UMTRI-89-28

THE 65 MPH SPEED LIMIT IN MICHIGAN: EFFECTS ON INJURY AND DEATH

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December 1989

UMTRI The University of Michigan Transportation Research Institute

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTRI-89-28		

4. Title and Subtitle	5. Report Date
The 65 MPH Speed Limit in Michigan: Effects on Injury and Death	December 1989
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Wagenaar, A.C., Streff, F.M., Schultz, R.H.	UMTRI-89-28
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
The University of Michigan Transportation Research Institute 2901 Baxter Road Ann Arbor, MI 48109-2150	11. Contract or Grant No. MPT-89-001A
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Michigan Office of Highway Safety Planning 300 S. Washington Square, Suite 300 Lansing, MI 48913	Final October 1, 1988- November 30, 1989
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Effective December 1987 and January 1988, the maximum speed limit on rural limited-access highways in Michigan was raised from 55 mph to 65 mph. This study examined the effects of the raised limit on traffic crashes, injuries, and deaths.

A multiple time-series design was used, comparing roads where the speed limit was raised with roads where the limit remained unchanged. Data were collected on the numbers and rates of crashes, injuries, and deaths from January 1978 through December 1988. Times series intervention analyses were conducted to estimate effects associated with the speed limit change while controlling for long-term trends, cycles, and other patterns. Statistical controls were also included for major factors known to influence crash and injury rates in the state.

Results revealed significant increases in casualties on roads where the speed limit was raised:

- 19.2% increase in fatalities
- 39.8% increase in serious (A-level) injuries
- 25.4% increase in moderate (B-level) injuries.

In addition, property-damage-only crashes increased 38.4%. Fatalities increased 38.4% on 55 mph limited-access freeways, suggesting that the 65 mph limit may have spillover effects on segments of freeways where the limit was not changed. The increased convenience of reduced travel time with the higher speed limit is obtained at a significant cost in terms of crash injuries and death.

17. Key Words	18. Distribution Statement
Motor vehicle crashes, Injuries, Speed limit laws, Time-series analysis, Social costs	Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	76	

This report was prepared in cooperation with the Michigan Office of Highway Safety Planning and the U.S. Department of Transportation, National Highway Traffic Safety Administration. Support of these organizations is gratefully acknowledged.

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Acknowledgments

The cooperation of the Michigan Department of Transportation in providing speed monitoring data and identifying speed limits for each specific segment of limited-access highway in the state is gratefully acknowledged. The offices of U.S. Congressman Carl Pursell and Michigan State Senator Cruce are thanked for their assistance in providing the materials necessary to compile the chronology on federal and state legislation to enact the 65 mph speed limit. Finally, we appreciate the assistance of Laura Ratzlaff with word processing and report production.

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1. INTRODUCTION

The purpose of this study is to determine the effects on morbidity and mortality due to motor vehicle crashes of raising the maximum speed limit from 55 mph to 65 mph on Michigan's rural interstates and other rural highways built to interstate standards. In April 1987, U.S. Senate Bill HR-2 was passed permitting states to raise the maximum speed limit to 65 mph on rural interstates. Michigan's governor signed Public Act 154 of 1987 on October 29, 1987, increasing speed limits on segments of Michigan's rural interstate highways from 55 to 65 mph. New speed limit signs were in place and the speed limit was officially increased to 65 mph on Michigan's rural interstate system on November 27, 1987. Furthermore, as a part of the massive budget reconciliation package passed in late December 1987, the U.S. Congress authorized a four-year demonstration project in which 20 states would be permitted to increase maximum speed limits from 55 to 65 mph on **non**interstate highways built to interstate standards. Michigan chose to participate in the demonstration project, and 65 mph speed limit signs were in place and the new limit was in force on all affected sections of rural noninterstate highways by the end of January 1988.

1.1. Role of Speed in Crashes

There are two major dimensions of the effects of the speed limit on crash involvement, average speed and variance in speeds. Higher speeds produce greater impact forces in crashes, increasing the probability of serious injury or death. Assuming that a vehicle strikes a fixed, unmoving object (such as a bridge abutment), the kinetic energy of the occupants must be dissipated in a fraction of a second. If vehicle occupants are not wearing safety belts, this energy will be dissipated by the body against the windshield, dashboard, steering column, or against a seat-back. Since the kinetic energy increases with the square of the speed, increased speed levels disproportionately increase the probability that occupants are injured. According to estimates calculated by Giamotty and associates (1980), a crash with an impact speed of 40 mph is **twice** as likely to result in serious injury (overall AIS greater than 2) than a crash with an impact speed of 30 mph. In short, if raising the speed limit to 65 mph increases average speeds on the road, the average speed at impact in traffic crashes would likely increase, with a consequent increase in probability of serious injury or death resulting from those crashes.

The second dimension of effects of the speed limit is speed variance. Speed variance refers to the distribution of speeds present on a given road in a given area. That is, how many cars are going faster or slower than the average speed? An increase in the proportion of vehicles on the road that are traveling significantly slower or faster than the average speed increases the probability of traffic crashes (Lave, 1985; Garber and Gadirau, 1988). Conversely, having all vehicles traveling at the same speed reduces the probability of traffic crashes. The role of changing the speed limit on speed variance is not fully understood. There is a general statistical phenomenon whereby the variance of a measure increases as the mean increases. Based on this common pattern, an increase in average speed resulting from raising the speed limit would also be expected to increase the variance in speeds. This is intuitively reasonable, since some drivers, who prefer driving at 55, will continue to do so after the limit is raised. Other drivers will take advantage of the raised limit to increase their speeds. The result is increased speed variance, which is likely to increase the number of crashes. In short, if the 65-mph limit increases speed variance, a possible result is an increased number of traffic crashes, causing an increase in the number of motorists killed or injured.

There is another factor that may influence how the speed limit change affects speed variance: design speed. Design speed is "the maximum safe speed that can be maintained over a specified section of highway when conditions are favorable such that the design features of the highway govern" (Garber and Gadirau, 1988). Garber and Gadirau found that speed variance increased as the difference between the posted speed limit and the design speed of the road segment increased. Perhaps this is because drivers tend to increase their driving speed as the geometric characteristics of the roadway improve, regardless of the posted speed limit. Speed variance was found to be at a minimum on road segments where the posted speed limit was 6 to 12 mph below the design speed. If this pattern held true for the State of Michigan, raising the speed limit would not increase speed variance as otherwise expected, and would not have as deleterious effects on highway safety as expected. However, it is also worth noting that design speeds of interstates were for a greatly different vehicle fleet. Current passenger cars have, on the whole, lower driver eye heights, and less acceleration power. The same guard rail that redirected the 4000 lb. car may turn the 2000 lb. car over. To help isolate the effects of the raised speed limit, average speed, and speed variance, we examined both numbers of traffic crashes and levels of injury severity.

1.2. Estimates of the Effect of the 65 mph Speed Limit in Other States

Using Box-Tiao time-series intervention modeling, McCarthy (1988) found no effects of raising the speed limit on Indiana's rural interstates on the total number of crashes, number of fatal crashes, number of injury crashes, or the number of injuries or fatalities from crashes. McCarthy examined six months of data after the limit was raised (June 1, 1987 through December 31, 1987). A potential confounding factor was implementation of a mandatory safety belt use law in Indiana one month after the speed limit was raised.

Brackett and Pendleton (1988) examined effects of the speed limit change in Texas, using speed and crash data from January 1982 through June 1988, including 12 months of post-law data. Using analysis-of-variance methods, they found average speeds increased significantly. However, speed variance (estimated by subtracting the mean speed from the 85^{th} percentile speed) decreased over the same period. Crash data suggested that crash frequency and severity increased on rural interstates with new 65-mph limit. The authors conclude that serious crashes (those resulting in fatal or serious injuries) increased approximately 20%.

Brown, Maghsoodloo, and McArdle (1989) examined the first 12 months with the 65-mph limit in Alabama. Using chi-squared tests, they found an 18% increase in total crashes on roads with the 65-mph limit. There was no change in the distribution of crashes by injury severity. They also found evidence of a spillover effect on roads where the speed limit was not increased.

Baum, Lund, and Wells (1988) found a 15% increase in fatalities on rural interstates in the 38 states which increased the speed limit in 1987. They observed no increases in states which did not change the speed limit. The 15% estimate is based on comparisons between the ratio of deaths on rural interstates to deaths on other roads in the months following the speed limit increase and the average of those same months from the period 1982-1986.

The National Highway Traffic Safety Administration provided a report to the U.S. Congress summarizing the effects of the 65-mph speed limit during 1987 (National Highway Traffic Safety Administration, 1989). According to this report, average travel speeds increased from 60.3 mph to 62.2 mph in states with increased speed limits, while speeds changed from 57.2 to 57.6 mph in states that retained 55 mph. No data were available on speed variance on these roads. Of the 38 states which raised the speed limit on at least some of the eligible rural interstate highways, 27 states had increased fatality frequencies and 11 had either no increase or a decrease in fatalities in 1987 compared to 1986. Of the ten states with eligible roadways that retained the 55-mph limit, fatalities increased or remained unchanged in six states, and decreased in four states. Collectively, the 38 states that raised their speed limits experienced a 19% increase in rural interstate fatalities while the ten states that retained the 55-mph limit experienced a 7% increase in rural interstate fatalities. NHTSA took into account the amount of travel by examining fatality rates per mile traveled, and found a 14% increase in the 38 states that increased the speed limit. No change was found in the ten states where the speed limit remained unchanged. Using regression analyses to model long-term fatality trends, a 16% increase in fatalities occurred in 1987 from levels expected based on the historical relationship between fatalities and travel mileage. Finally, the National Highway Traffic Safety Administration examined nonfatal crash data in seven states (Arizona, Louisiana, New Mexico, North Carolina, Indiana, Missouri, and Texas). Experiences in these states varied, but increases in the number of crashes and nonfatal injuries were approximately the same magnitude as increases in fatalities.

Garber and Graham (1989) examined the effects of the 65-mph speed limit in the 40 states which adopted the new limit before March 1988. Based on regression analyses, they found effects varied across states. Significant increases in rural interstate fatalities were found in ten of the states, significant decreases were found in two of the states, and the changes in the remaining 18 states were not statistically significant. A 15% increase in fatalities on rural interstates was the estimated median effect across all states. A statistically significant spillover effect to noninterstate rural highways was detected in eight cases, and estimates indicating possible spillover effects (though not statistically significant) were detected in 18 additional states. A 5% increase in fatalities on rural noninterstate highways was the median spillover effect across all states.

Effects of the increased speed limit in states raising the speed limit between April and June 1987 on fatal and nonfatal injury crashes were investigated by McKnight, Klein, and Tippetts (1989). Time series intervention modeling of monthly crash data for January 1982 through July 1988 revealed a significant 27.1% increase in fatal crashes. No significant change was found in fatal crashes on 55 mph urban interstates and rural noninterstate roads. Interestingly, there was a significant 10.4% increase in fatal crashes on rural interstates in states which did not raise the limit, and a significant 12.7% increase in fatal crashes on other 55 mph highways in these states. Of the 16 time-series models for examining effects of the speed limit change on injury crashes that were examined, only one model (the ratio of the number of injury crashes on 65 mph rural interstates to those on 55 mph highways) showed a significant effect of the speed limit change (20% increase).

While several studies to date have found increased fatalities and injuries following implementation of a raised speed limit from 55 to 65 mph, other studies failed to find such an effect. One key to examining these different findings is the use of different strategies to analyze the data. Time-series analyses such as those used by McCarthy (1988), and McKnight and others (1989) are the preferred analysis strategy because they control seasonal and other trends present in most crash data. Other specialized regression techniques such as those used by NHTSA (1989) and Garber and Graham (1989) also control for some of the trends in the data, but do not do so as efficiently or completely as time-series analysis. Thus, estimates from regression models may be biased by autocorrelations which remain uncontrolled, potentially yielding inaccurate conclusions. Other analysis strategies such as ANOVA and Chi-squared tests suffer because of violations in the basic assumptions on which these tests are based. The present study uses time-series analytic techniques to determine specific effects of the 65 mph speed limit in Michigan in the first year with the new law. Additional research is needed for a fuller understanding of the longer-term effects of this policy change.

2. METHODS

2.1. Research Design

Our goal was to answer the question: Did the increase in the maximum speed limit from 55 to 65 mph on rural interstates and rural highways built to interstate standards in Michigan **cause** a change in motor vehicle crash deaths, injuries, and property damage? It is not sufficient to find that changes in these outcomes are associated with implementation of the law. The research should be designed so that observed changes can be best explained by the increased speed limit. Other possible explanations for observed changes must be controlled as much as possible.

Alternate explanations for observed changes in deaths and injuries at the time of the speed limit change were controlled in three ways. First, a monthly time-series design was used to control for multi-year trends, cycles, and other regular patterns in the outcome variables. Measurement of a significant change beginning the exact month the speed limit was raised strengthens the argument that observed differences were due to changes in speed limit.

Second, the time-series statistical models included several covariates, such as vehicle miles traveled, unemployment rate, and alcohol consumption, to control for their effects on deaths, injuries, and property damage. Inclusion of covariates in the time-series models further increases confidence that observed differences are a result of changes in speed limit. In addition, the effects of other major policy changes known to influence injury rates, such as the compulsory safety belt law, were statistically controlled.

The use of multiple comparison time series is the third strategy used to increase confidence that the raised speed limit is responsible for observed changes in deaths, injuries, and property damage. Comparisons were made between specific road segments where the speed limit was raised and roads where the limit remained unchanged. Specifically, we compared changes in the outcome measures for road segments where the limit was raised to 65 mph with (1) limited-access highway segments where the limit remained at 55 mph, and (2) all other roads, where existing speed limits remained unchanged. The primary effects of the new 65-mph limit were expected only on those segments with the higher limit. While there may be some spillover effects on other road segments where the speed limit remained unchanged, any such spillover effects were expected to be small compared to the main effects.

2.2. Data Collection

2.2.1. Crashes

Data on motor vehicle crashes from January 1978 through December 1988 were obtained from the Michigan State Police. Records were available on all traffic crashes occurring in Michigan reported to any state, county, or municipal police agency. Monthly time-series variables were constructed one year at a time by generating multiple bivariate tables stratified by a combination of variables of interest (e.g., fatal crashes on rural interstates where the speed limit was increased to 65 mph). Frequency counts in such tables were extracted to form individual 12-month time-series. These eleven 12-month time series were then combined to produce the 132-month time series used in these analyses. Specific variables and code values used to construct the time series are summarized here. Complete descriptions of each variable are available in codebooks prepared and distributed annually by the University of Michigan Transportation Research Institute Data Center. Variable numbers and code values corresponding to the 1987 codebook are enclosed in parentheses for reference. For example, "V1:1-2" refers to variable number one, code values one and two as documented in the 1987 codebook.

Cases included in all time-series were filtered to exclude motor vehicle crashes involving pedestrians and/or pedalcycles (V41:1). This global filter limited data analyzed to crashes which involve motor vehicles, since the raised speed limit is unlikely to affect the behavior of pedestrians and pedalcyclists.

Each crash and injury record in the data set was stratified by whether the crash occurred on a section of limited-access highway currently posted at 65, a section of limited-access highway where the speed limit remained 55 mph, or another class of road. The Michigan Department of Transportation provided a list of speed limits by specific road segments for all of Michigan's limited-access highways (Appendix A). This list provided data on the speed limit of limited-access roads by "control section" and the mile location within each control section.

Exact crash location and the speed limit in effect at the location of each crash were identified by merging the speed limit by control section data with data available on each traffic crash. First, all crashes on roads without a highway number in the Michigan crash data (V20:9--highway class: county road, city street, or unknown) were classified as occurring on "other roads." Remaining roads were classified based on the list of speed limits for each control section. The highway control section was derived for each crash by combining the county code (V12) with the route code through the county (V14). The mile point in the control section is recorded by the police officer investigating each crash (V15). Using these variables, each crash was classified as occurring on: (1) a limited-access highway posted 65 mph, (2) a limited-access highway posted 55 mph, or (3) other road.

