law: effective 1/1/88, secondary, fine $25

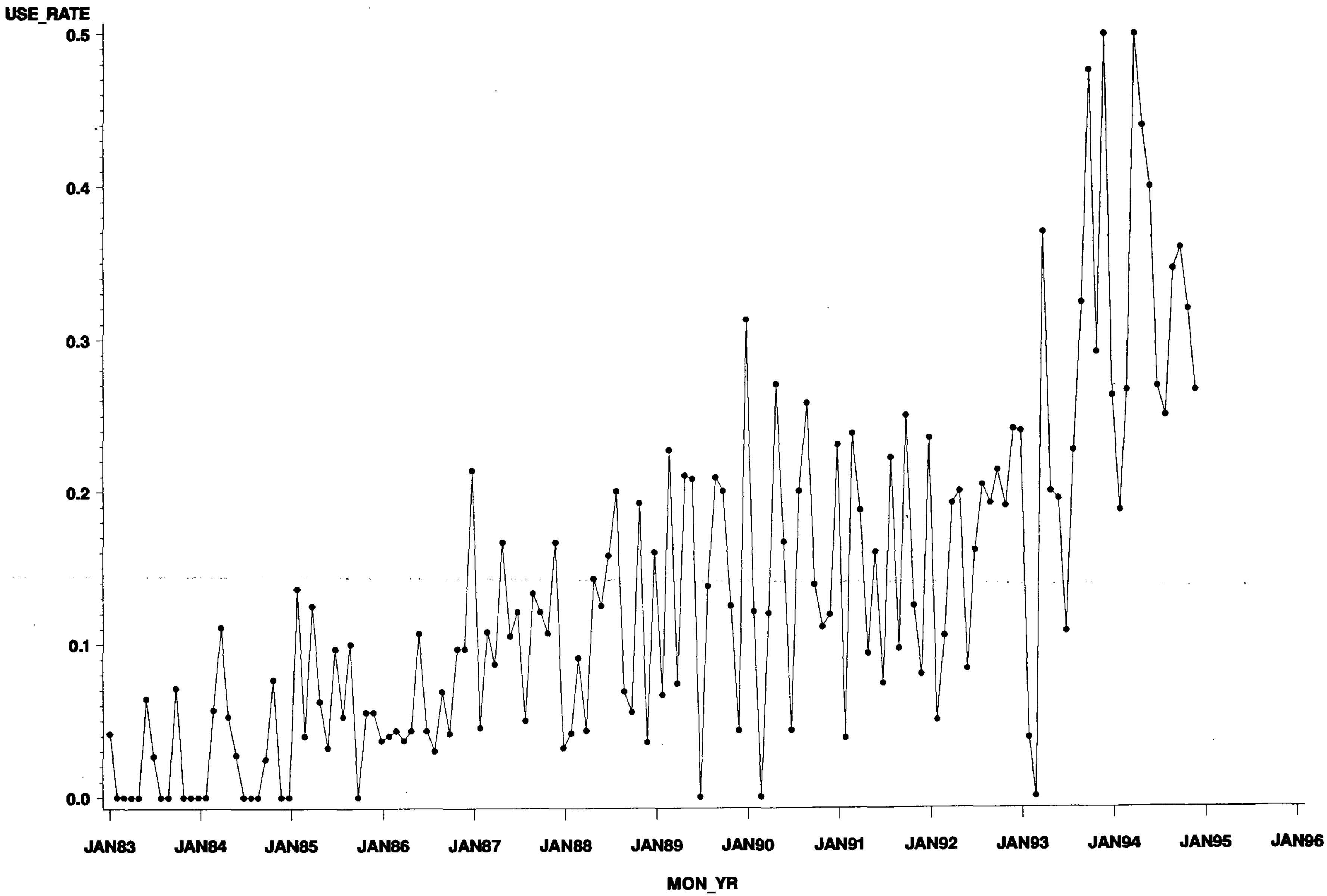


Law: effective 6/11/86, secondary
fine 1/1/87, $47

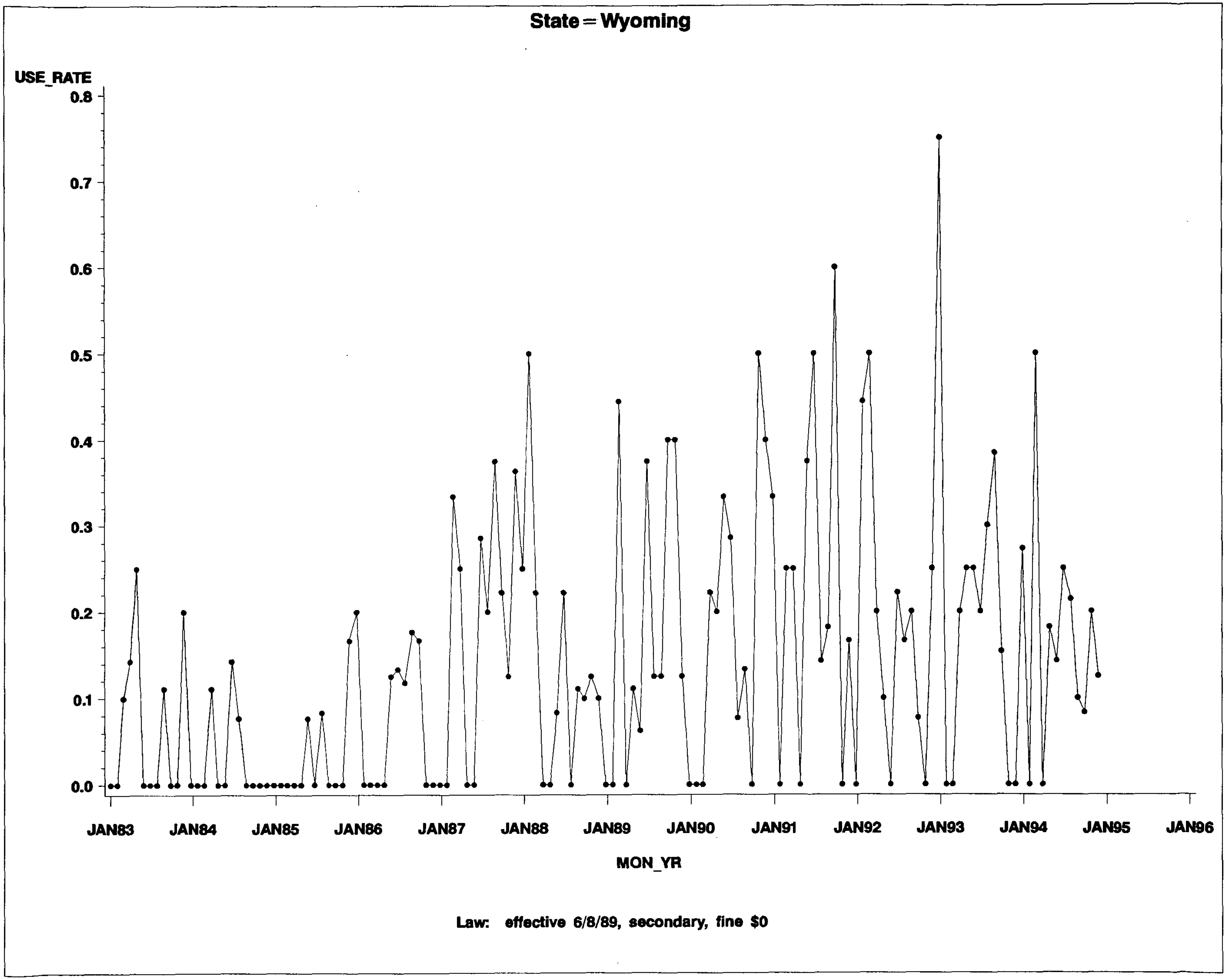


Law: effective 12/1/87, secondary, fine $30.90

State = West Virginia



Law: effective 9/1/93, secondary, fine $25


State = Wyoming
USE_RATE
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
MON_YR
Law: effective 6/8/89, secondary, fine $0

Appendix 3. Several alternative time series models of safety belt use rates

The results of estimating the time series models are presented for the autoregressive processes of orders 3 (AR(3)) and 13 (AR(13)), moving average errors processes of orders 3 (MA(3)) and 13 (MA(13)), and ARMA processes of orders (1,3), (3,1) and (2,2). The estimate of the coefficient of safety belt use law indicator (or fine indicator, or enforcement option indicator) is given, followed by the coefficient's standard deviation (in parentheses). Missing values (due to non-convergence of the estimation algorithm) are marked by "-".

