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THE EFFECTIVENESS OF THE 55 MPH NATIONAL MAXIMUM SPEED LIMIT AS A LIFE SAVING BENEFIT

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Prepared by:

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16. Abstract

The following report contains an analysis of the life saving benefits resulting from the 55 mph NMSL from 1974-1979. Monthly fatality data from 1970-1979 was used in a time series model to arrive at the estimated safety benefits (lives saved). The time series model relates changes in monthly fatalities to changes in monthly vehicle miles traveled, introduction of safety improvements and the implementation of the 55 mph NMSL law. Increases in highway fatalities in 1976-1979 compared to the 1974-1975 level led to a detailed examination and analysis of the composition of these fatalities in order to determine possible causes for the increases. Based upon the available data, it was concluded that 55 mph compliance had eroded somewhat in 1977 and 1978 thus resulting in some fatality increases. The statistical time series model estimated annual life saving benefits as follows:

	LIVES SAVED
1974	7,532
1975	7,532
1976	7,216
1977	6,794
1978	6,423
1979	6,454
TOTAL	41,951

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METRIC CONVERSION FACTORS

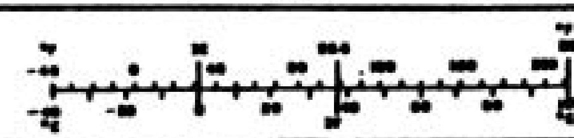
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Sy
		LENGTH		
mm	millimeters	0.04	inches	
cm	centimeters	0.4	inches	
m	meters	3.3	feet	
m	meters	1.1	yards	
km	kilometers	0.6	miles	
		AREA		
cm^2	square centimeters	0.16	square inches	
m^2	square meters	1.2	square yards	
km^2	square kilometers	0.4	square miles	
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	
kg	kilograms	2.2	pounds	
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	



SUMMARY

A great many reasons have been put forth in attempting to explain the dramatic reduction in highway fatalities observed to have begun in January 1974, the official date of the imposition of the 55 mph National Maximum Speed Limit (NMSL). The traffic safety literature contains a wide range of conflicting views as to the causal factors and magnitudes of these reductions in highway fatalities. These views range from the entire reduction to half of the reduction in highway fatalities being attributable to the lower speeds. A recent National Safety Council report 1/ claims that "reduced speeds still are a major factor in keeping down the death total, accounting for 44 percent of the difference between actual and expected totals for 1977. In numerical terms, there would have been 5,550 additional deaths in 1977, if there had been no 55 mph laws, and consequently no reduced speeds."

The following report contains an analysis of the life saving benefits resulting from the 55 mph NMSL from 1974-1979. Monthly fatality data from 1970-1979 was used in a time series model to arrive at the estimated safety benefits (lives saved). The time series model relates changes in monthly fatalities to changes in monthly vehicle miles traveled, introduction of safety improvements and the implementation of the 55 mph NMSL law.

Increases in highway fatalities in 1976-1979 compared to the 1974-1975 level led to a detailed examination and analysis of the composition of these fatalities in order to determine possible causes for the increases. Based upon the available data, it was concluded that 55 mph compliance had eroded somewhat in 1977 and 1978 thus resulting in some fatality increases.

The statistical time series model estimated annual life saving benefits as follows:

	LIVES SAVED
1974	7,532
1975	7,532
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TOTAL	41,951

THE EFFECTIVENESS OF THE 55 MPH NATIONAL MAXIMUM SPEED LIMIT AS A LIFE SAVING BENEFIT

Introduction

Six years have elapsed since the passage of the 55 mph NMSL. A large number of studies regarding both the fuel saving and safety benefits of this law have been published. A review of the traffic safety literature reveals (1) a great variation in the estimated safety benefits of the 55 mph NMSL, and (2) a lack of national level evaluations covering the total period since implementation.

The National Highway Traffic Safety Administration (NHTSA) strongly supports the 55 mph NMSL and believes that it is one of the most effective countermeasures to have been used in reducing highway fatalities. In a memorandum by Joan Claybrook, NHTSA Administrator, dated July 6, 1977, life savings resulting from the 55 mph NMSL were estimated to be between 4,000 and 5,000 per year based upon analyses up to that time. In October 1979, an NHTSA/FHWA Task Force was established to review all previous studies of the safety benefits of the 55 mph NMSL and develop a technical report indicating a consensus of the safety benefits. Due to the lack of valid updated studies, and differences of opinion among task force members, only a survey report containing a range of life saving estimates was released. It is strongly felt by the authors of this paper, that the safety benefits of the 55 mph NMSL have been underestimated and it is the purpose of this paper to present the authors' views and conclusions.

The Nature of Speed

Any analysis of the effectiveness of a national speed reduction program such as the 55 mph NMSL should be accompanied by a discussion of the nature of speed and why one should expect reductions in fatalities and serious injuries resulting from a reduction in speed.

The traffic safety literature is replete with statistical analyses of the effect of speed and speed changes on accidents and injuries. A most widely cited study conducted by Solomon 2/ indicates that:

- o Accident severity increased as speed increased, especially at speeds exceeding 60 mph.
- o The fatality rate was highest at very high speeds and lowest at about the average speed.
- o The accident involvement rate and the injury and property damage rates were highest at very low speeds, lowest at about the average speed of all traffic and increased at the very high speeds, particularly at night. Thus, the greater the variation in speed of any vehicle from the average speed of all traffic, the greater its chances of being involved in an accident.