The following monthly (V2) time-series variables were constructed for each road segment type.

A. Total number of vehicles involved in crashes per month by highway type.

B. Total number of crashes per month by:

(1) single vehicle involved (V39:01)
(2) car-car crash (V39:02)
(3) car-truck crash (V39:03).

C. Total number of vehicles involved in crashes per month by:

(1) vehicle damage low (V118:1-2)
(2) vehicle damage medium (V118:3-4)
(3) vehicle damage high (V118:5-8).

D. Total number of vehicles involved in crashes per month by:

(1) male driver (V150:1)
(2) female driver (V150:2).

E. Total number of vehicles involved in crashes per month by:

(1) driver age 15-24 years (V147:15-24)
(2) driver age 25-54 years (V147:25-54)
(3) driver age 55 years and older (V147:55-98).

F. Total number of vehicles involved in crashes per month by:

(1) vehicle sustained property damage only (V139:5)
(2) vehicle occupant sustained injury (no fatality) (V139:2-4)
(3) vehicle occupant was killed (V139:1).

G. Total number of injured occupants per month by:

(1) injury severity=fatal (V210:1), weighted by number of fatalities (V140)
(2) injury severity=serious (V210:2), weighted by number of serious injuries (V141)
(3) injury severity=moderate (V210:3), weighted by number of moderate injuries (V142)
(4) injury severity=minor (V210:4), weighted by number of minor injuries (V143).

2.2.2. Covariates

Covariates used include implementation of the adult safety belt law, number of vehicle miles traveled in the state, proportion of licensed drivers under age 25, aggregate beer consumption in the state, and percent of the labor force unemployed. Monthly figures for total vehicle miles traveled on all roads were obtained from the Federal Highway Administration. Data on the number of licensed drivers by age and gender were also obtained from the Federal Highway Administration. Monthly wholesale beer distribution in Michigan was obtained from the U.S. Beer Institute. Data on percent of the labor force unemployed were obtained from the Michigan Department of Management and Budget. These data are derived from the U.S. Bureau of Labor Statistics' monthly estimates of civilian labor force (CLF), employed, and unemployed based on the Current Population Survey.

2.2.3. Travel Speeds

Quarterly data on measured speeds of vehicles on the road were obtained from the Michigan Department of Transportation (MDOT) for the 1982-88 period. MDOT measures speeds throughout the state for compliance with the compulsory federal 55-mph speed limit monitoring program and a separate state speed monitoring program. Data are collected with pneumatic tube speed measuring devices at some locations, and permanent magnetic speed loops imbedded in the pavement at other locations. Speeds are sampled at 44 sites annually.[1] Approximately one-third of these sites are sampled quarterly, with the remaining sampled annually. With the cooperation of MDOT, we identified the location of each sample site and the current posted speed limit at each site. Of interest was the long-term trend of vehicles exceeding 55 mph and 65 mph for roads currently posted at 55-mph and 65-mph speed limits.

2.3. Statistical Analyses

Each dependent variable was plotted for the full 1978 through 1988 period, including a centered moving average line, useful for discerning overall trends (Appendix B). The moving average line was created by summing the six data points preceding and the six data points following each point and dividing this sum by twelve. This procedure is repeated for each of the data points in the series with the exception of the first and last six points. Monthly crash frequencies and rates often have substantial "noise" or variance around a general trend that masks underlying patterns. Moving average trend lines eliminate much of this "noise," making visual identification of general trends more straightforward.

The goal of the time-series analyses is to estimate changes in motor vehicle crash involvement and severity associated with increasing speed limits from 55 to 65 mph on rural interstates and other limited-access highways built to interstate standards. Box-Jenkins and Box-Tiao (Box and Jenkins, 1976; Box and Taio, 1975) methods were employed to control for

[1]Data on measured travel speeds is missing for the first quarter of 1986 and the first quarter of 1987 due to problems with the monitoring equipment.

long-term trends and seasonal cycles, and to estimate changes beginning the first month after the increased speed limit took effect. The Box-Jenkins approach is a versatile time-series modeling strategy that can model a wide variety of trend, seasonal, and other recurring patterns.

At a conceptual level, the analytic strategy involves explaining as much of the variance in each variable as possible on the basis of its past history, before attributing any of the variance to another variable, such as the increased speed limit. The intervention-analysis approach is particularly appropriate for this study, because the objective is to identify significant changes in deaths, injuries, and crashes associated with the increased speed limit, independent of observed regularities in the history of each variable. In short, controlling for baseline trends and cycles with time-series models produces more accurate estimates of the effects of the speed limit change.

After controlling for long-term trends, cycles, and other regularities with Auto-Regressive Integrated Moving Average (ARIMA) models, we added a transfer function to each model with a step function for the month the speed limit was raised to estimate the associated change in each outcome variable. In addition, we added a second transfer function to the time-series models to estimate the anticipatory effect of the policy change. Considerable debate and media coverage of the speed limit issue occurred throughout 1987, as bills were introduced, passed, and signed at the federal and state level. The resulting publicity may have resulted in a small portion of the law's effects occurring before the law actually took effect. To determine whether this was the case, we constructed a second intervention variable *a priori*, based on knowledge of publicity concerning the speed limit. The anticipatory effect variable had the value zero from January 1978 through December 1986 (Figure 2.1). The anticipatory effect variable incremented .01 per month from January through March 1987, because of publicity surrounding discussions of possible speed limit increase legislation. An additional increment of .31 was added in April to account for the sudden increase in publicity associated with the April congressional override of the president's veto of the bill raising the speed limit. The variable incremented an additional .02 per month for May through September, representing the Michigan discussion and debate of a proposed increase in speed limit. An increment of .52 was added in October 1987, the month

Governor Blanchard signed the bill raising the speed limit on Michigan rural interstate highways to 65 mph. Finally, an increment of .04 was added for November 1987, such that all monthly increments summed to 1.0.

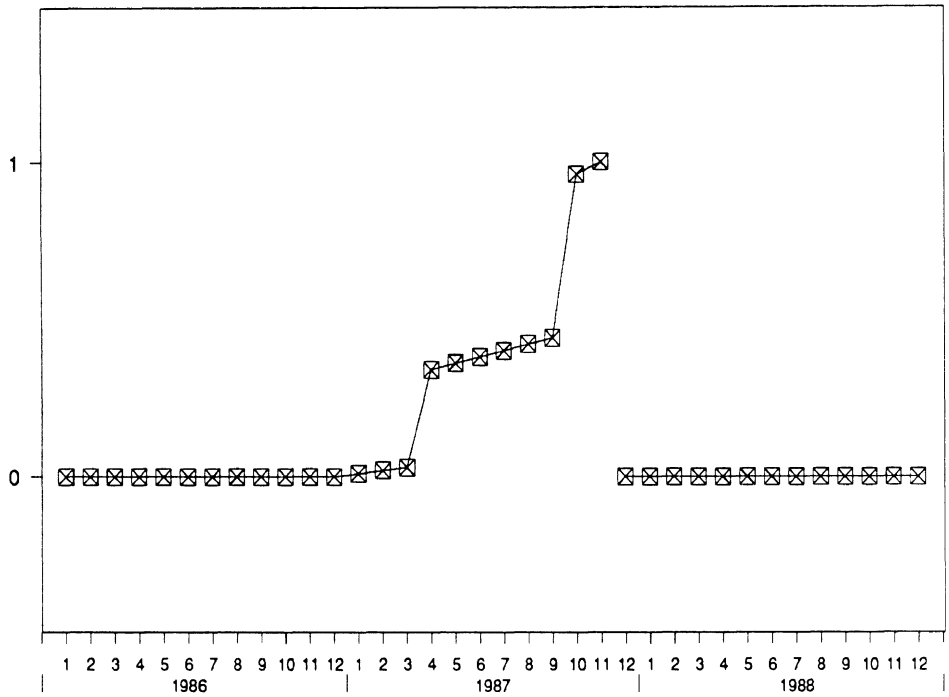

Figure 2.1: Functional Form of Anticipatory Effect Variable

A number of covariates were included in the time-series models to account for changes in casualties due to these other factors, and obtain a more accurate estimate of the effect attributable specifically to the speed limit change. Covariates included Michigan's compulsory safety belt use law, aggregate vehicle miles traveled, proportion of the licensed driver population under age 25, beer consumption, and unemployment. These variables are potential confounding factors because of established associations with traffic crash involvement. The safety belt law significantly reduced injury rates in Michigan (Streff, Wagenaar, and Schultz, in press). Aggregate vehicle miles traveled is a major index of exposure to risk of injury. The proportion of young drivers influences injury rates because of the overrepresentation of young drivers in traffic crashes. A measure of alcohol consumption was included because of the substantial proportion of crashes that involve alcohol-impaired drivers. Wholesale beer distribution was selected as the measure of alcohol consumption in preference to total absolute alcohol from all beverages (beer, wine, and distilled spirits) because the majority of impaired drivers are impaired as a result of beer consumption (Berger and Snortum, 1985). Furthermore, previous research has documented the relationship between wholesale beer distribution and the number of traffic crashes (at lags of zero to two months; Wagenaar, 1984a). Finally, the unemployment rate was included (with lags of zero to four months) because previous research has shown its relationship with motor vehicle crash involvement (Wagenaar, 1984b; Evans and Graham, 1987; Wagenaar and Streff, 1989; Streff, Wagenaar and Schultz, 1989).

Finally, results from time-series models were compared across road segments experiencing the recent increase in speed limit and those with unchanged limits. Differential effects of the speed limit change were compared across men and women, number and type of vehicles involved in the crash, driver age groups, vehicle damage level, and injury severity.

3. RESULTS

Results of time-series analyses clearly revealed significant increases in crash-induced injuries on road segments where the maximum speed limit was increased from 55 mph to 65 mph (Table 3.1, Figure 3.1). Effects attributable to the increased speed limit include a 39.8% increase in serious (A-level) injuries and a 25.4% increase in moderate (B-level) injuries on road segments with the 65 limit. The number of minor (C-level) injuries did not change significantly. The number of vehicles involved in property-damage-only crashes increased 16.1% after the limit was increased. Finally, the number of deaths on freeways with the 65-mph limit increased 19.2% and fatalities on limited-access freeways posted at 55 mph increased 38.4%.[2]

We believe these results reflect increased morbidity, mortality, and property damage causally attributable to the policy raising the speed limit for two reasons. First, the increases began immediately after the signs for the higher speed limit were posted. Second, with the notable exception of fatalities on limited-access highways that remained at 55 mph, the increases were found only on those specific road segments where the posted speed limit was changed.

We examined available data on travel speeds measured at 55 sites throughout the State of Michigan, to assess the effect of the new law on actual travel speeds (Figure 3.1). The proportion of motorists traveling over the posted speed limit has been increasing throughout the 1980s. In addition to this gradual upward trend, there was a noticeable further increase in travel speeds in 1988. This increase is particularly apparent at those sites where the limit was raised to 65 (see the dotted line in Figure 3.2). Increasing travel speeds may reflect a decline in public support and police enforcement of the 55 limit in the 1980s (U.S. House of Representatives, 1985).

[2]Although the 95% confidence interval (-.05 to 42.7) for the estimated increase in fatalities on 65 mph freeway segments associated with the speed limit increase includes zero, the increase is statistically significant using a one-tailed test, consistent with our directional hypothesis of increased injuries and deaths following the increase in speed limit.

Although the actual posting of the new 65-mph speed limit signs occurred in late November 1987, considerable discussion and publicity regarding the pending increase in the limit occurred throughout 1987. As a result, we hypothesized that a small portion of the effect of the increased limit might have occurred before the new signs were actually posted, in anticipation of the formal change in late November and December of 1987. We tested this hypothesis by incorporating another variable into each time-series model to estimate this anticipatory effect. The anticipatory and implementation effects were then simultaneously estimated. Results revealed significant increases in serious and moderate injuries in anticipation of the speed limit change, but no significant anticipatory effects on fatalities, minor injuries, or property-damage-only crashes (Table 3.1). We re-estimated each time-series model excluding the anticipatory effect variable to determine the effect of inclusion of this variable on the estimates of the implementation effects. Results showed virtually no differences in estimated implementation effects (Table 3.2).

In addition to analyses of the speed limit effects by injury severity, we assessed differential effects of the law by crash configuration, extent of vehicle damage, gender, and age (Table 3.3, Figure 3.3 and Figure 3.4). There were no significant differences in the size of the increase in crashes associated with the 65 limit across any of these groups. The increased injuries, deaths, and property damage after the 65 limit took effect were experienced by both males and females.

The quasi-experimental research design, including experimental series of road segments where the speed limit was raised and comparison series of road segments where the limit remained unchanged, controlled for many threats to a causal interpretation of observed increases in casualties. To provide further confidence that other major factors influencing crash outcomes could not explain observed effects, we re-estimated each time-series model including a series of covariates that previous studies have demonstrated influence crash and injury rates (Wagenaar, 1984a; Wagenaar, 1984b; Wagenaar and Streff, 1989; Streff, Wagenaar, and Schultz, 1989). Results of models including covariates revealed larger estimated increases in fatalities, moderate injuries, and property-damage-only crashes associated with the 65 speed limit than models without these covariates (Table 3.4). Observed increases in casualties associated with the 65 speed limit cannot be attributed to other factors such as the compulsory safety belt law, changes in vehicle miles traveled, economic conditions, alcohol consumption, or changing demographics of the driver population. If anything, estimated effects without statistical controls for these factors understate the deleterious effects of the 65 limit on casualty outcomes.

Finally, our findings do not support the argument that the 65-mph limit has little effect on safety since 65 mph is closer to the design speed of freeways than 55 mph. Recall from section 1.1 that Garber and Gadirau (1988) found speed variance to be related to the difference between the posted limit and the design speed. Increasing the limit on limited-access highways to 65 reduces the gap between the posted speed and design speed. If speed variance is reduced accordingly, the higher limit would not be expected to result in increased number of crashes. Available data did not permit conclusive analyses of the intervening role of speed variance in Michigan. Nevertheless, our findings of substantially increased injuries and noninjury crashes following the higher limit reduce the plausibility of arguing, on the basis of safety, in favor of closing the gap between design speed and the posted limit by increasing the posted limit.