	AR(3)	AR(13)	MA(3)	MA(13)	ARMA(3,1)	ARMA(1,3)	ARMA(2,2)
Alabama	0.0839 (0.1503)	0.0472 (0.1560)	0.0841 (0.1517)	- -	0.0824 (0.1531)	- -	0.1189 (0.1478)
fine:	0.0158 (0.0058)	0.0157 (0.0061)	0.0159 (0.0060)	- -	0.0156 (0.0061)	- -	0.0146 (0.0059)
Arizona	0.1940 (0.1125)	0.3143 (0.0939)	0.1914 (0.1106)	0.1968 (0.1078)	- -	- -	- -
Arkansas	0.1153 (0.2680)	-0.1438 (0.3037)	0.1133 (0.2670)	- -	0.1154 (0.2694)	- -	- -
California	0.0889 (0.1073)	0.0950 (0.1161)	0.0918 (0.1078)	0.1366 (0.1255)	0.0832 (0.1083)	0.1417 (0.1434)	0.0786 (0.1076)
primary:	0.2507 (0.0880)	0.2868 (0.1046)	0.2523 (0.0884)	0.2538 (0.1039)	0.2511 (0.0886)	0.3037 (0.1129)	0.2532 (0.0879)
Colorado	0.4870 (0.1252)	- -	0.4713 (0.1257)	0.4810 (0.1359)	- -	0.4926 (0.1339)	0.4529 (0.1624)
Connecticut	0.6820 (0.1867)	0.6969 (0.2234)	0.6837 (0.1875)	- -	0.7004 (0.1977)	- -	0.6903 (0.1917)
Florida	0.3578 (0.0777)	0.5085 (0.0617)	0.3741 (0.0767)	- -	0.3620 (0.0927)	0.3502 (0.1082)	0.3839 (0.1131)
fine:	0.0031 (0.0034)	-0.0047 (0.0025)	0.0022 (0.0033)	- -	0.0034 (0.0042)	0.0071 (0.0051)	0.0049 (0.0049)
Georgia	0.2677 (0.1007)	0.2722 (0.0930)	0.2663 (0.1018)	- -	- -	- -	- -
Illinois	0.7034 (0.2695)	0.3708 (0.2621)	0.7198 (0.2648)	- -	-0.4682 (0.5118)	0.7270 (0.2679)	0.7391 (0.2616)
secondary:	0.1516 (0.1596)	0.2711 (0.1410)	0.1452 (0.1577)	- -	0.6937 (0.2844)	0.1421 (0.1574)	0.1366 (0.1576)
Indiana	0.5355 (0.0867)	0.5394 (0.0877)	0.5354 (0.0808)	0.5359 (0.0886)	- -	0.5348 (0.0805)	0.4621 (0.1026)
Iowa	0.3143 (0.1944)	0.3696 (0.2026)	0.3166 (0.1987)	0.3211 (0.2012)	0.3412 (0.1808)	0.3204 (0.1981)	- -
fine:	0.0079 (0.0080)	0.0050 (0.0083)	0.0080 (0.0083)	0.0040 (0.0082)	0.0066 (0.0074)	0.0078 (0.0082)	- -
Kansas	0.4218 (0.1716)	- -	0.4169 (0.1687)	- -	0.3929 (0.1794)	0.4324 (0.1685)	0.4134 (0.1762)
fine:	0.0414 (0.0149)	- -	0.0415 (0.0147)	- -	0.0234 (0.0139)	0.0268 (0.0116)	0.0414 (0.0154)
Kentucky	0.1773 (0.1173)	0.0827 (0.1107)	- -	0.1602 (0.1454)	0.1742 (0.1198)	0.1577 (0.2190)	0.1711 (0.2025)
Louisiana	0.5995 (0.2438)	0.7036 (0.2451)	0.6603 (0.2455)	- -	0.5233 (0.2588)	- -	0.4797 (0.2590)
fine:	-0.0054 (0.0096)	-0.0083 (0.0098)	-0.0074 (0.0096)	- -	-0.0005 (0.0101)	- -	-0.0025 (0.0099)
Maryland	0.5486 (0.1150)	0.5516 (0.0967)	0.5519 (0.1149)	- -	0.5537 (0.1145)	0.5564 (0.1149)	0.5936 (0.1135)
Massachusetts	0.2225 (0.3338)	0.2377 (0.3105)	0.2321 (0.3248)	0.3462 (0.3277)	0.1848 (0.3316)	0.2845 (0.3190)	0.1769 (0.3283)
Michigan	0.7366 (0.1214)	- -	0.7415 (0.1166)	- -	0.7041 (0.1444)	- -	- -
Minnesota	0.3111 (0.1460)	0.3767 (0.1374)	0.3111 (0.1429)	- -	0.3224 (0.1559)	- -	0.3386 (0.1589)