One can conclude that as speed increases from the average speed, accident involvement rates and severity of injuries increase. Why does this occur? What factors in the speed/safety relationship cause these events to take place? The simplest element of the speed/safety relationship which can be isolated is the concept of the dissipation of kinetic energy resulting from an accident. Energy is calculated using the vehicle mass, a constant and the speed of the vehicle, a variable under the control of the driver. Wadsworth 3/ defines a motor vehicle accident as an unwanted rate of exchange of kinetic energy given by the following formula:

$$\textbf{Kinetic Energy} = \tfrac{1}{2}\,\textbf{Mass} \times (\textbf{Velocity})^2$$

Any increase in speed (velocity) increases the kinetic energy to be dissipated by the square of that velocity rather than the velocity itself. For example, a 20 percent increase in speed from 50 to 60 mph will result in a 44 percent increase in kinetic energy to be dissipated, thereby increasing the severity of accidents and associated injuries.

For any given instant of time, traffic flow on a segment of road can be described by at least two important statistical measures: the mean or average speed and variation in speed, usually expressed by the standard deviation of the speed distribution. Solomon showed empirically that the greater the variation in speed from the average speed of all traffic, the greater the chance of being involved in an accident, hence a higher accident involvement rate. R. Michaels 4/ showed that both accident involvement rates as well as injury and fatality rates vary directly with changes in the standard deviation of travel speeds. As one approaches the average speed, the accident involvement rates are minimized.

E. Hauer 5/ concluded that there is a very strong correlation between Solomon's involvement rate curves and the number of passive and active overtakings by passing and passed vehicles. Based upon a mathematical formulation, he concludes that the number of overtakings is minimal when vehicles travel at the median speed*. As a vehicle departs from the median speed in either direction, it is either overtaken by or it overtakes other vehicles. The greater the departure, the greater the number of overtakings. The most important consideration however, is that overtakings vary directly with the magnitude of the deviations from the median speed, which in turn leads to vehicle conflicts resulting in increased accident involvement rates.

Empirically, there is very strong evidence that as the average speed decreases, a corresponding decrease in the standard deviation is noted. In an analysis conducted by Cerelli 6/, a reduction in the standard deviation of vehicle speeds was noted on all major rural highway systems after the 55 mph NMSL was imposed. This was accomplished by greatly reducing the number of vehicles traveling at higher speeds thereby compressing speeds toward a lower average speed. Although there is no analytic or theoretical basis for predicting the reduction in speed variation resulting from a reduction in average speed,

* The median speed is defined as that speed at which half of the drivers are traveling above and half are traveling below.

it can be shown empirically that the resulting compression of higher speeds results in a smaller standard deviation and hence less dispersion among the individual vehicle speeds. Less speed variation in turn results in a smaller number of overtakings which decreases the probabilities of crash involvement.

In summary, based upon the evidence, it can be argued that lower, uniform speeds, acceptable to the public and properly enforced, produce lower accident involvement rates. In addition, lower speeds also result in less severe injuries in the event of an accident.

A National Experiment

Since the imposition of the 55 mph NMSL, the motor vehicle driving public has had six years to modify its driving behavior in keeping with the letter or spirit of the 55 mph NMSL. If any modification of this behavior has taken place, it should be evident in the accident statistics collected during this time frame. Based upon the previous speed discussion, one should expect to observe national reductions in accidents, fatalities and injuries on those roads affected by the 55 mph NMSL, along with reductions in speed.

One can view this as a simple pre/post experiment comparing accident statistics before and after the imposition of the law for significant changes in accident levels. However, many events took place during the six year period which precludes one from performing a simplistic analysis of speed reduction effectiveness. Specifically, highway, vehicle and driver improvements are continually being introduced in small increments and must be accounted for. Sufficiently large changes in the amount of travel as measured by vehicle miles traveled (VMT) have taken place over the period to be considered an important factor. From 1970-1979, VMT increased over 33.5% (from 11,181 to 14,931 hundred million miles). From 1976 on, over half of the States repealed their mandatory motorcycle helmet laws resulting in a decrease in helmet use and an increase in the frequency of fatal head injuries 7/. The mix of vehicle size has been steadily changing from the larger full size cars down to the compact and sub-compact sizes thereby increasing the potential for increased severity of injury. Smaller cars offer less protection in that the kinetic energy dissipation takes place over a smaller surface. Therefore, greater collapse and higher injury severity can be expected. Also, some analysts claim that the recession of 1975 has had significant impact in reducing fatalities during this period 8/. In addition to these confounding factors, accident data is not available for 55 mph versus non-55 mph roads during the pre and post evaluation periods.

Evaluation Approach

A statistical approach using time series analysis 9/ was selected to derive an impact estimate of the 55 mph NMSL as a life saving benefit. The period covered is the 1970 through 1979 time frame using national monthly fatalities as the impact measure. The approach taken is to evaluate the baseline fatality level (non-55 mph period) for 1970 through 1973 and compare it to the 1974 through 1979 fatality level (55 mph period) considering the confounding factors previously mentioned. The ultimate result will be the development of a statistical evaluation model which contains all of the factors considered to significantly affect fatalities for the ten year period 1970 through 1979 to determine the steady state or average change attributable to the 55 mph NMSL. Further detailed analysis will be performed on the 1975 through 1979 data to adjust the steady state change due to the change in the degree of 55 mph noncompliance which may have taken place during this time frame.