(Text continues on page 31)

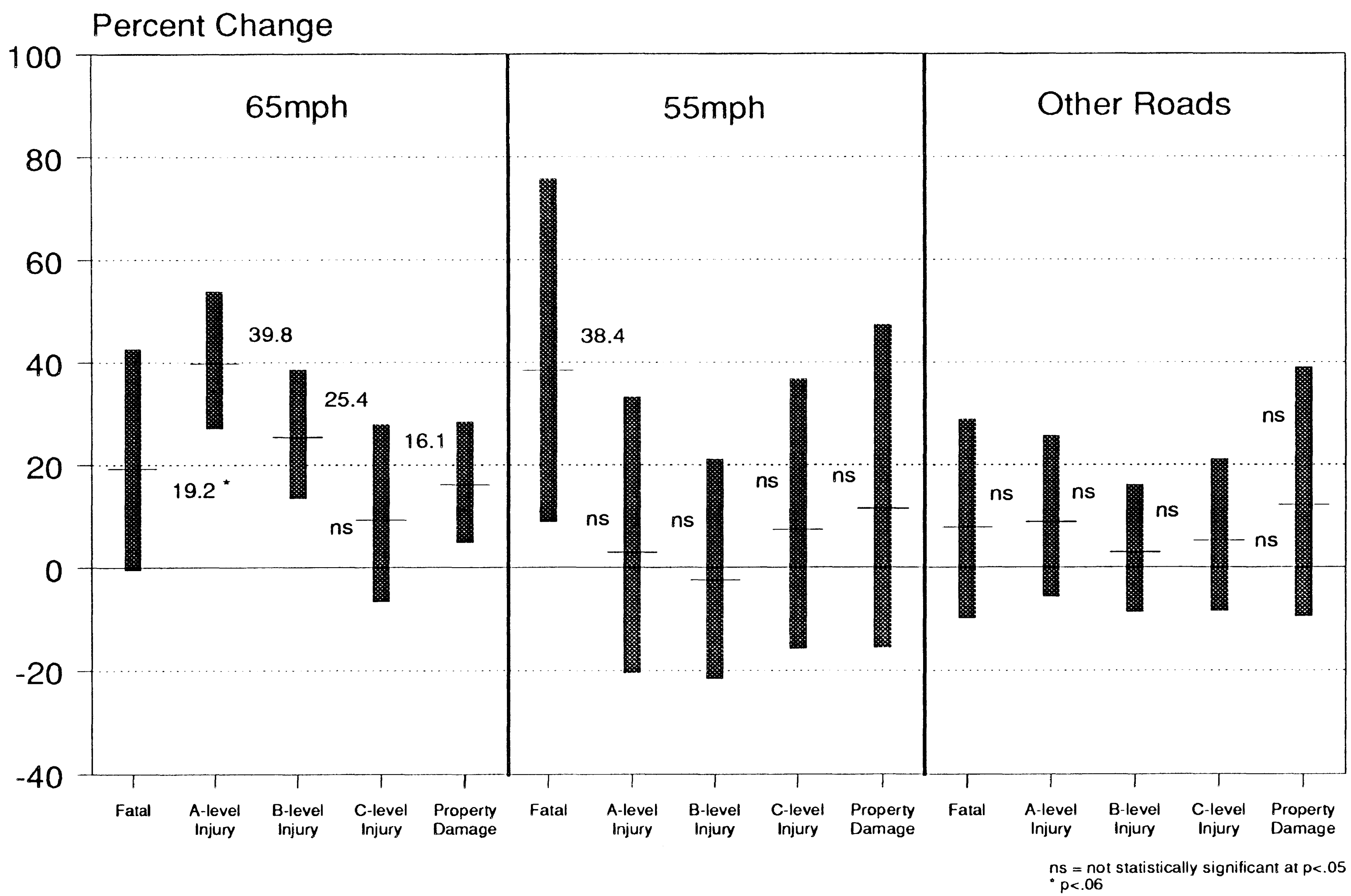

Figure 3.1: Effects of Increase in Maximum Speed Limit by Injury Level

Table 3.1. Effects of Increase in Maximum Speed Limit: Results from Time-Series Models with Anticipatory and Implementation Effects

	Estimate	Standard Error	Percent Change	90% Confidence Interval Low	High
Fatalities					
65 MPH Highways					
ARIMA (0, 0, 5) $(0, 1, 1)_{12}$					
$R^2 = 0.03$					
Anticipatory Effect	0.2881	0.2998			
Implementation Effect	0.1754	0.1094	19.2	- 0.5	42.7
55 Limited-access Highways					
ARIMA (0, 0, 0) $(0, 1, 1)_{12}$					
$R^2 = 0.17$					
Anticipatory Effect	0.3021	0.3025			
Implementation Effect	0.3251*	0.1454	38.4	9.0	75.8
All Other Roads					
ARIMA (0, 1, 1) $(0, 1, 1)_{12}$					
$R^2 = 0.72$					
Anticipatory Effect	0.0719	0.1278			
Implementation Effect	0.0750	0.1085	7.8	- 9.8	28.9
Serious Injuries					
65 MPH Highways					
ARIMA (0, 0, 0) $(0, 1, 1)_{12}$					
$R^2 = 0.46$					
Anticipatory Effect	0.4937*	0.1424			
Implementation Effect	0.3353*	0.0581	39.8	27.1	53.9
55 Limited-access Highways					
ARIMA (0, 1, 8) $(0, 1, 1)_{12}$					
$R^2 = 0.31$					
Anticipatory Effect	0.2742	0.1719			
Implementation Effect	0.0292	0.1566	3.0	-20.4	33.2
All Other Roads					
ARIMA (0, 1, 1) $(0, 1, 1)_{12}$					
$R^2 = 0.89$					
Anticipatory Effect	0.0659	0.0861			
Implementation Effect	0.0851	0.0874	8.9	- 5.7	25.7
Moderate Injuries					
65 MPH Highways					
ARIMA (0, 0, 7) $(0, 1, 1)_{12}$					
$R^2 = 0.50$					
Anticipatory Effect	0.2191*	0.1232			
Implementation Effect	0.2266*	0.0609	25.4	13.5	38.6

Table 3.1. Continued

	Estimate	Standard Error	Percent Change	90% Confidence Interval Low	High
55 Limited-access Highways					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.38					
Anticipatory Effect	0.0412	0.1477			
Implementation Effect	-0.0254	0.1319	- 2.5	-21.5	21.1
All Other Roads					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.88					
Anticipatory Effect	0.0526	0.0709			
Implementation Effect	0.0294	0.0731	3.0	- 8.7	16.1
Minor Injuries					
65 MPH Highways					
ARIMA (0, 0, 7) (0, 1, 1)$_{12}$					
R^2 = 0.66					
Anticipatory Effect	0.2197	0.1735			
Implementation Effect	0.0892	0.0955	9.3	- 6.6	27.9
55 Limited-access Highways					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.57					
Anticipatory Effect	0.1188	0.1608			
Implementation Effect	0.0715	0.1472	7.4	-15.7	36.8
All Other Roads					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.77					
Anticipatory Effect	0.0626	0.0857			
Implementation Effect	0.0510	0.0853	5.2	- 8.5	21.1
Property Damage Only Crashes					
65 MPH Highways					
ARIMA (0, 0, 1) (0, 1, 1)$_{12}$					
R^2 = 0.82					
Anticipatory Effect	0.1479	0.1235			
Implementation Effect	0.1491*	0.0618	16.1	4.9	28.5
55 Limited-access Highways					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.80					
Anticipatory Effect	0.1284	0.1686			
Implementation Effect	0.1090	0.1690	11.5	-15.5	47.3
All Other Roads					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.83					
Anticipatory Effect	0.1081	0.1233			
Implementation Effect	0.1147	0.1304	12.2	- 9.5	39.0

*Statistically significant at $p < .05$, one-tailed test.

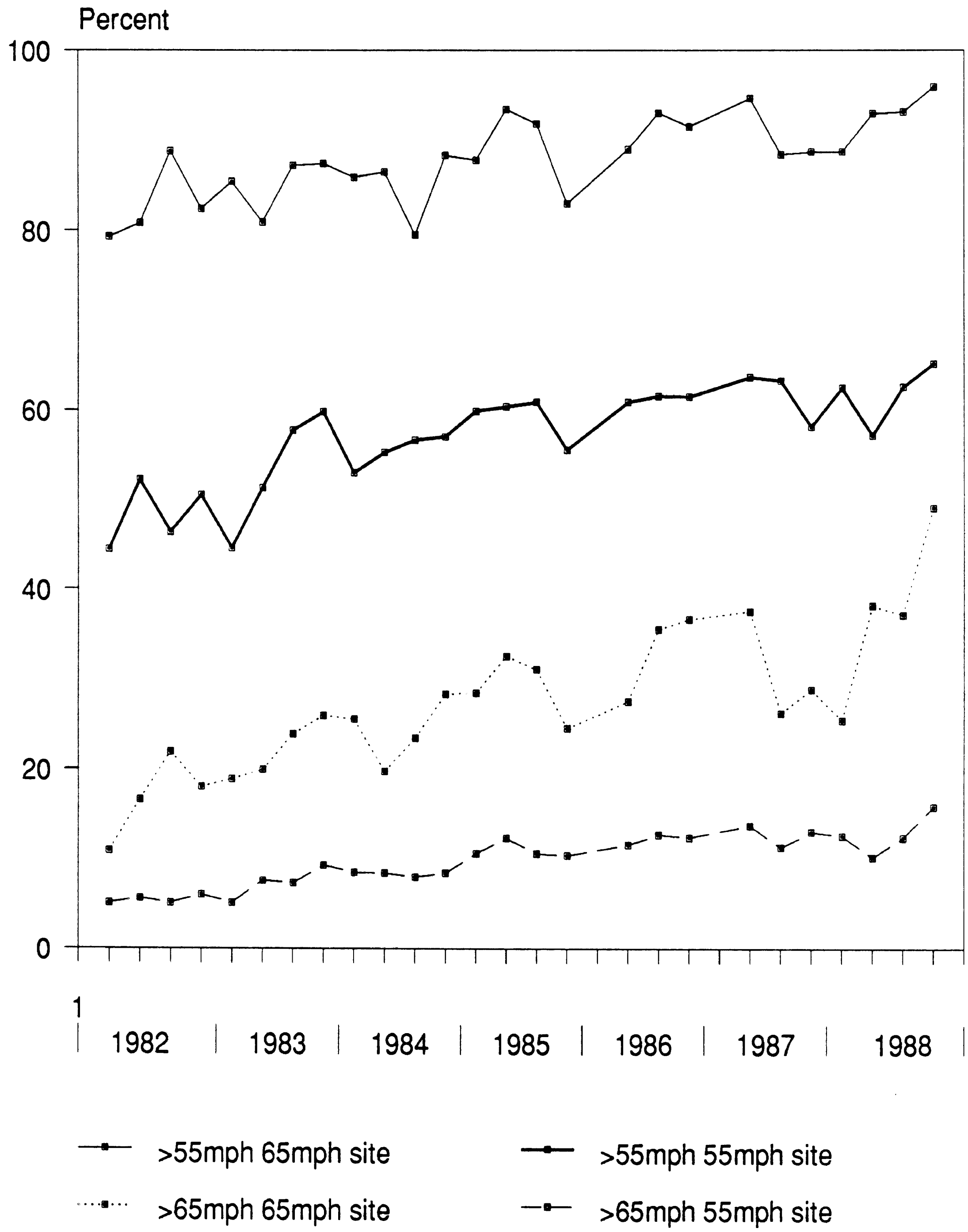

Figure 3.2: Travel Speeds Measured on 55 Sites throughout Michigan: 1982-1988

Table 3.2. Effects of Increase in Maximum Speed Limit: Results from Time-Series Models with Implementation Effect Only

	Estimate	Standard Error	Percent Change	90% Confidence Interval Low	High
Fatalities					
65 MPH Highways					
ARIMA (0, 0, 5) (0, 1, 1)$_{12}$					
R^2 = 0.03					
Implementation Effect	0.1699	0.1089	18.5	- 0.9	41.8
55 Limited-access Highways					
ARIMA (0, 0, 0) (0, 1, 1)$_{12}$					
R^2 = 0.18					
Implementation Effect	0.2796*	0.1381	32.3	5.4	66.0
All Other Roads					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.72					
Implementation Effect	0.0353	0.0819	3.6	- 9.5	18.5
Serious Injuries					
65 MPH Highways					
ARIMA (0, 0, 0) (0, 1, 1)$_{12}$					
R^2 = 0.41					
Implementation Effect	0.3128*	0.0624	36.7	23.4	51.5
55 Limited-access Highways					
ARIMA (0, 1, 8) (0, 1, 1)$_{12}$					
R^2 = 0.30					
Implementation Effect	-0.1424	0.1094	-13.3	-27.6	3.8
All Other Roads					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.89					
Implementation Effect	0.0334	0.055	3.4	- 5.5	13.2
Moderate Injuries					
65 MPH Highways					
ARIMA (0, 0, 7) (0, 1, 1)$_{12}$					
R^2 = 0.49					
Implementation Effect	0.2028*	0.0606	22.5	10.9	35.3
55 Limited-access Highways					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.38					
Implementation Effect	-0.0505	0.0949	- 4.9	-18.7	11.1

Table 3.2. Continued

	Estimate	Standard Error	Percent Change	90% Confidence Interval Low	High
All Other Roads					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
$R^2 = 0.88$					
Implementation Effect	-0.0120	0.0453	- 1.2	- 8.3	6.4
Minor Injuries					
65 MPH Highways					
ARIMA (0, 0, 7) (0, 1, 1)$_{12}$					
$R^2 = 0.66$					
Implementation Effect	0.0456	0.0896	4.7	- 9.7	21.3
55 Limited-access Highways					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
$R^2 = 0.57$					
Implementation Effect	-0.0052	0.1041	-0.5	-16.2	18.1
All Other Roads					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
$R^2 = 0.77$					
Implementation Effect	0.0054	0.055	0.5	- 8.2	10.1
Property Damage Only Crashes					
65 MPH Highways					
ARIMA (0, 0, 1) (0, 1, 1)$_{12}$					
$R^2 = 0.82$					
Implementation Effect	0.1254*	0.0589	13.4	2.9	24.9
55 Limited-access Highways					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
$R^2 = 0.80$					
Implementation Effect	0.0124	0.1093	1.2	-15.4	21.2
All Other Roads					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
$R^2 = 0.83$					
Implementation Effect	-0.0340	0.0795	- 3.3	-15.2	10.2

*Statistically significant at $p < .05$, one-tailed test.

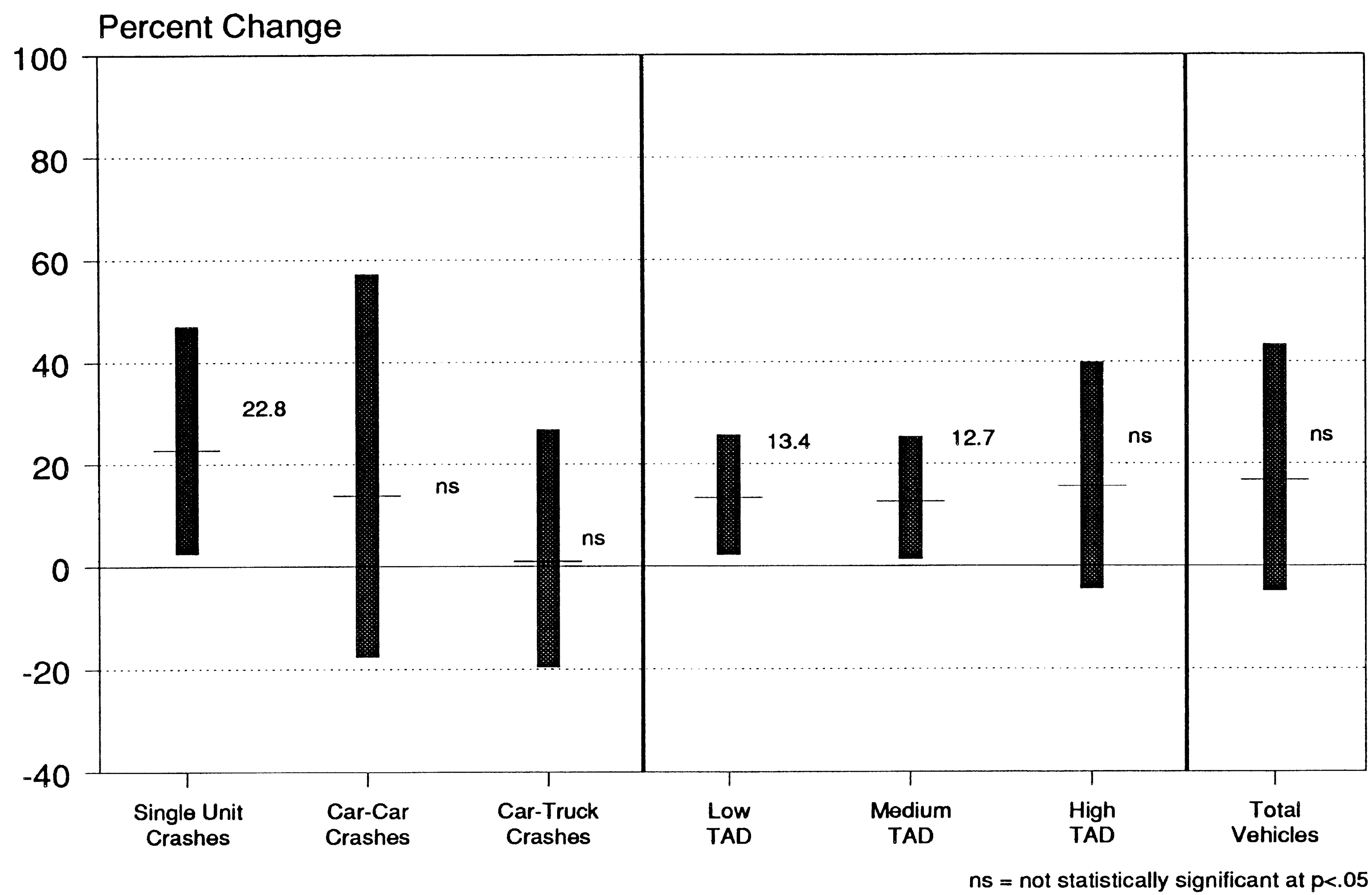

Figure 3.3: Effects of Increase in Maximum Speed Limit by Crash Configuration and Vehicle Damage Level