fine:	0.0097 (0.0104)	0.0132 (0.0109)	0.0103 (0.0102)	- -	0.0097 (0.0107)	- -	0.0092 (0.0112)
Mississippi	-0.1708 (0.1428)	- -	-0.1602 (0.1366)	- -	- -	-0.2040 (0.1922)	-0.1495 (0.1914)
secondary:	0.0484 (0.0985)	- -	0.0491 (0.0946)	- -	- -	0.0469 (0.1215)	0.0426 (0.1446)
Missouri	0.3554 (0.1201)	- -	0.3506 (0.1189)	- -	0.3527 (0.1192)	0.3340 (0.1148)	0.2928 (0.1147)
fine:	0.0306 (0.0138)	- -	0.0294 (0.0137)	- -	0.0297 (0.0138)	0.0247 (0.0144)	0.0175 (0.0140)
New Jersey	1.0549 (0.1016)	- -	1.0555 (0.1021)	1.0852 (0.1241)	1.0510 (0.1044)	- -	1.0621 (0.1330)
New Mexico	0.5471 (0.1707)	0.4201 (0.1432)	0.5394 (0.1639)	- -	0.5559 (0.1758)	0.5775 (0.1998)	0.6158 (0.1803)
New York	1.0848 (0.0679)	- -	1.0868 (0.0651)	- -	1.1086 (0.0740)	1.0857 (0.0673)	- -
N. Carolina	0.6007 (0.0916)	0.7365 (0.0637)	0.6021 (0.0892)	0.6800 (0.0918)	0.5961 (0.0938)	0.6127 (0.1221)	0.6016 (0.0903)
fine:	0.0206 (0.0041)	0.0182 (0.0029)	0.0205 (0.0040)	0.0204 (0.0043)	0.0207 (0.0042)	0.0204 (0.0043)	0.0205 (0.0041)
Ohio	0.5035 (0.1488)	- -	0.5087 (0.1495)	- -	0.5002 (0.1495)	- -	0.5910 (0.1534)
fine:	0.0025 (0.0077)	- -	0.0022 (0.0077)	- -	0.0026 (0.0077)	- -	-0.0034 (0.0079)
Oklahoma	0.7745 (0.1540)	0.8448 (0.1784)	0.7637 (0.1654)	- -	0.7725 (0.1577)	0.8248 (0.1978)	- -
Oregon	0.6340 (0.1257)	0.6505 (0.0880)	0.6455 (0.1037)	- -	0.6445 (0.1054)	- -	0.5877 (0.1116)
Pennsylvania	0.0224 (0.1148)	0.0065 (0.1160)	0.0188 (0.1121)	- -	0.0257 (0.1166)	0.0272 (0.1158)	0.0233 (0.1153)
fine:	0.0110 (0.0115)	0.0106 (0.0116)	0.0098 (0.0113)	- -	0.0159 (0.0116)	0.0158 (0.0115)	0.0161 (0.0115)
S. Carolina	0.5941 (0.1034)	- -	0.5937 (0.1034)	- -	0.5941 (0.1039)	0.5932 (0.1045)	0.5938 (0.1044)
Tennessee	0.2750 (0.0849)	0.3142 (0.0825)	0.2888 (0.0791)	0.3096 (0.0872)	0.3082 (0.1011)	0.2810 (0.0979)	0.2922 (0.1453)
fine:	0.0072 (0.0029)	0.0057 (0.0027)	0.0067 (0.0027)	0.0064 (0.0028)	0.0081 (0.0033)	0.0070 (0.0030)	0.0094 (0.0046)
Texas	0.6167 (0.1144)	0.5561 (0.0872)	0.6776 (0.1061)	- -	- -	- -	- -
fine:	0.0124 (0.0036)	0.0116 (0.0029)	0.0127 (0.0037)	- -	- -	- -	- -
Virginia	0.4082 (0.0708)	- -	0.4128 (0.0740)	0.5533 (0.0832)	- -	0.5427 (0.0810)	0.5581 (0.0812)
Washington	0.2055 (0.0973)	0.1087 (0.0851)	0.2013 (0.0979)	- -	0.3325 (0.1484)	0.2663 (0.1094)	- -
fine:	0.0092 (0.0031)	0.0106 (0.0026)	0.0093 (0.0031)	- -	0.0100 (0.0049)	0.0101 (0.0034)	- -
W. Virginia	0.4024 (0.0945)	0.3730 (0.0677)	- -	- -	0.3570 (0.1011)	0.3844 (0.1250)	0.2247 (0.2473)
Wisconsin	0.6946 (0.1692)	- -	0.7088 (0.1740)	0.7488 (0.1871)	- -	0.7683 (0.2659)	0.6708 (0.1551)