The statistical model consists of a mathematical relationship which expresses the degree to which the safety index, vehicle miles traveled (a measure of the volume of travel activity) and the presence of the reduced speed limit, affects monthly fatalities during the nine year period from January 1970 -December 1979. A least squares statistical technique known as Box-Tiao Intervention Analysis 10/ was utilized for the multivariate analysis to minimize the variation between the model and actual data. The mathematical expression known as the transfer function relates the time series VMT, speed, and safety index to fatalities.

One of the problems associated with the analysis of time series accident data (data collected over equal time intervals) is that the data tends to be dependent. This means that each point could be correlated with previous data points. For example, seasonality and trends in the data represent dependence or autocorrelation. In the case of 12-month seasonality, each data point is related to a data point occurring 12 months previously. High and low accident volumes occur during various months of the year, which cause a seasonal pattern. Trends also represent dependence and autocorrelation in that the data points in an upward trend for each month are generally numerically larger than the previous month. Therefore, each month's accidents can be expressed as a function of the previous month's accidents. Data dependence or autocorrelation must be accounted for before any meaningful analysis can be conducted. The Box-Jenkins Time Series Analyses 9/ approach has been used to determine the time series parameters and the transfer function estimates.

This technique is a generalization of the linear regression model:

$$Y_i = b_o + b_1 X_i + e_i$$

where the basic assumption that the covariance $(e_i, e_j) = 0$ for $i \neq j$ represents a severe constraint for application to traffic accident data due to factors such as seasonality. The Box-Jenkins technique relies heavily on the autocorrelation function (ACF) for the identification of the correlation (normalized covariance) structure; and permits the parsimonious use of time series parameters to account for this dependence. Parsimony is the practice of using the least possible number of parameters for adequate representation.

Design Approach

An ideal design approach for the evaluation model would produce a measure of the change in the fatal and injury accident levels before vs. after the imposition of the 55 mph NMSL on two sets of roads: those roads whose speed limits were reduced to 55 mph versus those roads whose speed limit remained unchanged, for the period 1970 through 1979. A comparison of the changes in level would then lead one to conclude whether the 55 mph NMSL was an effective life saving countermeasure. Since this design must be treated as a quasi-experimental design, i.e., one in which the sampling units being measured are not selected at random, a multiple time series design is most suited for controlling against all threats to internal validity 11/. In a multiple time series design, two or more time series are examined before and after some intervention point (imposition of the 55 mph NMSL) to determine if a change in trend or a change in the level of fatalities has occurred in the experimental time series without a corresponding change in a comparison series. If so, one can then conclude with some statistical confidence that the change was due to the intervention effect, provided the intervention was the only effect beginning in 1974 and continuing through the entire time period.

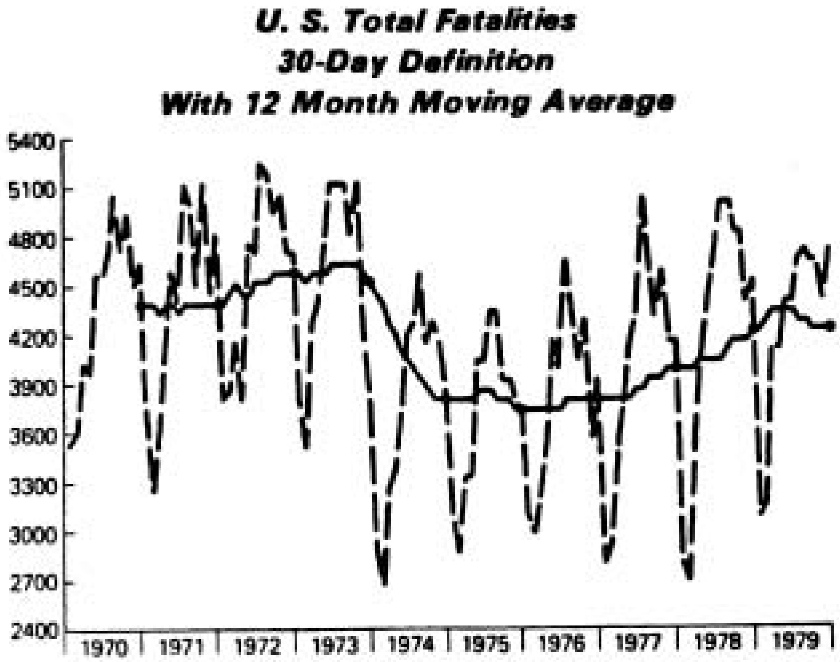
This approach has been successfully applied to the analysis of State fatality data, where the data could be segregated by posted speed limit 12,13/. However, in this case, since fatalities could not be separated by posted speed limit road, total fatalities were used as the impact measure. The assumption is that if any impact resulted from the imposition of the 55 mph NMSL, it would be reflected as a change in the level of fatalities on 55 mph posted roads which are embedded in total fatalities. In addition, due to the lack of monthly injury accident data, it was not possible to measure the effect of the 55 mph NMSL on the injury accident level.

Evolution of the 55 MPH Evaluation Model

In the development of a statistical model, an impact measure is selected which reflects the ultimate measure of the process or system being evaluated. Input measures or explanatory variables are selected which logically affect the impact measure. The statistical analysis generates the relationships between the explanatory variables and the impact measure. The goal is to explain as much of the variation in the impact measure using the least number of logically related explanatory variables.

The purpose of this part of the analysis was to derive an evaluation model which yields an estimate of the life saving benefits attributable to the 55 mph NMSL. The final model should relate fatalities to factors affecting fatalities over time. The first step in the process was to develop a univariate model for fatalities which is based solely on its own past history. The univariate model can only be used to forecast future activity based entirely on the past; it cannot relate the effect of one variable to another. However, the analyst gains a better understanding of the time series characteristics of fatalities from the decomposition of the raw data. Figure 1 is a graph of monthly fatalities with its 12 month moving average.