Table 3.3. Differential Effects of Increase in Maximum Speed Limit to 65 by Crash Configuration, Vehicle Damage Level, Gender, and Age

	Estimate	Standard Error	Percent Change	90% Confidence Interval Low	High
Crash Configuration					
Single Vehicle					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.86					
Anticipatory Effect	0.1812	0.1347			
Implementation Effect	0.2051*	0.1096	22.8	2.5	47.0
Car-car					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.71					
Anticipatory Effect	0.1718	0.2195			
Implementation Effect	0.1296	0.1966	13.8	-17.6	57.3
Car-truck					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.76					
Anticipatory Effect	0.0195	0.1704			
Implementation Effect	0.0096	0.1383	1.0	-19.6	26.8
Vehicle Damage Level					
Low					
ARIMA (0, 0, 1) (0, 1, 1)$_{12}$					
R^2 = 0.81					
Anticipatory Effect	0.0930	0.1253			
Implementation Effect	0.1258*	0.0625	13.4	2.3	25.7
Medium					
ARIMA (0, 0, 1) (0, 1, 1)$_{12}$					
R^2 = 0.81					
Anticipatory Effect	0.1167	0.1300			
Implementation Effect	0.1198*	0.0643	12.7	1.4	25.3
High					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.69					
Anticipatory Effect	0.2015	0.1484			
Implementation Effect	0.1447	0.1156	15.6	- 4.4	39.8

Table 3.3. Continued

	Estimate	Standard Error	Percent Change	90% Confidence Interval Low	High
Gender					
Male Driver Rate					
ARIMA (0, 0, 0) (0, 1, 1)$_{12}$					
R^2 = 0.77					
Anticipatory Effect	0.1284	0.1123			
Implementation Effect	0.1193*	0.0533	12.7	3.2	23.0
Female Driver Rate					
ARIMA (0, 0, 0) (0, 1, 1)$_{12}$					
R^2 = 0.83					
Anticipatory Effect	0.2359*	0.1211			
Implementation Effect	0.1481*	0.0599	16.0	5.1	28.0
Age					
Age 15-24 Rate					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.77					
Anticipatory Effect	0.0961	0.2075			
Implementation Effect	0.1847	0.2058	20.3	-14.3	68.7
Age 25-55 Rate					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.81					
Anticipatory Effect	0.2201	0.1420			
Implementation Effect	0.1728	0.1070	18.9	- 0.3	41.7
Age 56+ Rate					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.68					
Anticipatory Effect	0.2834*	0.1381			
Implementation Effect	0.1757*	0.0783	19.2	4.8	35.6
Total Vehicles Crashed					
ARIMA (0, 1, 1) (0, 1, 1)$_{12}$					
R^2 = 0.80					
Anticipatory Effect	0.1534	0.1496	16.6	- 8.9	49.1
Implementation Effect	0.1553	0.1241	16.8	- 4.8	43.3

*Statistically significant at $p < .05$, one-tailed test.

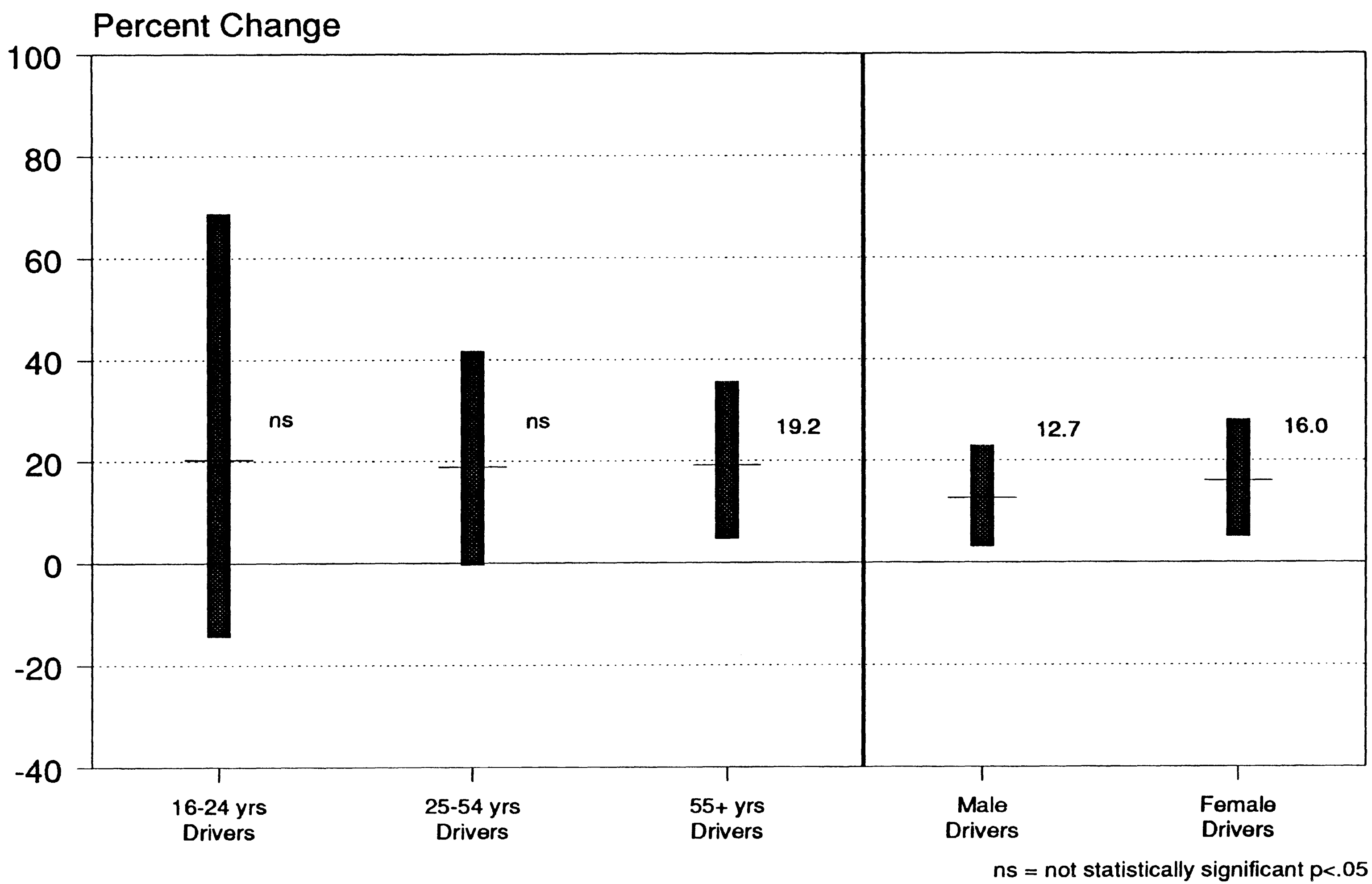

Figure 3.4: Effects of Increase in Maximum Speed Limit by Age and Gender

Table 3.4. **Effects of Increase in Maximum Speed Limit: Results from Time-Series Models with Anticipatory Effects, Implementation Effects, and Controls for Effects of Covariates**

		Estimate	Standard Error	Percent Change	90% Confidence Interval Low	High
Fatalities						
65 MPH Highways						
ARIMA (0, 0, 5) $(0, 1, 1)_{12}$						
$R^2 = 0.10$						
Anticipatory Effect		0.8352	0.3741			
Implementation Effect		0.3945	0.1705	48.4	12.1	96.4
Adult Belt Law		-0.4901	0.1616			
Vehicle Miles Traveled		0.7413	0.9104			
Unemployment Rate	Lag 0	0.2749	0.5107			
	Lag 1	0.3071	0.6364			
	Lag 2	-1.000	0.6620			
	Lag 3	-0.2650	0.6421			
	Lag 4	0.3383	0.5038			
Beer Consumption	Lag 0	0.0966	0.8253			
	Lag 1	-0.0029	0.8134			
	Lag 2	1.434	0.8122			
Percent Young Drivers		-0.9469	0.5509			
Serious Injuries						
65 MPH Highways						
ARIMA (0, 0, 0) $(0, 1, 1)_{12}$						
$R^2 = 0.49$						
Anticipatory Effect		0.4322	0.1809			
Implementation Effect		0.2764	0.0887	31.8	13.9	52.5
Adult Belt Law		-0.0175	0.0799			
Vehicle Miles Traveled		0.2014	0.3846			
Unemployment Rate	Lag 0	-0.3372	0.2376			
	Lag 1	-0.0474	0.3075			
	Lag 2	0.1673	0.3289			
	Lag 3	0.1748	0.3191			
	Lag 4	-0.1384	0.2453			
Beer Consumption	Lag 0	0.8060	0.3765			
	Lag 1	0.2168	0.3742			
	Lag 2	-0.5671	0.3730			
Percent Young Drivers		-0.3883	0.2895			

Table 3.4. Continued

		Estimate	Standard Error	Percent Change	90% Confidence Interval Low	High
Moderate Injuries						
65 MPH Highways						
ARIMA (0, 0, 0) (0, 1, 1)$_{12}$						
$R^2 = 0.51$						
Anticipatory Effect		0.2839	0.1525			
Implementation Effect		0.2647	0.0848	30.3	13.3	49.8
Adult Belt Law		0.0393	0.0712			
Vehicle Miles Traveled		-0.2752	0.3247			
Unemployment Rate	Lag 0	0.1035	0.2045			
	Lag 1	-0.0307	0.2655			
	Lag 2	0.0272	0.2811			
	Lag 3	0.0174	0.2819			
	Lag 4	-0.2512	0.2163			
Beer Consumption	Lag 0	0.2253	0.3205			
	Lag 1	0.2186	0.3186			
	Lag 2	0.1899	0.3099			
Percent Young Drivers		-0.5948	0.2622			
Minor Injuries						
65 MPH Highways						
ARIMA (0, 0, 0) (0, 1, 1)$_{12}$						
$R^2 = 0.67$						
Anticipatory Effect		0.3374	0.2404			
Implementation Effect		0.1802	0.1516	19.7	- 6.7	53.7
Adult Belt Law		0.0468	0.1185			
Vehicle Miles Traveled		-0.8417	0.4090			
Unemployment Rate	Lag 0	0.0257	0.2251			
	Lag 1	-0.0200	0.2626			
	Lag 2	-0.2387	0.2795			
	Lag 3	0.3863	0.2741			
	Lag 4	-0.3669	0.2403			
Beer Consumption	Lag 0	0.0547	0.3559			
	Lag 1	0.7039	0.3515			
	Lag 2	0.0163	0.3453			
Percent Young Drivers		-0.5313	0.4365			

Table 3.4. Continued

	Estimate	Standard Error	Percent Change	90% Confidence Interval Low	High
Property Damage Only Crashes					
65 MPH Highways					
ARIMA (0, 0, 0) (0, 1, 1)$_{12}$					
R^2 = 0.84					
Anticipatory Effect	0.2342	0.1722			
Implementation Effect	0.2413	0.1036	27.3	7.3	50.9
Adult Belt Law	0.1631	0.0798			
Vehicle Miles Traveled	-0.8257	0.2957			
Unemployment Rate Lag 0	-0.0900	0.1680			
Lag 1	-0.0834	0.2053			
Lag 2	0.2430	0.2181			
Lag 3	-0.0356	0.2118			
Lag 4	-0.2136	0.1761			
Beer Consumption Lag 0	0.1406	0.2615			
Lag 1	0.1805	0.2609			
Lag 2	-0.2293	0.2588			
Percent Young Drivers	-0.4472	0.3037			

4. DISCUSSION

Raising the speed limit to 65 mph was followed by increased casualties due to motor vehicle crashes. On road segments where the limit was raised, the percentage increases in injury and death were large (16 to 40%). Fortunately, the limited-access highways where the limit was raised are relatively safe, compared to other roads in the state. Because limited-access highways have relatively low injury and death rates, the proportional increase in casualties on these roads represents a smaller increase in the actual number of people killed or injured than would occur if the limit were raised on other types of roads. Nevertheless, our results show that 27 additional people were killed, 222 experienced serious injuries, and 271 experienced moderate injuries in the first 13 months with the raised limit (Table 4.1). Estimated total costs in terms of the rational investment to prevent these additional injuries and fatalities is $57 million. Similar costs to prevent property-damage-only crashes total over $4.8 million.

Many observers argue that there are also substantial benefits of the raised limit, primarily cost savings due to reduced travel time. Miller (1989) argues that the costs of the raised limit in terms of years of life lost from premature death and injury are roughly equal to the years saved from reduced travel time. However, Miller also points out that the costs and benefits are not equally distributed--savings accrue to all drivers and passengers of motor vehicles, but costs are born disproportionately by the those who are killed or injured in crashes. Furthermore, the risk of death or injury is not equally distributed throughout the population of motorists (young males are at higher risk, for example). It is widely argued by public health ethicists that equal aggregate costs and benefits of a public policy should not be considered off-setting if the **distribution** of the costs and benefits is unequal (Beauchamp, 1976).

There are other issues that are part of the debate concerning the appropriate maximum speed limit. One might argue that there are other policies that can prevent as much or more damage than the 55-mph limit, perhaps at lower cost or at least with a different distribution of costs. The majority of the public supports the 65-mph limit (52%; Wagenaar, Streff, and Maybee, 1987), a fact used to argue for maintenance of the 65 limit, or to argue for better dissemination of information regarding increased casualties caused by higher speeds. Although we found ambiguous evidence of spill-over effects in this short-term study, it is possible that higher speeds on selected (safer) road segments over the long-term may gradually spread to other (less safe) road segments, increasing the deleterious effects of the raised speed limit.

Table 4.1 Estimated Injuries Attributable to Increase in Speed Limit to 65 mph

	Actual	Expected[1]	Difference	Costs[2]
Fatalities	1,558	1,531	27	$44,142,408
Serious Injuries	22,250	22,028	222	9,436,666
Moderate Injuries	43,504	43,233	271	3,544,472
Total Casualties	67,312	66,792	520	$57,123,546
Property Damage Only Crashes	623,016	620,808	2,208	4,813,440
Total	**690,328**	**687,600**	**2,728**	**$61,936,986**

Notes:

[1]Expected represents the estimated number of deaths or injuries that would have occurred in the 13-month post-law period analyzed had the speed limit not changed.

[2]Based on 1988 adjusted willingness-to-pay values of $1,634,904 per fatality, $42,508 per serious injury, $13,079 per moderate injury, $2,180 per property-damage-only crash. Original calculated in 1986 dollars, adjusted annually by consumer price index to 1988 dollars.

Ultimately, support or opposition to the 65 limit must be based on one's structure of values. Is the increased convenience of faster travel worth the increased deaths and injuries? Each individual may make their own decisions regarding these trade-offs. But a safe and efficient transportation system is inherently a collective good. Therefore, collective acknowledgement and public debate on the benefits and costs of alternative speed limit policies is necessary (Beauchamp, 1988). Moreover, decisions regarding appropriate speed limits must be based on the welfare of the community as a whole. Results of the current study showing increased deaths and injuries following the raised speed limit are a central dimension of the debate.