Appendix 4. Cross-sectional time series models of safety belts use rates

The simplest cross-sectional time series model is the variance-components model, which has the following form.

$$y_{it}=const+b_1x_{1it}+...+b_kx_{kit}+u_{it},\quad i=1,...,N,\quad t=1,...,T,$$

where $\{u_{it}=\nu_i+e_t+\varepsilon_{it}\}$ and $\{\nu_i,\ i=1,...,N\}$, $\{e_t,\ t=1,...,T\}$, and $\{\varepsilon_{it},\ i=1,...,N,\ t=1,...,T\}$, are assumed to be independent.

Here y_{it} represents the dependent variable, $x_{1it},...,x_{kit}$ represent the regressors, which vary from state to state (i=1,...,N) and across time (t=1,...,T), and u_{it} is the error term, which is composed of the state-specific term ν_i , the time-dependent term e_t , and a term depending on both time and state ε_{it} .

The results of estimation of the regression coefficients $x_{1it},...,x_{kit}$ (for the states with reliable monthly use rates), are presented below.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-3.001652	0.243649	-12.319585	0.0001
MONTH_YR	1	0.002893	0.000670	4.318238	0.0001
INCOME_P	1	0.227200	0.099154	2.291397	0.0220
HW_SPEND	1	0.006255	0.009644	0.648588	0.5166
CRIME_RT	1	0.000686	0.000182	3.772226	0.0002
EDU_HS	1	0.016873	0.004390	3.843472	0.0001
URB_POP	1	-0.008754	0.002725	-3.211874	0.0013
UNEMP_RT	1	-0.025154	0.005231	-4.808838	0.0001
LAW	1	0.315379	0.044315	7.116776	0.0001
PRIMARY	1	0.197590	0.035722	5.531379	0.0001
ALL_VEH	1	0.011982	0.035709	0.335537	0.7372
ALL_SEAT	1	0.038771	0.039385	0.984416	0.3250
FINE	1	0.004377	0.001334	3.281661	0.0010

One immediately notices that the most significant coefficients are those corresponding to the variable indicating the presence of a safety belt use law and whether the law was primary.

Another possible model is the first order autoregressive model with contemporaneous correlation. It postulates the following structure of the error term u_{it} .

$$u_{it}=\rho_i u_{i,t-1}+\varepsilon_{it},$$

$$E(\varepsilon_{it}\varepsilon_{jt})=\varphi_{ij}.$$

This model incorporates autoregressive structure of error terms over time and accounts for possible correlations between states at each point in time. The estimates for this model are as follows.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-2.629430	0.074684	-35.207314	0.0001
MONTH_YR	1	0.005216	0.000303	17.187437	0.0001
INCOME_P	1	0.129366	0.041710	3.101585	0.0019
HW_SPEND	1	-0.001903	0.004952	-0.384342	0.7007
CRIME_RT	1	0.000095081	0.000059942	1.586205	0.1128
EDU_HS	1	0.005440	0.001271	4.281439	0.0001
URB_POP	1	0.000044306	0.000927	0.047793	0.9619
UNEMP_RT	1	-0.015679	0.003041	-5.156260	0.0001
LAW	1	0.289001	0.020334	14.212390	0.0001
PRIMARY	1	0.089912	0.020164	4.458906	0.0001
ALL_VEH	1	0.040627	0.013542	3.000033	0.0027
ALL_SEAT	1	0.100305	0.022805	4.398363	0.0001
FINE	1	0.005072	0.000767	6.613313	0.0001

The third cross-sectional time series regression model considered is the so-called mixed variance-component moving average error process. The regression error structure under this model is

$$u_{it}=a_i+b_t+e_{it},$$

$$e_{it}=\alpha_0\varepsilon_t+\alpha_1\varepsilon_{t-1}+\ldots+\alpha_m\varepsilon_{t-m},$$

where $\{a_i,\ i=1,\ldots,k\}$, $\{b_t,\ t=1,\ldots,T\}$, and $\{\varepsilon_j\}$ are independent families, each consisting of independent, identically distributed, mean zero random variables. Thus, for each i=1,...,k, ε_{it} is a realization of a moving average process of order m.

The model was estimated for m=1,2,3,4,5,6, and 13, with quite similar results. Presented here are the results for the case m=5.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-2.897623	0.251143	-11.537741	0.0001
MONTH_YR	1	0.002236	0.000772	2.896673	0.0038
INCOME_P	1	0.423885	0.110031	3.852415	0.0001
HW_SPEND	1	-0.004131	0.013729	-0.300942	0.7635
CRIME_RT	1	0.000557	0.000214	2.611083	0.0091
EDU_HS	1	0.011863	0.004489	2.642585	0.0083
URB_POP	1	-0.008676	0.002831	-3.064439	0.0022
UNEMP_RT	1	-0.011895	0.007443	-1.598214	0.1101
LAW	1	0.290510	0.061215	4.745696	0.0001
PRIMARY	1	0.148414	0.049073	3.024347	0.0025
ALL_VEH	1	0.015376	0.049573	0.310162	0.7565
ALL_SEAT	1	0.152751	0.054838	2.785479	0.0054
FINE	1	0.005704	0.001848	3.086551	0.0020

Appendix 5. Estimating the effect of safety belt use laws on highway fatalities using the model of Hoxie and Skinner

In the paper "Effects of Mandatory Seatbelt Use Laws on Highway Fatalities in 1985", Hoxie and Skinner (1987) developed a pooled, cross-section regression model to study the relationship between traffic fatalities and state safety belt use laws. In their original paper, Hoxie and Skinner used the FARS data on fatalities from 1975 to 1985. They updated the results in 1988, using the data through September of 1987. The results presented below represent a further update (through 1994) and an extension of their work.