FIGURE 1



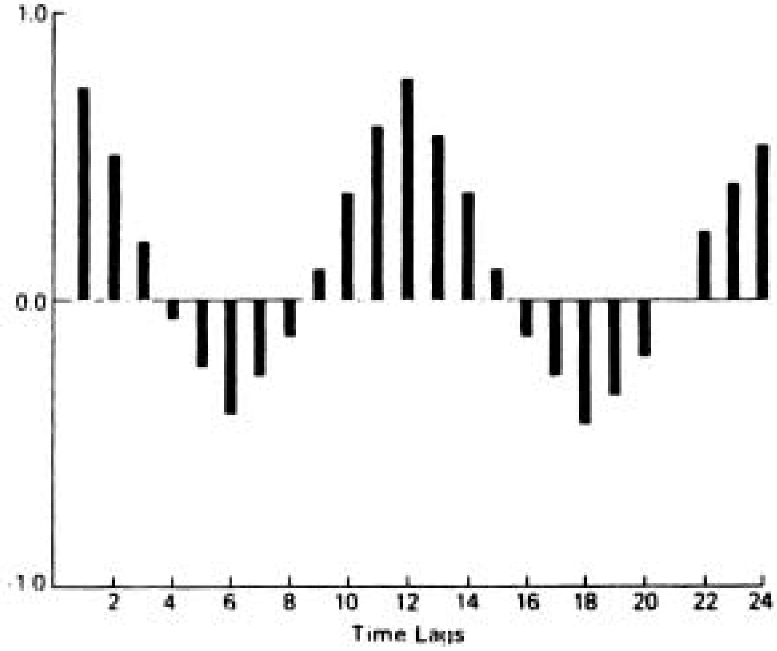
Two observations are immediately evident:

- o The series is dominated by a distinct seasonal pattern (annual cycle), and
- o There was an unusually large drop in fatalities between 1973 and 1974.

In addition, the years 1974-1976 were at approximately the same level, with upward growth during 1977-1978, and a leveling off of fatalities in 1979. Figure 2 is a graph of the autocorrelation function (ACF) of raw fatalities.

FIGURE 2

Graph Of Autocorrelation Function Of Fatalities



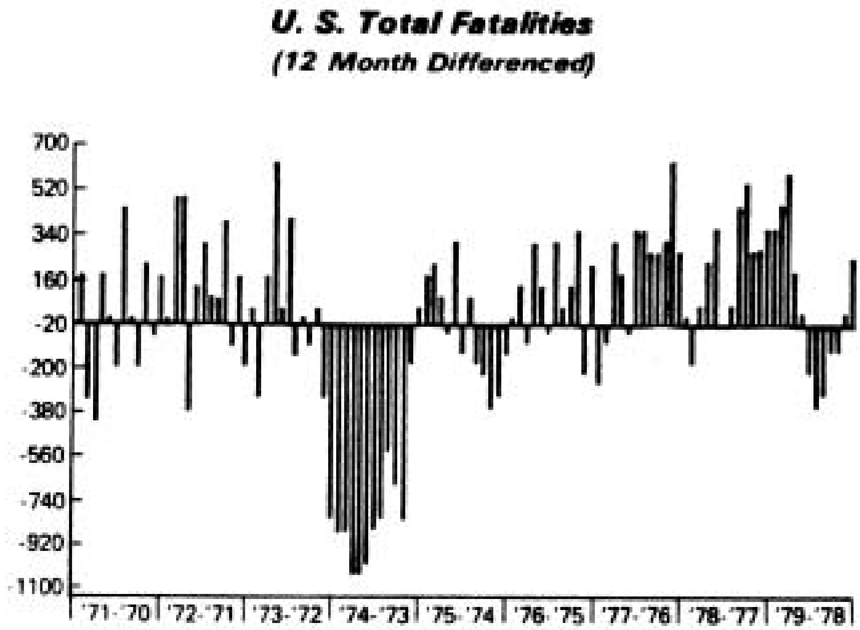
The nondecaying sinusoidal wave pattern, with a period of 12 time lags (months) is characteristic of the seasonal pattern evident in Figure 1. The series is nonstationary* in that there appears to be a sustained high correlation with previous observations at, for example, 12 month intervals (i.e., observations at time period t are correlated with time periods t-12, t-24, t-36, etc.). This nonstationarity was eliminated by performing a 12 month seasonal difference of the fatality data:

$$(1-B^{12})\, Y_t = Y_t - Y_{t-12} \tag{1}$$

producing the series depicted in Figure 3 in deviations from the mean.

* Where the process does not remain in equilibrium about a constant mean level, i.e., having no natural mean. 9/