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Appendix A

Chronology of Events Concerning Speed Limit Changes in the U.S. and the State of Michigan

U.S. Congressional Action on Speed Limit Law

01/03/87 A proposal to amend HR 3129 (transportation funds) allowing states to increase speed on rural interstates lost by 20 votes in the House. The proposal was later adopted by the Senate 56-36.

01/17/87 Lobbying to amend HR 2 (transportation funds) with allowing states to increase speed limits.

01/21/87 HR 2 passed in House 401-20 at $90B over 5 years. Uphold 331-88 using H Res 38, barring any amendments, thereby barring speed limit amendment vote.

02/03/87 Senate debates speed limit amendment and passes it 65-33.

02/04/87 Senate passes HR 2 96-2 with amendment allowing increased speed limits. Bill was $65.4B over 4 years. With the disparity, a conference with House members is necessary.

Administration officials may recommend presidential veto. There is a consensus that if the bill is not in place by May 1, many jobs will be in jeopardy.

02/19/87 Secretary of Transportation Elizabeth Dole voiced support for increase in speed limit on rural interstates where traffic volumes are 10K per day or less.

02/23/87 Conference starts on HR 2. Talks of tying in safety provisions, such as minimal safety belt use rates, with speed limit increases.

02/24/87 National Governors Association votes 24-7 to switch its position from 55 to Senate provision.

03/05/87 House conferees back away from their position on maintaining 55. Negotiators unable to agree on way to link higher limits with safety requirements. Exempting demonstration project funds from spending ceilings would be point of presidential veto.

House: demonstration funds not deducted from states' allotments. No project would need matching (state or local) funds either.

Senate: all demonstration funds are from states allotments and matching funds are required. No project is exempt from spending ceiling as well.

On March 4, a compromise on the demonstration projects is reached.

50% project costs, $178M annually over 5 years, is exempt from ceilings. Funds split evenly between designated House and Senate projects.

30% not from regular apportionments but from funds to be allocated at the discretion of the transportation secretary.

20% from state or local sources.

03/10/87 House conferees get proposal to allow House to vote separately on 65, after the vote on the final measure covering all other aspects of reauthorization legislation. If 65 is not approved, Senate votes on highway package that would retain 55.

03/18/87 House votes to adopt HR 2 407-17.

House approves 65 (H Con Res 77) 217-206.

03/19/87 President Reagan letter called HR 2 "seriously flawed."[1] Immediately following receipt of this message, Senate votes to adopt the measure (conference report) on HR 2 79-17.

03/20/87 Senate adopts 65 60-21.

03/25/87 Reagan visits Capitol Hill to ask House GOP members for support.

03/27/87 Reagan vetoes HR 2, calls bill "filled with pork."[2]

03/31/87 House overrides veto 350-73.

04/01/87 Senate sustains veto 65-35.

Senate adopts motion to reconsider override vote 59-41.

04/02/87 Reagan visits Capitol Hill and meets with Republicans in old Senate Chamber, then with the 13 holdouts in Senator Dole's office.

Senate overrides veto 67-33.

12/22/87 Public Law 100-202 includes a plan by Don Nickles, R-OK, to allow states to raise the speed limit to 65 mph on rural highways, primarily state turnpikes, that meet the same design standards as Interstate highways. Some 6,000 miles of roads in 43 states would be eligible for a 65 mph posting under this plan.[3]

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[1]Congressional Quarterly dated 3/21/87, p.521.

[2]Congressional Quarterly dated 3/28/87, p. 566.

[3]Congressional Quarterly dated 10/31/87, p. 2659.

Michigan Legislation Action on Speed Limit Law[4]

03/17/87	Introduction of SB 135 by Sen. Cruce. Bill to increase the speed limit and provide for primary enforcement of seatbelts; assigned to committee on Local Government and Veterans.
03/19/87	Introduction of SB 163 by Sen. Fessler. Bill to increase the speed limit; assigned to Committee on State Affairs, Tourism and Transportation.
03/25/87	SB 163 reported out of committee.
	SB 135 heard in committee, but not reported out.
04/01/87	SB 163 passes Senate and sent to House.
05/13/87	House passes SB 163.
05/20/87	Sen. Ehlers sponsors amendment to SB 163 to ban radar detectors; amendment passes 21 - 15; rejected in the House and SB 163 is sent to conference committee.
06/17/87	Conference report without radar detector ban sent to Governor Blanchard and vetoed by him.
10/01/87	SB 135 on Senate General Orders.
10/07/87	SB 135 passes Senate and sent to House.
10/29/87	SB 135 with House amendments on $5 surcharge concurred in.
	Approved by Governor Blanchard.

[4]Compiled by Anne Mervenne of Sen. Cruce's office

Appendix B

Speed Limits by Road Segment

NON-INTERSTATE SPEEDS - URBAN-55MPH/RURAL-65MPH/RURAL-55MPH

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
US-10 - I-75 (BAY CO) TO M-115 (CLARE CO)								
	I-75 TO 4 MI RD (BAY CO)	09101	XX			10.40	11.60	01.20
	4 MI RD (BAY CO) TO	09101		XX		00.00	10.40	10.40
	M-115 (CLARE CO)	56044		XX		00.00	19.40	19.40
		56045		XX		00.00	06.80	06.80
		37032		XX		00.00	07.20	07.20
		18023		XX		00.00	01.30	01.30
		18024		XX		00.00	07.90	07.90
US-23 - STATE LINE (MONROE CO) TO I-75 (GENESEE CO)								
	STATE LINE (MONROE CO) TO	58034		XX		00.00	16.70	16.70
	1.5 MI S OF TEXTILE RD	58033		XX		00.00	08.10	08.10
	(WASHTENAW CO)	81076		XX		00.00	08.00	08.00
	TEXTILE RD TO WARREN RD	81076	XX			08.00	09.90	01.90
	(WASHTENAW CO)	81074	XX			00.00	07.40	07.40
		81103	XX			00.00	02.90	02.90
		81075	XX			01.60	02.10	00.50
	WARREN RD (WASHTENAW CO)	81075		XX		02.10	09.10	07.00
	TO GRAND BLANC RD	47013		XX		00.00	07.00	07.00
	(GENESEE CO)	47014		XX		00.00	18.30	18.30
		25031		XX		00.00	09.70	09.70
	GRAND BLANC RD TO I-75	25031	XX			09.70	12.40	02.70
	(GENESEE CO)							
US-27	BAGLEY RD [OLD US-27]	29011		XX		10.60	22.30	11.70
	(GRATIOT CO) TO I-75	29014		XX		00.00	04.40	04.40
	(CRAWFORD CO)	37013		XX		00.00	11.70	11.70
		37014		XX		00.00	14.70	14.70
		18033		XX		00.00	12.90	12.90
		18034		XX		00.00	12.20	12.20
		72013		XX		00.00	12.20	12.20
		72014		XX		00.00	12.30	12.30
		20016		XX		00.00	06.30	06.30
US-31 - STATE LINE (BERRIEN CO) TO FREEWAY END (MASON CO)								
	STATE LINE TO WALTON RD	11056			XX	00.00	03.00	03.00
	(BERRIEN CO)	11057				NOT YET BUILT		
	I-196 TO WASHINGTON	03032			XX	00.00	02.30	02.30
	(ALLEGAN CO)							
	M-104 (OTTAWA CO) TO	70016			XX	00.00	02.90	02.90
	WILSON RD (OTTAWA CO/							

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	MUSKEGON CO LINE)							
	WILSON RD (OTTAWA CO/	61074	XX			00.00	03.80	03.80
	MUSKEGON CO LINE) TO	61072	XX			00.00	04.40	04.40
	M-120 (MUSKEGON CO)	61075	XX			00.00	04.10	04.10
	M-120 (MUSKEGON CO) TO	61075		XX		04.10	18.80	14.70
	FREEWY END (MASON CO)	64014		XX		00.00	07.60	07.60
		64015		XX		00.00	18.30	18.30
		53031		XX		00.00	09.80	09.80
US-127 - M-50 S. JCT (JACKSON CO) TO I-69 E. JCT								
	M-50 TO 1.5 MI NORTH OF	38111	XX			09.10	14.40	05.30
	PARNALL RD (JACKSON CO)	38131	XX			00.00	02.90	02.90
	1.5 MI N OF PARNALL RD	38131		XX		02.90	10.50	07.60
	(JACKSON CO) TO COLLEGE	33031		XX		00.00	09.70	09.70
	RD (INGHAM CO)	33035		XX		00.00	05.80	05.80
	COLLEGE RD (INGHAM CO) TO	33035	XX			05.80	06.50	00.70
	I-69 E JCT (CLINTON CO)	33045	XX			02.10	05.50	03.40
		33171	XX			00.00	01.50	01.50
		33172	XX			00.00	01.90	01.90
		19081	XX			00.00	03.10	03.10
US-131 FROM "U" AVE (KALAMAZOO CO) TO FREEWAY END (WEXFORD CO)								
	"U" AVE N 1.0 MI (KALAMAZOO CO)	39013			XX	00.00	01.00	01.00
	1.0 MI N OF "U" AVE TO	39013	XX			01.00	06.60	05.60
	"H" AVE (KALAMAZOO CO)	39014	XX			00.00	05.80	05.80
	"H" AVE (KALAMAZOO CO)	39014		XX		05.80	13.00	07.20
	TO 0.5 MI S OF 84TH ST	03111		XX		00.00	08.10	08.10
	(KENT CO)	03112		XX		00.00	16.20	16.20
		41131		XX		00.00	02.50	02.50
	0.5 MI S OF 84TH ST N	41131	XX			02.50	17.90	15.40
	TO 7 MI RD (KENT CO)	41132	XX			00.00	04.80	04.80
	7 MI RD (KENT CO) N TO	41132		XX		04.80	13.10	08.30
	FREEWAY END S OF CADILLAC	41133		XX		00.00	08.70	08.70
	(WEXFORD CO)	59012		XX		00.00	13.10	13.10
		54013		XX		00.00	08.40	08.40
		54014		XX		00.00	16.10	16.10
		67016		XX		00.00	05.60	05.60
		67017		XX		00.00	07.60	07.60
		67015		XX		00.00	12.10	12.10
		83031		XX		00.00	04.30	04.30
US-131BR - US-131 TO FREEWAY END AT WESTNEDGE AVE (KALAMAZOO CO)								
	US-131 TO 12TH ST (KALAMAZOO CO)	39051			XX	05.00	05.90	00.90

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	12TH ST TO FREEWAY END AT WESTNEDGE (KALAMAZOO CO)	39051	XX			00.00	05.00	05.00
M-10	US-24 TO I-75 WAYNE AND OAKLAND CONTIES	63081	XX			00.00	05.20	05.20
		82112	XX			00.00	09.90	09.90
		82111	XX			00.00	01.40	01.40
M-14	US-23 [E JCT] (WASHTENAW CO) TO I-275 (WAYNE CO)							
	US-23 (E JCT) TO DIXBORO RD (WASHTENAW CO)	81103	XX			02.90	04.40	01.50
	DIXBORO RD (WASHTENAW CO) TO N TERRITORIAL RD (WAYNE CO)	81103		XX		04.40	11.10	06.70
		82102		XX		00.00	00.90	00.90
	N TERRITORIAL RD TO I-275 (WAYNE CO)	82102	XX			00.90	06.60	06.00
M-39	ENTIRE ROUTE THROUGH WAYNE CO AND OAKLAND CO	82192	XX			00.00	11.10	11.10
		82193	XX			00.00	04.00	04.00
		63171	XX			00.00	01.30	01.30
M-47	US-10 (BAY CO) TO FREE-WAY END (SAGINAW CO)	09091			XX	00.00	02.10	01.20
		73075			XX	00.00	02.10	02.10
M-20/US-10BR	US-10 E JCT TO FREEWAY END 0.25 MI E OF WASHINGTON (MIDLAND CO)	56023			XX	02.30	04.30	02.00
M-53	VAN DYKE TO WASHINGTON SQUARE (MACOMB CO)	50011	XX			09.90	12.60	02.70
		50013	XX			00.00	08.10	08.10
M-60	I-94 TO SPRING ARBOR RD (JACKSON CO)	38061	XX			13.00	16.00	03.00
M-13 CONN	US-23 TO M-13 (BAY CO)	09111	XX			00.00	02.50	02.50
M-25/BS-75	I-75 E TO 0.5 E OF M-13 (BAY CO)	09042	XX			00.00	03.50	03.50
M-59	ENTIRE ROUTE THROUGH OAKLAND CO AND MACOMB CO	63043	XX			00.00	10.70	10.70
		50023	XX			00.00	02.00	02.00
		50022	XX			00.00	09.40	09.40
M-102	ENTIRE ROUTE THROUGH OAKLAND CO	63021	XX			00.00	04.10	04.10

STATEWIDE TOTALS BY ROUTE

RTE NO.	URBAN 55MPH	RURAL 65MPH	RURAL 55MPH	TOTAL MILES
US-10	01.20	53.00	00.00	54.20
US-23	15.40	74.80	00.00	90.20
US-27	00.00	98.40	00.00	98.40
US-31	12.30	50.40	08.20	70.90
US-127	18.80	23.10	00.00	41.90
US-131	31.60	118.20	01.00	150.80
US-131BR	05.00	00.00	00.90	05.90
M-10	16.50	00.00	00.00	16.50
M-14	07.50	07.60	00.00	15.10
M-39	16.40	00.00	00.00	16.40
M-47	00.00	00.00	03.30	03.30
M-20/US-10BR	00.00	00.00	02.00	02.00
M-53	10.80	00.00	00.00	10.80
M-60	03.00	00.00	00.00	03.00
M-13 CONN	02.50	00.00	00.00	02.50
M-25/BS-75	03.50	00.00	00.00	03.50
M-59	22.10	00.00	00.00	22.10
M-102	04.10	00.00	00.00	04.10
STWD	170.70	425.50	15.40	611.60

INTERSTATE SPEEDS - URBAN-55MPH/RURAL-65MPH/RURAL-55MPH

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
I-69 (STATE LINE TO PORT HURON)								
	STATE LINE TO BL-69	12033		XX		00.00	12.60	12.60
	(CHARLOTTE)	12034		XX		00.00	09.47	09.47
		13073		XX		00.00	16.13	16.13
		13074		XX		00.00	09.04	09.04
		23061		XX		00.00	09.53	09.53
	BL-69 TO I-96 (S JCT)	NON-FWY						
	I-96 (S JCT) TO I-96	23152	XX			00.00	06.75	06.75
	(N JCT)	19022	XX			07.71	10.16	02.45
	GRAND RIVER AVENUE TO PEACOCK ROAD							
	GR RIVER TO DAGGETT RD	19043		XX		00.00	05.25	05.25
	DAGGETT RD TO US-127	19043	XX			05.25	09.38	04.13
	US-127 TO TEMP I-69	19042		XX		00.00	08.26	08.26
	TEMP I-69 TO PEACOCK RD	NON-FWY						
	PEACOCK RD TO 1.2 MILE E OF M-52 (PERRY)	NON-FWY						
	1.2 MILE E OF M-52 TO	76023		XX		01.20	17.62	16.42
	2.0 MILES W OF MORRISH	25042		XX		00.00	02.97	02.97
	RD (SWARTZ CREEK)							
	2.0 MILES W OF MORRISH	25042	XX			02.97	10.23	07.26
	RD TO OAK RD (DAVISON)	25085	XX			00.00	02.95	02.95
		25084	XX			00.00	09.70	09.70
	OAK RD TO WADHAMS RD	25084		XX		09.70	11.71	02.01
	(PORT HURON)	44043		XX		00.00	07.25	07.25
		44044		XX		00.00	17.57	17.57
		77024		XX		00.00	11.55	11.55
		77023		XX		00.00	12.42	12.42
	WADHAMS RD TO I-94	77023	XX			12.42	15.80	03.38
	(FREEWAY ENDING)							
I-75 (STATE LINE TO SAULT STE MARIE/PORT OF ENTRY/INTERNATIONAL BRIDGE)								
	STATE LINE (TOLEDO) TO	58151		XX		00.00	15.26	15.26
	SO. ROCKWOOD SVL (600 FT	58152		XX		00.00	09.96	09.96
	S OF READY RD)	58152	XX			09.96	11.55	01.59
	SO. ROCKWOOD SVL TO 1.0	82191	XX			00.00	13.96	13.96
	MILE W OF DIXIE HWY	82194	XX			00.00	08.51	08.51
	(OAKLAND CO)	82195	XX			00.00	02.28	02.28
		82251	XX			00.00	02.31	02.31