The dependent variable in the linear regression model of Hoxie and Skinner is the logarithm of the quarterly fatality rate (the number of fatalities in a state in a quarter divided by the state's population in that quarter). The fatalities modeled are those among front seat occupants of passenger motor vehicles.

The independent variables in the basic model of Hoxie and Skinner are: OTHER - logarithm of the fatality rate for all fatalities not included in the dependent variable (pedestrians, motorcycle riders, large truck occupants, rear seat and other vehicle occupants), QUARTER1 - QUARTER3 - dummy variables indicating quarters (3 variables), YR_75 - YR_93 - dummy variables for years (19 variables for the 20 years between 1975 and 1994), dummy variables for states (50 variables), state trend variables (50 variables, each taking value 1 for the first year, 2 for the second year, etc, for a given state, and 0 otherwise), and a variable indicating the presence of a mandatory use law (LAW). The law indicator variable had values prorated for partial quarters, i.e., if the law was in effect for a fraction of a quarter, the variable's value for that quarter was the corresponding fraction.

In estimating the model, Hoxie and Skinner used the weighted least squares method, with weights equal to the numbers of fatalities potentially affected by the law in each state, year, and quarter.

Besides the basic model, the authors considered several variations of the model, of which a model incorporating the indicator of primary enforcement of a law (PRIMARY), in addition to the variables of the basic model, is important in the present context.

The results of estimating Hoxie and Skinner's basic model utilizing the data for the period 1975 to 1994 are shown below. The dependent variable is the logarithm of per capita quarterly fatalities among front seat occupants of passenger vehicles (car, light truck and van).

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-2.759019	0.05155052	-53.521	0.0001
QUARTER1	1	-0.162088	0.00655299	-24.735	0.0001
QUARTER2	1	-0.110219	0.00594914	-18.527	0.0001
QUARTER3	1	-0.077422	0.00646818	-11.970	0.0001
OTHER	1	0.247858	0.01085290	22.838	0.0001
YR_75	1	0.187072	0.03026745	6.181	0.0001
YR_76	1	0.201904	0.02926133	6.900	0.0001
YR_77	1	0.217000	0.02835389	7.653	0.0001

YR_78	1	0.279638	0.02732422	10.234	0.0001
YR_79	1	0.259376	0.02649257	9.791	0.0001
YR_80	1	0.248103	0.02557830	9.700	0.0001
YR_81	1	0.218444	0.02469851	8.844	0.0001
YR_82	1	0.105944	0.02389688	4.433	0.0001
YR_83	1	0.094522	0.02301882	4.106	0.0001
YR_84	1	0.103430	0.02229856	4.638	0.0001
YR_85	1	0.083062	0.02090642	3.973	0.0001
YR_86	1	0.167072	0.01834650	9.106	0.0001
YR_87	1	0.201313	0.01715695	11.734	0.0001
YR_88	1	0.225556	0.01616536	13.953	0.0001
YR_89	1	0.210874	0.01548598	13.617	0.0001
YR_90	1	0.170409	0.01502247	11.344	0.0001
YR_91	1	0.115642	0.01461473	7.913	0.0001
YR_92	1	0.077593	0.01439255	5.391	0.0001
YR_93	1	0.071553	0.01416104	5.053	0.0001
LAW	1	-0.051829	0.01075390	-4.820	0.0001

(Coefficients of the dummy variables for states and state trends are omitted.)