FIGURE 3

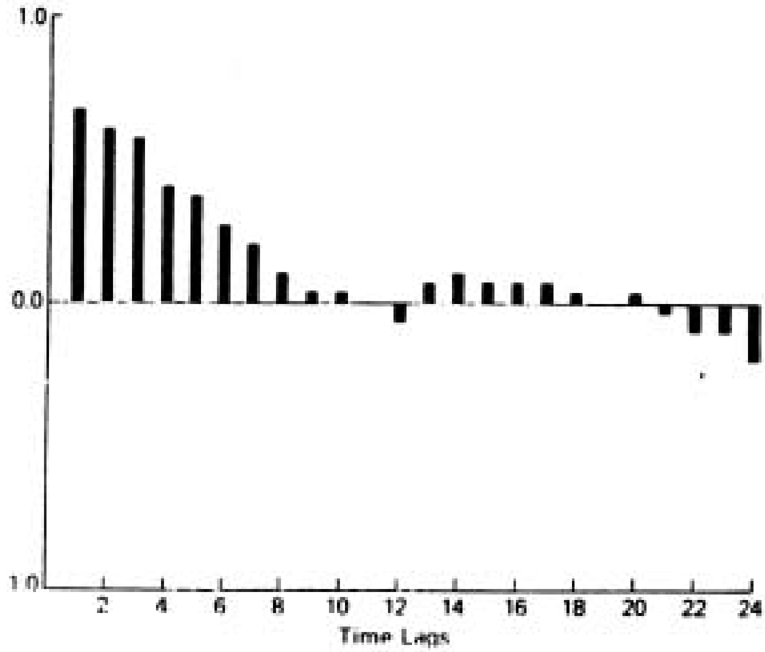


The seasonal pattern has disappeared from the series, as expected (although high correlation still exists at lag 12, but not lags 24, 36, etc.). The large drop in fatalities that occurred between 1973-1974 is manifested as large negative deviations for the differenced data '74-'73.

The leveling off of fatalities during 1975-1976 is evidenced by the next two years of data, and the growth during 1977-1978 is represented by the high concentration of positive deviations during '77-'76 and '78-'77. The autocorrelation function of the seasonally differenced series appears in Figure 4.

FIGURE 4

Graph Of Autocorrelation Function Of $(1-B^{12})Y_t$



This slowly decaying ACF, which indicates a high degree of serial correlation, results mostly from the large negative deviations during '74-'73, and suggests a change in level in this series. This can be accounted for in either one of two ways:

(1) a regular difference of the already seasonally differenced series; or
(2) through the introduction of exogenous (external) variables in the form of a multivariate analysis.

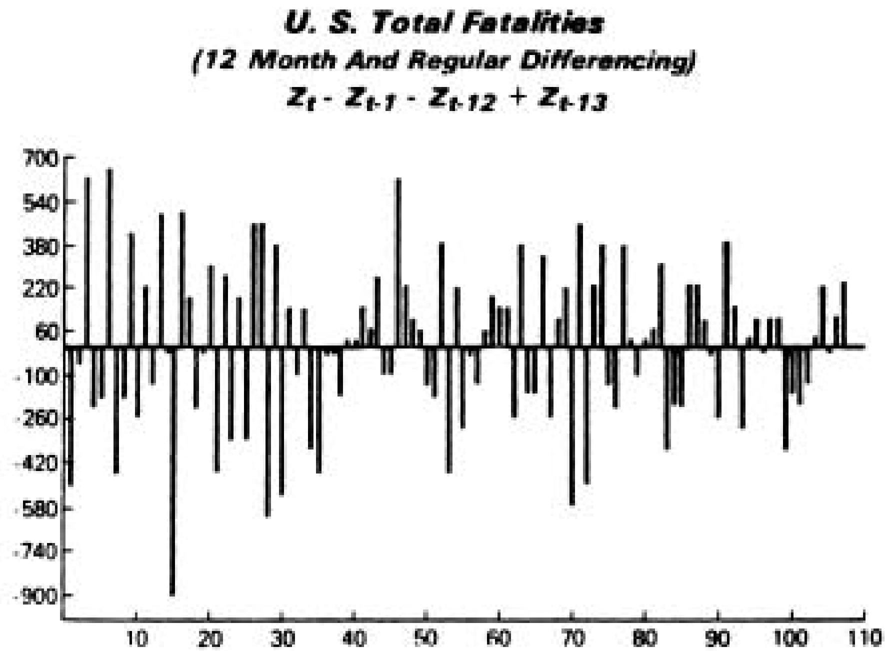
For the univariate analysis, a regular difference

$$(1-B)\ Y_t = Y_t - Y_{t-1}$$

was taken producing the series in Figure 5

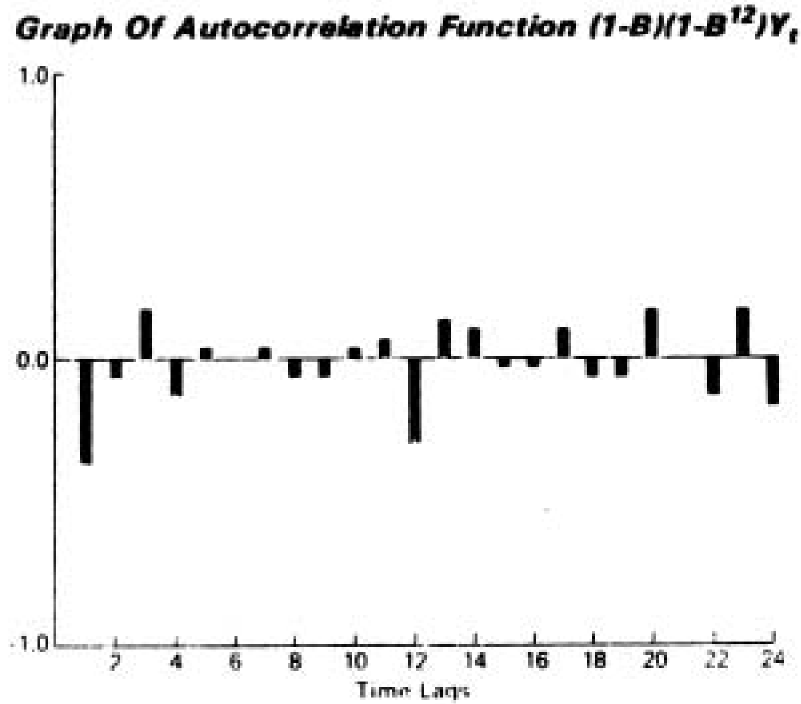
$$(1-B)(1-B^{12})\ Y_t = Y_t - Y_{t-1} - Y_{t-12} + Y_{t-13} \qquad \textbf{(2)}$$

FIGURE 5



The series no longer exhibits concentrations of large negative and positive deviations. Stationarity has been achieved by appropriate differencing, this being supported by the ACF in Figure 6.