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	SO. ROCKWOOD SVL TO 1.0	82252	XX			00.00	05.83	05.83
	MILE W OF DIXIE HWY	63174	XX			00.00	18.49	18.49
	(continued)	63172	XX			00.00	13.50	13.50
		63173	XX			00.00	02.83	02.83
	1.0 MILE W OF DIXIE HWY	63173		XX		02.83	14.56	11.73
	TO BALDWIN RD (S OF	25131		XX		00.00	01.60	01.60
	GRAND BLANC)							
	BALDWIN RD TO 0.5 MILE	25131	XX			01.60	08.80	07.20
	N OF STANLEY RD	25031	XX			12.17	15.12	02.08
		25032	XX			00.00	08.81	08.81
	0.5 MILE N OF STANLEY RD	25032		XX		08.81	16.43	07.62
	TO DIXIE HWY	73171		XX		00.00	10.50	10.50
	DIXIE HWY TO WILDER RD	73111	XX			00.00	09.33	09.33
		73112	XX			00.00	01.70	01.70
		73112		XX		01.70	03.78	02.08
		09034		XX		00.00	02.62	02.62
		09034	XX			02.62	05.12	02.50
		09035	XX			00.00	02.07	02.07
	WILDER RD TO SAULT STE	09035		XX		02.07	23.16	21.09
	MARIE/PORT OF ENTRY	06111		XX		00.00	19.46	19.46
	(EXCEPT MACKINAC BRIDGE)	65041		XX		00.00	15.29	15.29
		72061		XX		00.00	23.65	23.65
		20052		XX		00.00	05.90	05.90
		20014		XX		00.00	04.98	04.98
		20015		XX		00.00	14.24	14.24
		69013		XX		00.00	12.61	12.61
		69014		XX		00.00	13.11	13.11
		16093		XX		00.00	15.09	15.09
		16091		XX		00.00	12.37	12.37
		24071		XX		00.00	01.69	01.69
	(MACKINAC BRIDGE)	86000						04.37
		49025		XX		00.00	25.00	25.00
		17033		XX		00.00	17.58	17.58
		17034		XX		00.00	09.24	09.24
I-94	(STATE LINE TO PORT HURON/BLUE WATER BRIDGE)							
	STATE LINE TO STEVENS-	11014		XX		00.00	03.53	03.53
	VILLE SCL (1300 FT S OF	11015		XX		00.00	17.71	17.71
	JOHN BEERS RD)							
	STEVENSVILLE SCL TO	11015	XX			17.71	23.43	05.72
	TERRITORIAL RD	11016	XX			00.00	04.15	04.15
		11016			XX	04.15	05.35	01.20
		11016	XX			05.35	06.11	00.76
	TERRITORIAL RD TO 8TH ST	11016		XX		06.11	07.22	01.11
	(0.5 MILE W OF 9TH ST)	11017		XX		00.00	06.60	06.60
		11018		XX		00.00	02.04	02.04
		80023		XX		00.00	13.47	13.47
		80024		XX		00.00	10.55	10.55
		39024		XX		00.00	04.26	04.26

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	8TH ST (0.5 MILE W OF	39024	XX			04.26	09.29	05.03
	9TH ST) TO 31ST ST (2.0	39022	XX			00.00	07.01	07.01
	MILES W OF 35TH ST)							
	31ST ST TO KALAMAZOO	39022		XX		07.01	11.50	04.49
	CO LINE	39025		XX		00.00	04.36	04.36
	KALAMAZOO CO LINE	13081	XX			00.00	06.30	06.30
	TO BEADLE LAKE RD	13082	XX			00.00	01.45	01.45
	BEADLE LAKE RD TO	13082		XX		01.45	11.60	10.15
	BLACKMAN RD	13083		XX		00.00	13.51	13.51
		38102		XX		00.00	05.04	05.04
		38101		XX		00.00	07.32	07.32
	BLACKMAN RD TO 0.25	38101	XX			07.32	15.76	08.44
	MILE E OF SARGENT RD	38103	XX			00.00	00.75	00.75
	0.25 MILE E OF SARGENT	38103		XX		00.75	09.87	09.12
	RD TO BAKER RD	81104		XX		00.00	13.18	13.18
	BAKER RD TO 24 MILE RD	81104	XX			13.18	18.29	05.11
	(MACOMB CO)	81062	XX			00.00	09.13	09.13
		81063	XX			00.00	03.50	03.50
		81041	XX			00.00	02.30	02.30
		82021	XX			00.00	06.13	06.13
		82022	XX			00.00	16.60	16.60
		82023	XX			00.00	04.94	04.94
		82024	XX			00.00	04.02	04.02
		82025	XX			00.00	06.69	06.69
		50111	XX			00.00	17.77	17.77
		50112	XX			00.00	01.50	01.50
	24 MILE RD TO 1.0 MILE	50112		XX		01.50	06.16	04.66
	S OF M-25 (GRATIOT BLVD)	77111		XX		00.00	15.70	15.70
	1.0 MILE S OF M-25	77111	XX			15.70	25.82	10.12
	(GRATIOT BLVD) TO BLUE							
	WATER BRIDGE							
I-96 (MUSKEGON TO DETROIT)								
	US-31 TO ELLIS RD	61152	XX			00.00	01.00	01.00
	ELLIS RD TO M-11	61152		XX		01.00	05.45	04.45
	(REMEMBRANCE RD)	70064		XX		00.00	03.87	03.87
		70063		XX		00.00	14.25	14.25
	M-11 (REMEMBRANCE RD)	70063	XX			14.25	15.64	01.38
	TO WHITNEYVILLE RD	41026	XX			00.00	06.43	06.43
		41025	XX			00.00	11.54	11.54
		41024	XX			00.00	04.70	04.70
	WHITNEYVILLE RD TO BL-96	41024		XX		04.70	12.43	07.73
	(GRAND RIVER)	34043		XX		00.00	12.02	12.03
		34044		XX		00.00	13.54	13.54
		19022		XX		00.00	09.09	09.09

RTE	LOCATION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	BL-96 (GRAND RIVER) TO	19022	XX			09.09	10.16	01.07
	COLLEGE RD	23152	XX			00.00	06.75	06.75
		23151	XX			00.00	02.86	02.86
		33083	XX			00.00	03.69	03.69
		33084	XX			00.00	02.73	02.73
	COLLEGE RD TO 1.0 MILE	33084		XX		02.73	17.58	14.85
	W OF WIXOM	33085		XX		00.00	02.68	02.68
		47066		XX		00.00	08.76	08.76
		47065		XX		00.00	14.33	14.33
		47064		XX		00.00	04.48	04.48
		63022		XX		00.00	06.18	06.18
	1.0 MILE W OF WIXOM RD	63022	XX			06.18	19.24	13.06
	TO END (I-75)	82125	XX			00.00	03.21	03.21
		82122	XX			00.00	11.67	11.67
		82123	XX			00.00	07.83	07.83
		82124	XX			00.00	01.97	01.97
I-194	BATTLE CREEK AREA	13033	XX			00.00	03.37	03.37
I-196	(FROM I-94 THRU GRAND RAPIDS TO I-96)							
	I-94 TO 40TH AVE.	11111		XX		00.00	07.93	07.93
		80012		XX		00.00	09.66	09.66
		80013		XX		00.00	03.88	03.88
		03033		XX		00.00	12.46	12.46
		03034		XX		00.00	10.45	10.45
		03035		XX		00.00	06.71	06.71
		70024		XX		00.00	10.10	10.10
	40TH AVE (1.0 MILE W	70024	XX			10.10	12.20	02.10
	OF 32ND) TO I-96	70024			XX	12.20	15.68	03.48
		41029	XX			00.00	09.69	09.69
		41027	XX			00.00	04.21	04.21
I-275	FROM I-75 TO I-96							
	I-75 TO PENNSYLVANIA RD	58171		XX		00.00	07.88	07.88
		82291		XX		00.00	06.00	06.00
	PENNSYLVANIA RD TO I-96	82291	XX			06.00	10.32	04.32
		82292	XX			00.00	07.46	07.46
		82293	XX			00.00	04.63	04.63
I-296	GRAND RAPIDS AREA	41131	XX			14.61	17.93	03.32
		41132	XX			00.00	00.86	00.86
I-375	DETROIT AREA	82111	XX			03.45	04.00	00.55
I-475	FLINT AREA	25132	XX			00.00	16.89	16.89
I-496	LANSING AREA	23081	XX			00.00	03.37	03.37
		33044	XX			00.00	02.88	02.88
		33045	XX			00.00	05.54	05.54

RTE	LOCATION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
I-675	SAGINAW AREA	73101	XX			00.00	07.33	07.33
		73101			XX	07.33	07.80	00.47
I-696	DETROIT AREA	63101	XX			00.00	08.33	08.33
		63102	XX			00.00	01.08	01.08
		63103	XX			00.00	01.95	01.95
		50062	XX			00.00	02.71	02.71

STATEWIDE TOTALS BY ROUTE

RTE NO.	URBAN 55MPH	RURAL 65MPH	RURAL 55MPH	TOTAL MILES
I-69	36.62	139.47	00.00	177.09
I-75	102.99	272.67	00.00	375.66
I-94	127.42	146.80	01.20	275.42
I-96	79.89	116.24	00.00	196.13
I-194	03.37	00.00	00.00	03.37
I-196	16.00	61.19	03.48	80.67
I-275	16.14	13.88	00.00	30.02
I-296	04.18	00.00	00.00	04.18
I-375	00.55	00.00	00.00	00.55
I-475	16.89	00.00	00.00	16.89
I-496	11.79	00.00	00.00	11.79
I-675	07.33	00.00	00.47	07.80
I-696	20.44	00.00	00.00	20.44
STWD	443.61	751.25	05.15	1,200.01

Appendix C

Time Series Charts[1]

[1]The designation "65 mph" on these charts indicates road segments that changed from 55 to 65 mph speed limit in November 1987 and January 1988. These segments all had a 55 mph limit over the 1978 through 1986 period.