The analogous results for the model incorporating the indicator of primary enforcement are as follows.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-2.773537	0.05145821	-53.899	0.0001
QUARTER1	1	-0.162890	0.00653341	-24.932	0.0001
QUARTER2	1	-0.109760	0.00593036	-18.508	0.0001
QUARTER3	1	-0.076480	0.00644960	-11.858	0.0001
OTHER	1	0.244258	0.01083967	22.534	0.0001
YR_75	1	0.183713	0.03017549	6.088	0.0001
YR_76	1	0.198399	0.02917353	6.801	0.0001
YR_77	1	0.213761	0.02826813	7.562	0.0001
YR_78	1	0.276465	0.02724180	10.149	0.0001
YR_79	1	0.256259	0.02641283	9.702	0.0001
YR_80	1	0.244854	0.02550241	9.601	0.0001
YR_81	1	0.214950	0.02462702	8.728	0.0001
YR_82	1	0.102010	0.02383086	4.281	0.0001
YR_83	1	0.090485	0.02295679	3.942	0.0001
YR_84	1	0.100375	0.02223350	4.515	0.0001
YR_85	1	0.085072	0.02084171	4.082	0.0001
YR_86	1	0.170679	0.01829976	9.327	0.0001
YR_87	1	0.202638	0.01710279	11.848	0.0001
YR_88	1	0.222194	0.01612556	13.779	0.0001
YR_89	1	0.206632	0.01545701	13.368	0.0001
YR_90	1	0.166894	0.01498871	11.135	0.0001
YR_91	1	0.112146	0.01458255	7.690	0.0001
YR_92	1	0.073569	0.01436648	5.121	0.0001
YR_93	1	0.074534	0.01412646	5.276	0.0001
LAW	1	-0.033804	0.01126777	-3.000	0.0027
PRIMARY	1	-0.076990	0.01483995	-5.188	0.0001

(Coefficients of dummy variables for states and state trends omitted.)

The weighted least squares method of Hoxie and Skinner is based on the assumption that the variances of the residual errors are inversely proportional to the number of fatalities in each state, year and quarter. Although it is plausible that when the number of fatalities is larger the corresponding rate is a more reliable estimate, and thus should be subject to less variability, it is not clear that the inversely proportional relationship is accurate. The use of fatality numbers as weights may distort the analysis by emphasizing the larger states and the effects of safety belt use laws in those states. However, it is also clear that some adjustment for heteroscedasticity is desirable, since, as mentioned above, the reliability of the data on fatality rates is likely to vary among states. The cross-sectional time series regression methods (PROC TSCSREG of SAS) provide a framework which allows one to account not only for heteroscedasticity, but also for autocorrelations across time (within each state) and for inter-state correlations. The results of estimating the basic model using this method are given next.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-3.080243	0.050013	-61.589259	0.0001
QUARTER1	1	-0.216397	0.005338	-40.537107	0.0001
QUARTER2	1	-0.103824	0.005465	-18.998084	0.0001
QUARTER3	1	-0.038888	0.005406	-7.192932	0.0001
OTHER	1	0.166890	0.006303	26.479733	0.0001
YR_75	1	0.220898	0.067893	3.253612	0.0011
YR_76	1	0.226918	0.064796	3.502010	0.0005
YR_77	1	0.248595	0.061446	4.045732	0.0001
YR_78	1	0.286122	0.058068	4.927324	0.0001
YR_79	1	0.251468	0.054727	4.594979	0.0001
YR_80	1	0.271007	0.051397	5.272842	0.0001
YR_81	1	0.227349	0.048074	4.729094	0.0001
YR_82	1	0.103344	0.044777	2.307975	0.0211
YR_83	1	0.109241	0.041519	2.631083	0.0085
YR_84	1	0.087970	0.038282	2.297921	0.0216
YR_85	1	0.063068	0.034953	1.804381	0.0712
YR_86	1	0.123046	0.031634	3.889641	0.0001
YR_87	1	0.154791	0.028519	5.427621	0.0001
YR_88	1	0.191166	0.025572	7.475714	0.0001
YR_89	1	0.178252	0.022823	7.810299	0.0001
YR_90	1	0.153466	0.020276	7.568974	0.0001
YR_91	1	0.102088	0.017992	5.674098	0.0001
YR_92	1	0.067869	0.016207	4.187692	0.0001
YR_93	1	0.053113	0.014675	3.619324	0.0003
LAW	1	-0.063399	0.005839	-10.858468	0.0001

(Coefficients of dummy variables for states and state trends not shown.)

If the primary enforcement effect is incorporated into the model, then the cross-sectional time series regression procedure produces the following output.

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-3.076761	0.048481	-63.463695	0.0001
QUARTER1	1	-0.217167	0.005365	-40.478030	0.0001
QUARTER2	1	-0.104092	0.005492	-18.954978	0.0001
QUARTER3	1	-0.039528	0.005430	-7.280170	0.0001
OTHER	1	0.166351	0.006304	26.387703	0.0001
YR_75	1	0.213779	0.065099	3.283924	0.0010
YR_76	1	0.219456	0.062131	3.532174	0.0004
YR_77	1	0.241177	0.058942	4.091750	0.0001
YR_78	1	0.279383	0.055727	5.013453	0.0001
YR_79	1	0.244393	0.052549	4.650778	0.0001
YR_80	1	0.264344	0.049384	5.352870	0.0001