FIGURE 6



Significant correlations (spikes) appear at lags 1 and 12, but in general, the ACF is zero elsewhere, with no discernible pattern. At this point, a tentative model was postulated which accounted for the spikes at time periods 1 and 12.

$$(1-B)(1-B^{12})\,Y_t = (1-\theta_1 B)(1-\theta_{12}\,B^{12})\,a_t \tag{3}$$

where θ_i = moving average parameter of order i

a_t = Normally and independently distributed errors NID $(0,\sigma^2)$, referred to as white noise.

Using a least squares procedure, the parameters of the model were estimated as follows:

$$(1-B)(1-B^{12})Y_t = \underset{(.09)}{(1-.46B)}\underset{(.03)}{(1-.86B^{12})}\,a_t \tag{4}$$

The numbers in parentheses below (or above) the equation represent standard errors of the estimate. This convention will be used throughout the paper. Diagnostic checks applied to the residual series revealed no model inadequacies, thus this was the final univariate model for monthly fatalities.

In the next phase of model development, an explanatory variable for the effect of the 55 mph NMSL was introduced as an intervention variable in the form of zeros and ones to represent the absence or presence of the 55 mph NMSL respectively. The purpose of the intervention variable was to detect either a change in trend or a change in level of fatalities occurring from November 1973 through December 1979. The effect of this intervention variable (SPEED) contains the sum total of <u>all</u> of the effects associated with the implementation of the 55 mph NMSL, <u>i.e.</u>, the effect due to enforcement, public information and education, etc., and not solely the effect of posted speed limit signs. The months in which the 55 mph speed limit became effective in each State can be seen in Table 1 <u>14/</u>.

TABLE 1
Months in Which 55-MPH Speed Limit Became Effective in the 50 States

November 1973	December 1973	January 1974
Connecticut	Alaska	Arizona
Delaware	Florida	Arkansas
Hawaii	Maryland	California
Massachusetts	New Hampshire	Idaho
New Jersey	North Carolina	Maine
New York	North Dakota	Nevada
Oregon	Pennsylvania	Texas
Rhode Island	Virginia	Utah
Vermont	West Virginia	Wisconsin
Washington		

February 1974	March 1974
Colorado	Alabama
Georgia	Illinois
Kentucky	Indiana
Louisiana	Iowa
South Carolina	Kansas
	Michigan
	Minnesota
	Mississippi
	Missouri
	Montana
	Nebraska
	New Mexico
	Ohio
	Oklahoma
	South Dakota
	Tennessee
	Wyoming

As can been seen, not all States reduced their maximum speed limits to 55 mph in the same month. Therefore, November 1973 was selected as the first date of intervention nationally. The dummy variable SPEED (X_t) is a step function characterized by:

$$X_t = \begin{cases} 0, & t < \text{November 1973} \\ 1, & t \geq \text{November 1973} \end{cases}$$

Since the ultimate goal of the analysis was to relate the intervention variable X_t, to fatalities and since the fatality series must be seasonally differenced to induce stationarity, the following model was hypothesized:

$$(1 - B^{12})\ Y_t = w_o\ (1 - B^{12})\ X_{t-b} + n_t \tag{5}$$

where: Y_t = fatalities in month t

$(1 - B^{12})$ = seasonal differencing

w_o = impact of 55 mph NMSL

X_t = 55 mph intervention variable

b = delay time before impact is felt

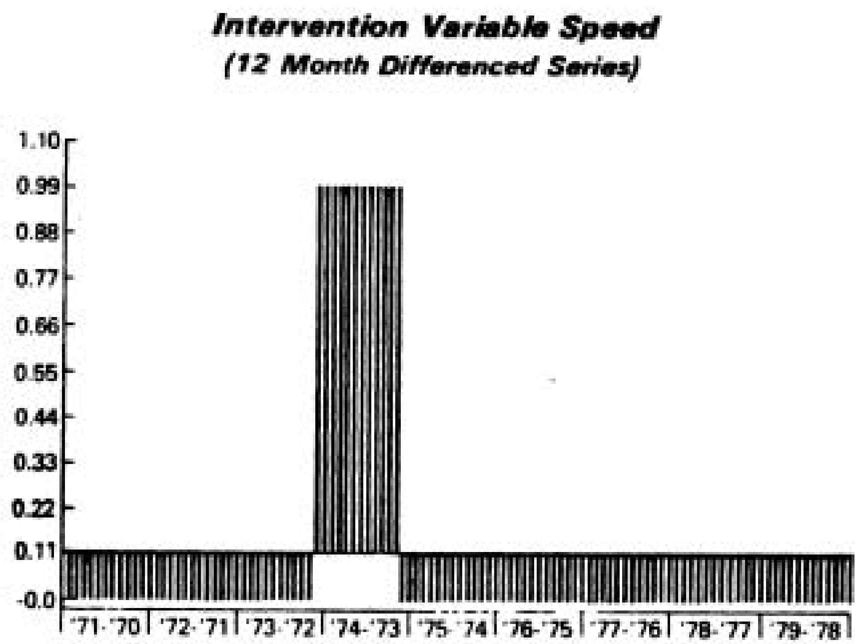
n_t = noise series, of the form used in the univariate model for time series characteristics (ARIMA).