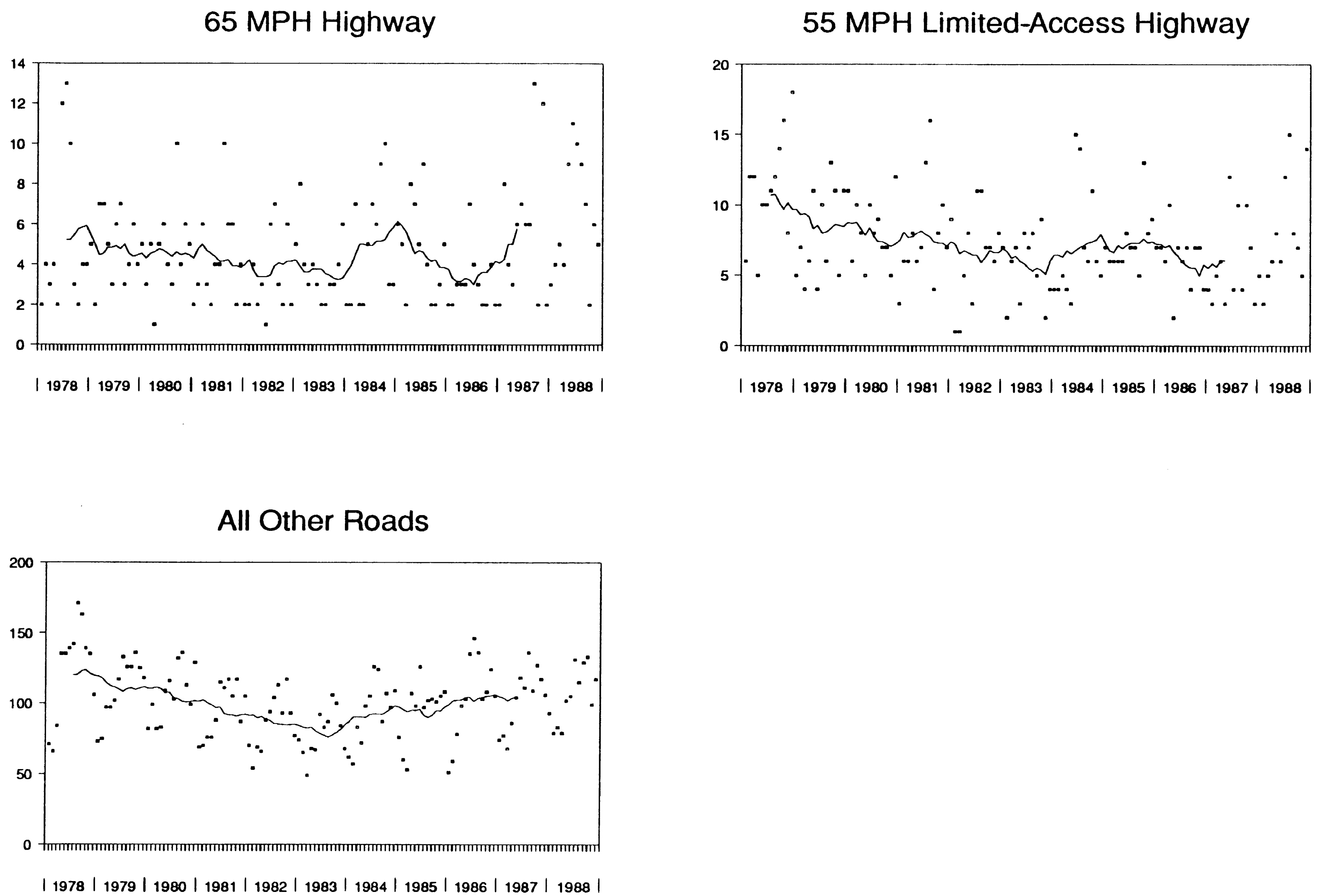

Figure C.1: Fatalaties by Highway Type

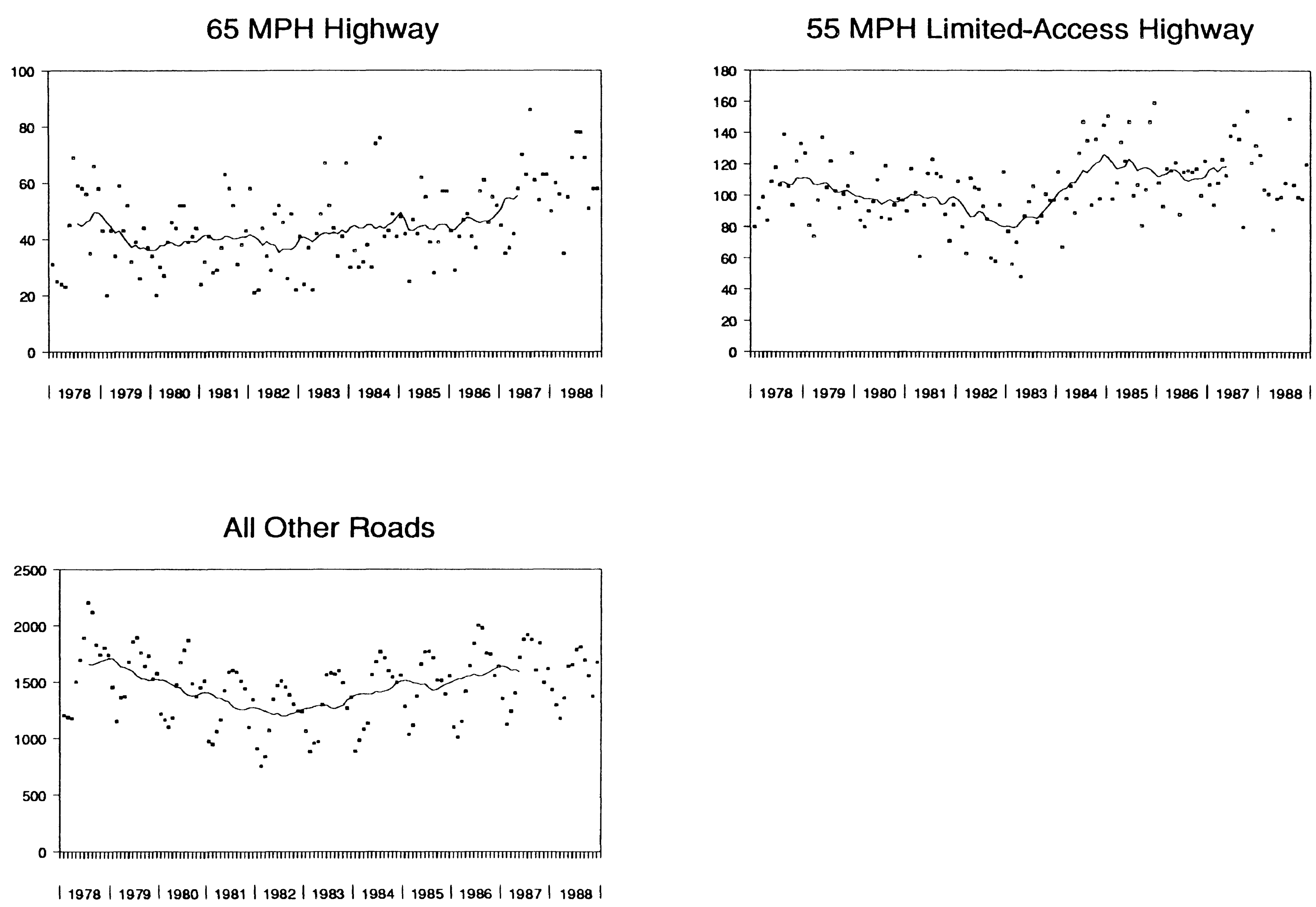

Figure C.2: A-level Injuries by Highway Type

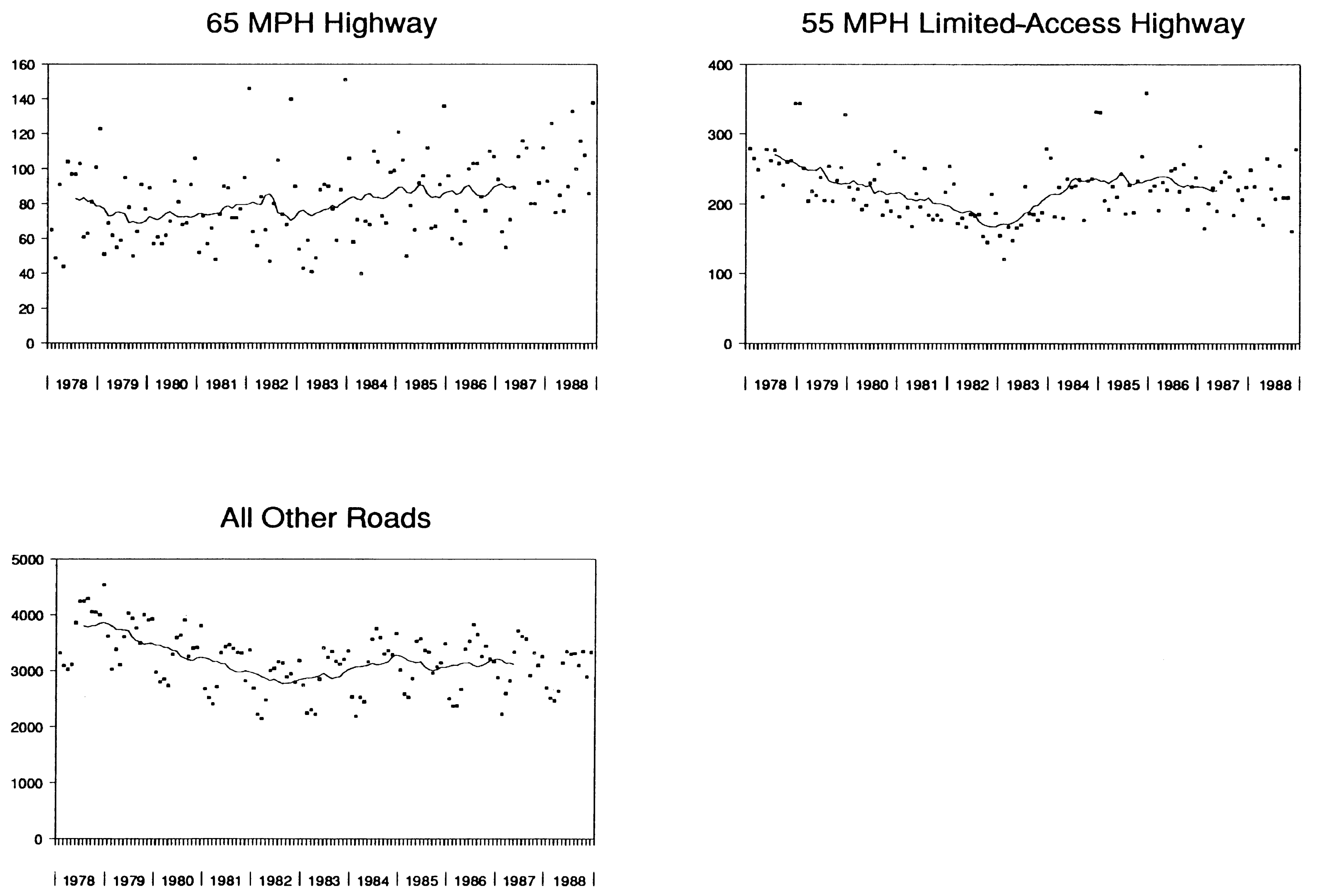

Figure C.3: B-level Injuries by Highway Type

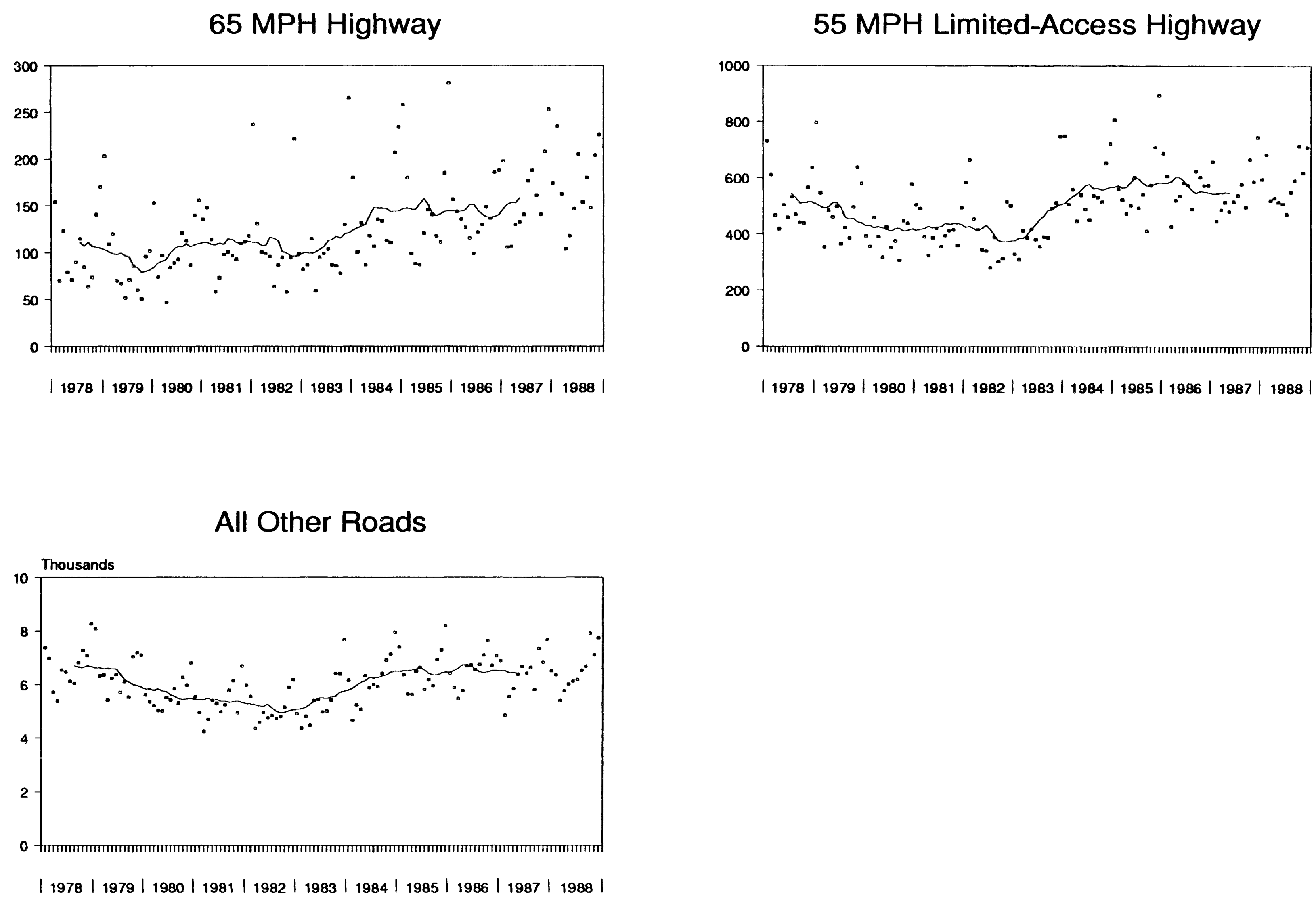

Figure C.4: C-level Injuries by Highway Type

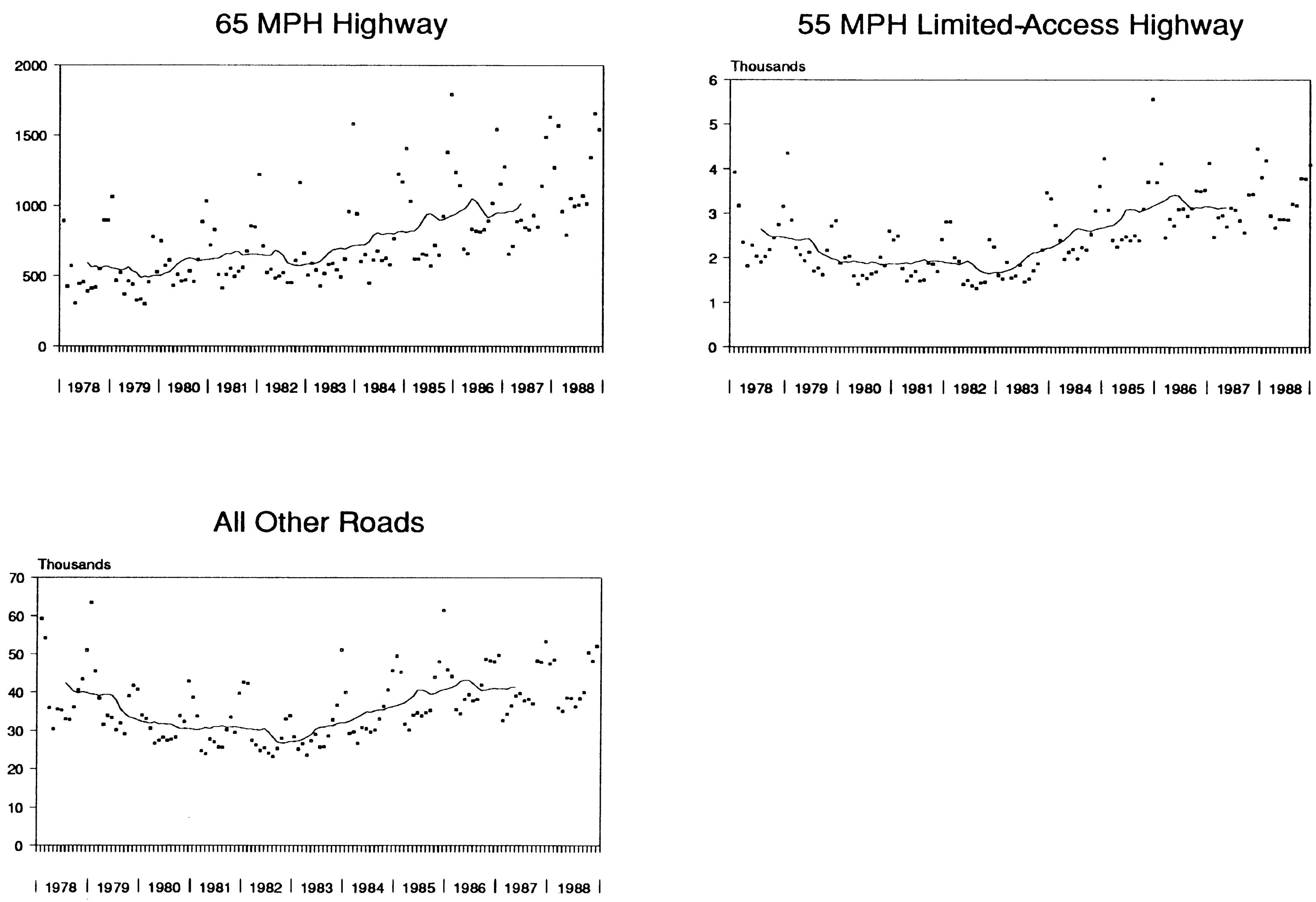

Figure C.5: Property Damage Only Crashes by Highway Type

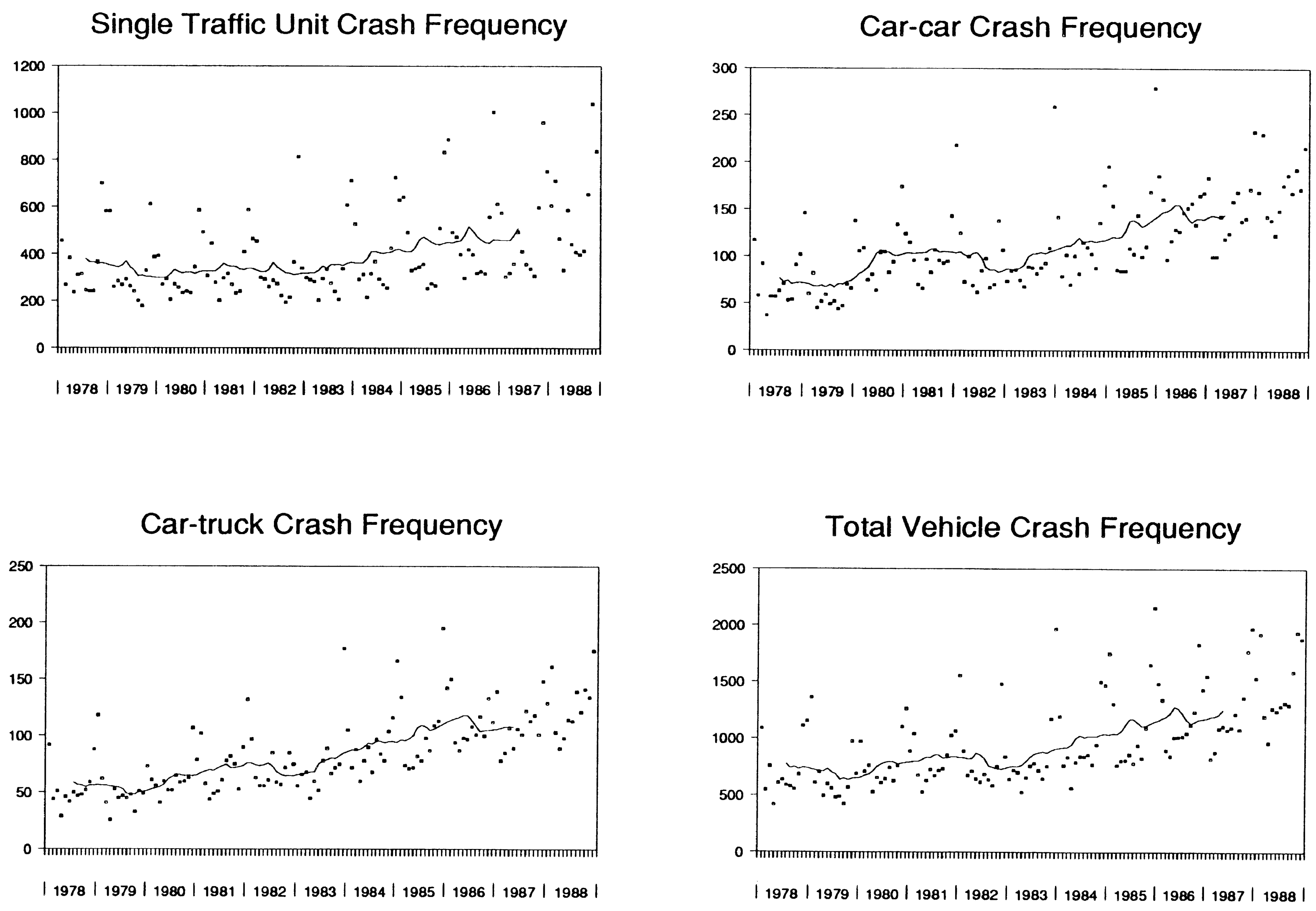