YR_81	1	0.221023	0.046227	4.781276	0.0001
YR_82	1	0.096186	0.043096	2.231910	0.0257
YR_83	1	0.103013	0.040005	2.574983	0.0101
YR_84	1	0.083280	0.036920	2.255680	0.0241
YR_85	1	0.061394	0.033731	1.820095	0.0688
YR_86	1	0.123604	0.030584	4.041538	0.0001
YR_87	1	0.154346	0.027633	5.585641	0.0001
YR_88	1	0.187424	0.024878	7.533858	0.0001
YR_89	1	0.174660	0.022295	7.833992	0.0001
YR_90	1	0.151888	0.019904	7.631079	0.0001
YR_91	1	0.101611	0.017777	5.715938	0.0001
YR_92	1	0.066089	0.016133	4.096540	0.0001
YR_93	1	0.053926	0.014702	3.667926	0.0002
LAW	1	-0.054789	0.006196	-8.842951	0.0001
PRIMARY	1	-0.041379	0.009867	-4.193558	0.0001

(No dummy variables for states and state trends shown.)

These estimates imply a 5.2 percent decline in fatalities due to the laws (weighted least squares estimate). When a variable indicating primary enforcement of the law is incorporated into the model, the weighted least squares results show a 3.4 percent decline in fatalities due to the law and an additional 7.7 percent decline due to primary enforcement. As mentioned above, neither least squares without weights nor least squares with weights proportional to the numbers of fatalities appear to be a satisfactory approach. The use of a pooled cross-sectional time series model adjusting for heteroscedasticity and correlations between states leads to more reliable estimates of a 5.5 percent decline in fatalities due to the law and an additional 4.1 percent decline due to primary enforcement. The same estimation method for the model without the primary enforcement variable gives an overall estimate of the law effect to be a 6.3 percent decline in fatalities.

These results differ somewhat from the estimated benefits of safety belt use laws based on use in fatal or potentially fatal crashes, which suggests a 12.6 percent reduction in fatalities due to enactment of a safety belt use law and a 5.9 percent reduction due to primary enforcement. There is no fully satisfactory explanation of this discrepancy. However, certain limitations of the Hoxie and Skinner model should be noted. Traffic fatalities depend on many factors not explicitly present in their model, such as technological changes (automobile crashworthiness, road conditions), social changes (driving styles, degree of risk taken), economic conditions (influencing miles driven, numbers of vehicles on the road), legislation on issues other than safety belt use (speed limits, alcohol, driving age), advances in medicine (emergency services and hospital's ability to treat injuries). The variable "other fatality rate" (mostly pedestrians, rear-seat occupants, as well as motorcyclists) is at best a very rough surrogate for these factors. Although it is found to be strongly correlated with the dependent variable "fatality rate among front-seat occupants", their exact relationship is not clear and may distort the effect of the law indicator variables in the model. The fatality rates in almost all states are highly seasonal, although with many irregularities and additional up-and-down trends over the years. The latter trends seem in many states to follow the economic cycles (increases in early to mid-1980's, declines in the end of 1980's and early 1990's). This effect is particularly pronounced in the Northeast, parts of the Midwest, Florida, and the West Coast. The model does not adequately reflect these factors, even though the dummy variables for the quarters are present. In particular, the effect of the introduction of safety belt use laws in some states in the mid-1980's might not be fully reflected in reduced fatality rates because of the upward trend in fatalities during that period. A visual examination of the time plots of the fatality rates in all 51 states supports this conjecture.

Viewed qualitatively, the results based on the Hoxie and Skinner model and the model of belt use rates in fatal crashes do not contradict each other. Both show significant reductions in fatalities due to safety belt use laws, using very different methodologies. The magnitudes of the effects differ, with the first model attributing about 5.5 percent reduction in fatalities to the laws (essentially, the secondary enforcement laws) and the second model suggesting about 12.6 percent reduction. However, considering the statistical errors in the estimates and the uncertainties inherent to the choice of models, the difference may not be significant. The findings based on the two models are much closer to agreement in estimating the effects of primary enforcement of the law: 4.1 percent reduction according to the Hoxie and Skinner method and 5.9 percent reduction according to the model based on belt use in fatal crashes. One can conclude that both models are in essential agreement as to the effect of primary enforcement, and show a reduction in fatalities in the neighborhood of 5 percent (in addition to the benefit due to the law itself). This finding can be considered to be the principal contribution of the present study. At the current state of the legislation pertaining to the safety belts, the issue of enforcement options rather than of passage of a law, is the most important, since the laws are already in place in almost all states.

*U.S. GOVERNMENT PRINTING OFFICE:1995-715-953/82478