Equation (5) can be rewritten as:

$$Y_t = w_o\ X_{t-b} + N_t; \quad \text{where } (1-B^{12})\ N_t = n_t.$$

Figure 7 is a graph of $(1-B^{12})\ X_t$, expressed in deviations from the mean.

FIGURE 7



A comparison of Figure 7 with Figure 3, $(1-B^{12})\ Y_t$, supports the appropriateness of X_t in explaining at least some of the changes that occurred between 1973-1974. The first step in the model building process is the identification of the form of the transfer function, which encompasses functions with step changes $(v(B) = w(B))$ as well as gradually increasing effects $(v(B) = w(B)/\delta(B))$, accounting for any possible delay time (t-b) between activity and effect. The crosscorrelation function (CCF) is used for transfer function model identification. The CCF exhibited a statistically significant negative spike at lag 0 (November 1973) and nothing elsewhere. The model form hypothesized contained just an w_o term to account for a step change in fatalities. After inspection of the ACF of the noise series $(n_t = Y_t - w_o X_t)$, a tentative model was proposed with the following estimates:

$$Y_t = \underset{(104.65)}{-687.41}\ X_t + \frac{(1+\underset{(.10)}{.44}B+\underset{(.11)}{.33}B^2+\underset{(.10)}{.31}B^3)\ (1-\underset{(.10)}{.50}B^{12})}{(1-B)\ (1-B^{12})}\ a_t \qquad \textbf{(6)}$$

Diagnostic checks of the residuals indicated no model inadequacies. The 55 mph NMSL law is estimated to have forestalled an average of 687.41 fatalities per month between November 1973 - December 1979.

There can be no doubt that equation (6) consisting of one intervention and the noise series is a simplistic representation of fatalities from 1970-1979. However is the model a valid representation of what actually occurred? To answer this question, consider the "process" which generates fatalities. During the period 1970-1973, fatalities were in a state of equilibrium (growing at an average rate of 700 fatalities per year, or 1.33%). In November 1973, the process was "shocked" by some intervention resulting in a change to a new but lower level. During 1974-1976, fatalities remained at this lower level in a state of equilibrium (45,196 -- 44,525 -- 45,523). Therefore, regardless of the factors influencing fatalities, such as increased exposure due to increased vehicle miles traveled and the increase in relative safety, the process was transformed from one state of equilibrium to another, but at a much lower level.

The model represented by equation (6) does not reflect changes in exposure levels as measured by vehicle miles traveled (VMT) nor does it directly account for the effect of the fuel shortage of 1973-1974. Since different regions of the country experienced fuel shortages at different time periods with varying degrees, explicit model representation was considered unlikely. However, it was felt that the introduction of the VMT variable in the model would account for changes in exposure nationally, including the changes resulting from the fuel shortage. VMT data is generated by the States using motor vehicle gasoline revenue and consumption data and then supplied to the Federal Highway Administration (FHWA). Although not all States follow a uniform procedure in deriving these estimates, the data is assumed to be consistent between years.

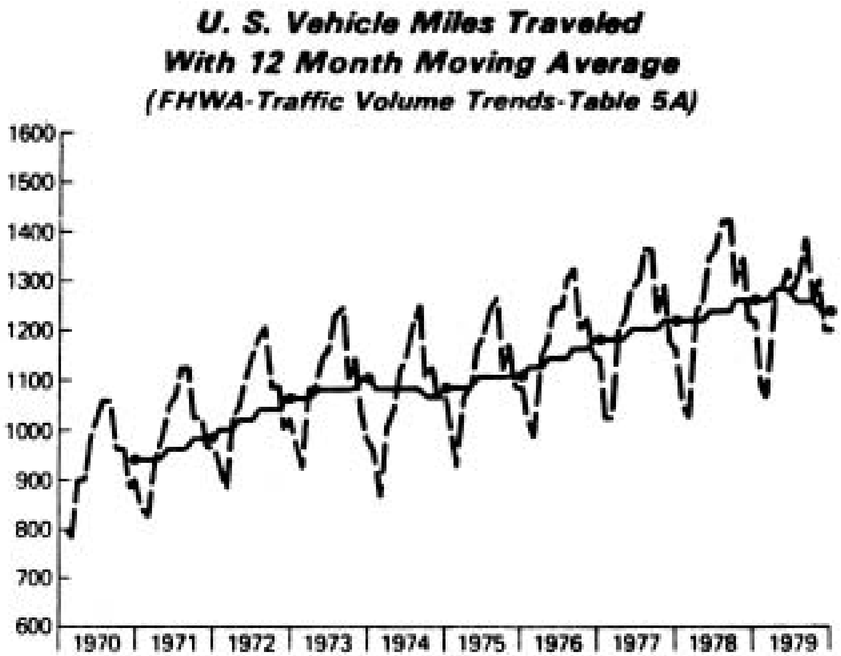
Therefore, in order to account for the fuel shortage and exposure (travel) a new model was hypothesized of the form:

$$Y_t = w_1 V_t + w_2 X_t + n_t \tag{7}$$

where V_t = vehicles miles traveled ($\times 10^8$)

Monthly vehicle miles traveled (VMT) is plotted in Figure 8.