Figure C.6: Crashes on 65 MPH Highways by Vehicle Type

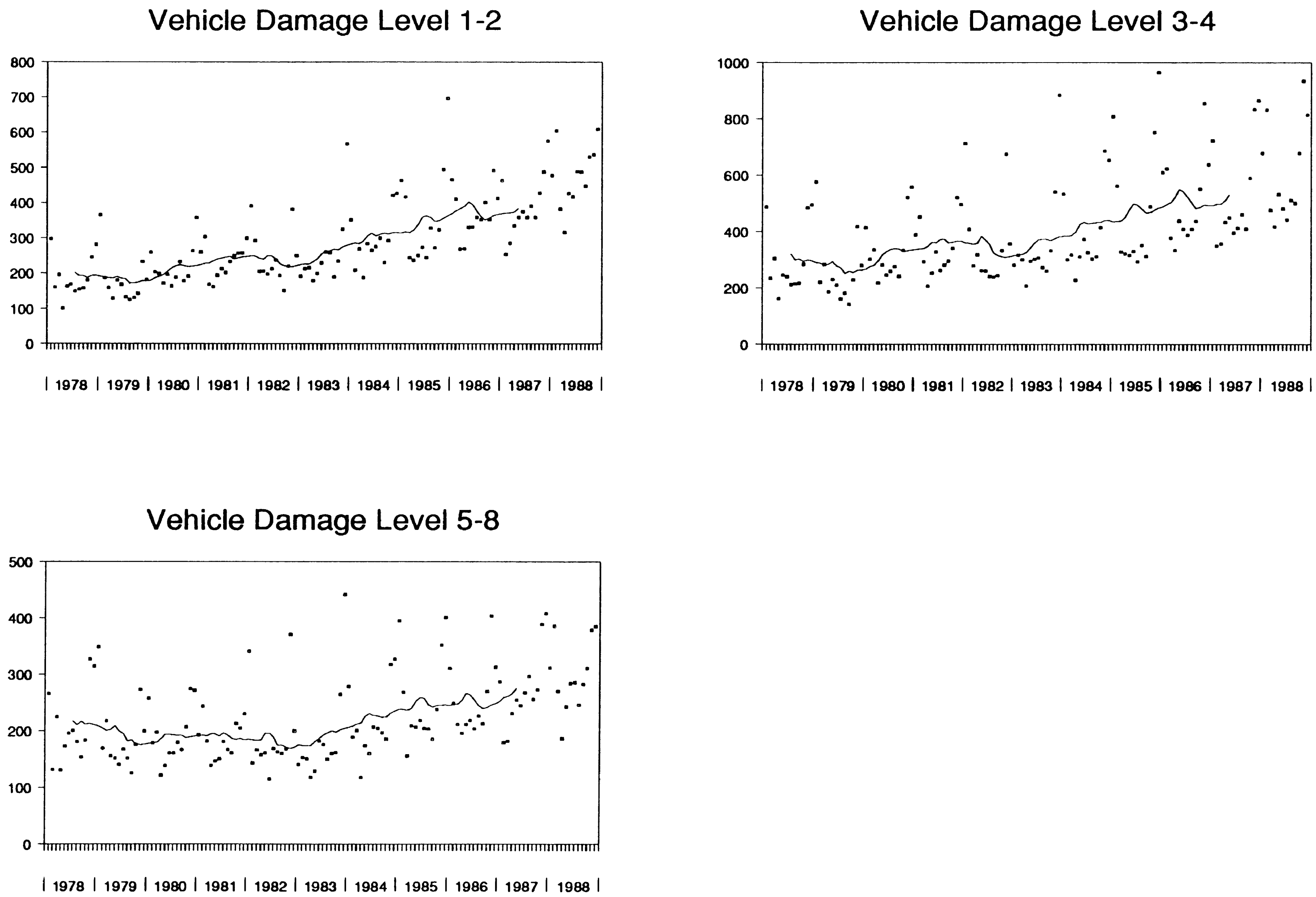

Figure C.7: Crashes on 65 MPH Highways by Vehicle Damage Level

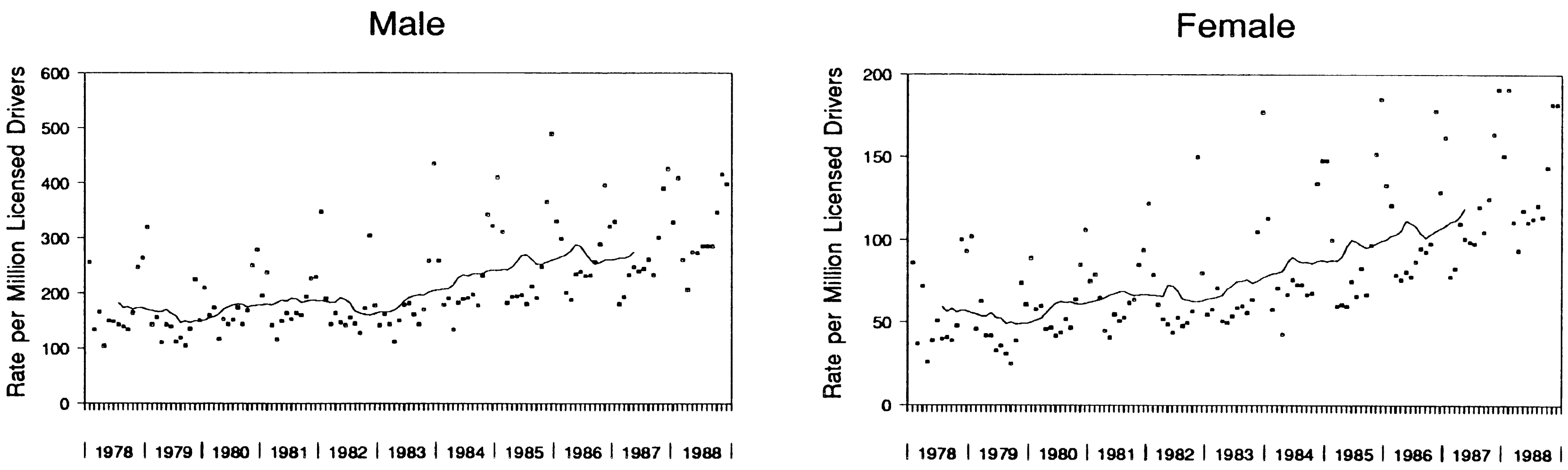

Figure C.8: Rate of Crashes on 65 mph Highways per Million Licensed Drivers, by Gender

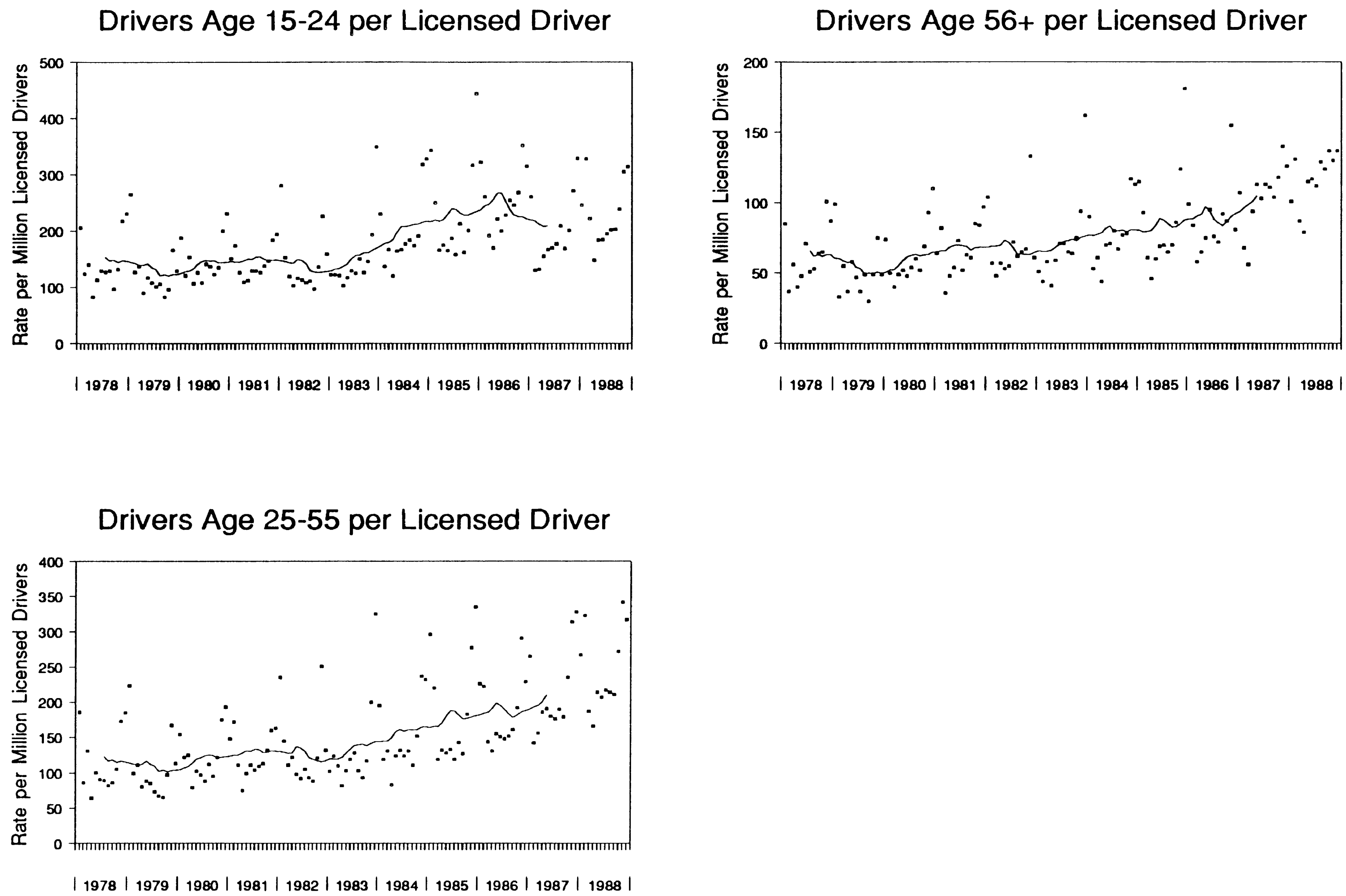

Figure C.9: Rate of Crashes on 65 mph Highways per Million Licensed Drivers, by Age

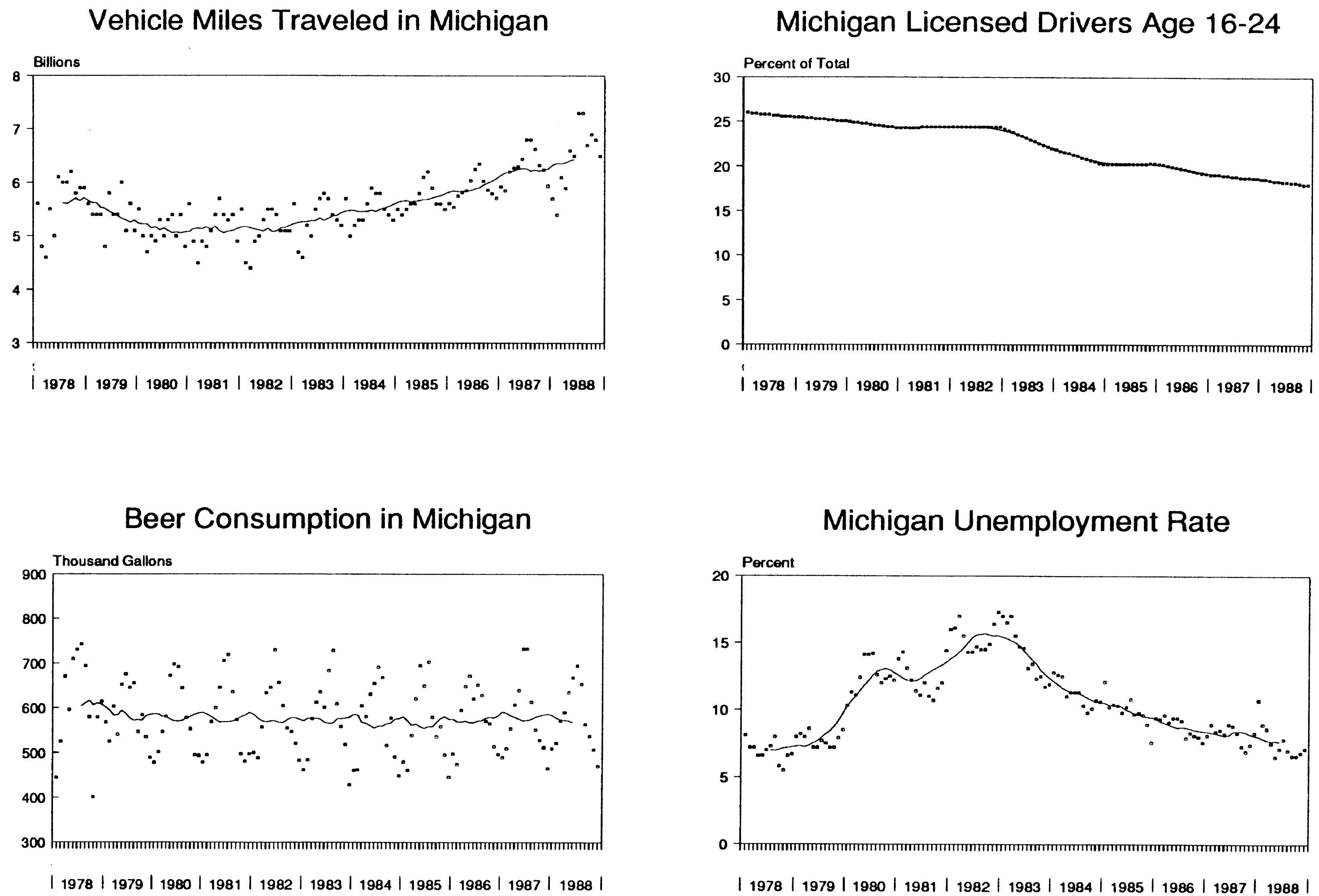

Figure C.10: Covariates Used in Time-series Models