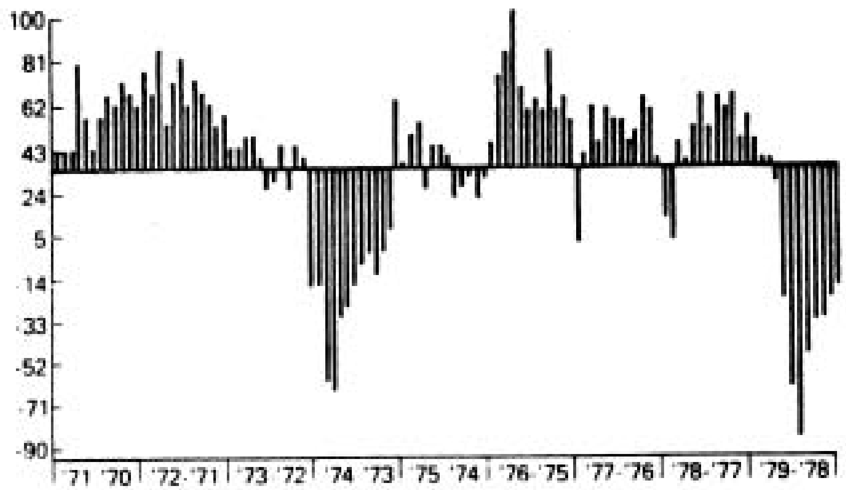
FIGURE 8



With the exception of 1974 and 1979, the series is increasing over time. Inspection of the autocorrelation function (ACF) suggested the need for a seasonal (12 month) difference as depicted in Figure 9.

FIGURE 9

U. S. Total VMT
(12 Month Differenced Series)



The large negative deviations occurring during the differenced periods of 1974 and 1979 indicate the reductions in travel during these years. An August 1975 NHTSA Technical Report 6/ makes the following observations on the change in VMT during 1973-1974.

TABLE 2

PERCENT CHANGE IN INDIVIDUAL MONTHLY TRAVEL 1974 vs. 1973

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
ıin Rural	-6.6	-9.6	-9.0	-5.7	-3.6	-3.2	-1.5	-1.4	-2.7	-1.4	-2.9	6.9
›cal Rural	-3.8	-5.1	-4.0	-2.4	-1.3	-1.4	-0.1	-1.0	-0.8	0.6	-1.0	4.2
·ban	-2.9	-8.4	-7.7	-4.2	-2.9	-2.4	-1.0	0.8	-1.3	-1.1	-0.6	4.4
׀l Systems	-4.2	-8.5	-7.7	-4.5	-3.0	-2.6	-1.1	-1.1	-1.8	-1.0	-1.4	5.2

PERCENT CHANGE IN CUMULATIVE MONTHLY TRAVEL 1974 vs. 1973

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Main Rural	-6.6	-8.1	-8.4	-7.7	-6.7	-6.0	-5.3	-4.7	-4.5	-4.2	-4.1	-3.3
Local Rural	-3.8	-4.4	-4.3	-3.7	-3.2	-2.8	-2.4	-2.2	-2.0	-1.8	-1.7	-1.3
Urban	-2.9	-5.6	-6.3	-5.8	-5.1	-4.7	-4.1	-3.7	-3.4	-3.2	-3.0	-2.4
All Systems	-4.2	-6.3	-6.8	-6.2	-5.5	-4.9	-4.3	-3.9	-3.6	-3.4	-3.2	-2.6

"The basic facts depicted in these tables are:

(1) Reduction in travel, which started in July 1973, continued through November 1974, and averaged 2.6 percent for the year.

(2) The reduction was greater in main rural than in urban and local rural areas.

(3) The reduction was more severe during the months of January through March, with a peak in February of 8.5 percent."

It is also worth noting the similarity between the seasonally differenced VMT series and the seasonally differenced fatality series during '74-'73. (Figures 3 and 9)

The final univariate model derived from the VMT series was:

$$(1-B)(1-B^{12})\ V_t = (1-.10B)\ (1-.23B^{12})\ a_t \tag{8}$$

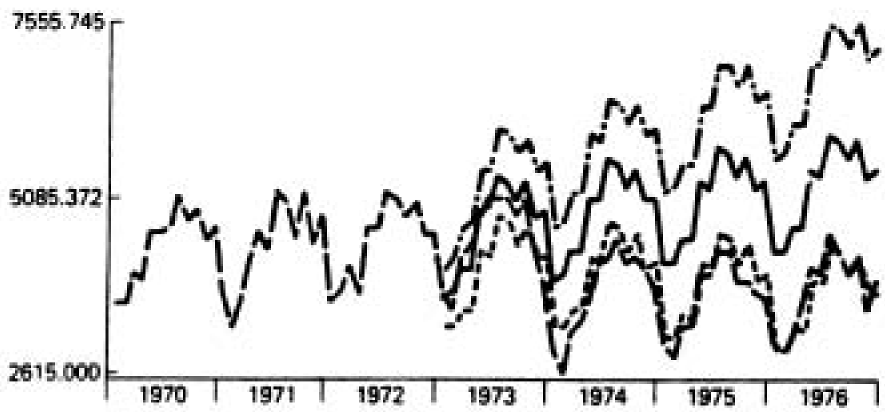
The use of VMT as an independent variable appears justified both from an exposure point of view and ability to account for fuel shortages. This was further supported when the crosscorrelation with fatalities which yielded a statistically significant spike at lag zero of .46 (approximate standard error of .11). A transfer function/intervention model using fatalities as a function of VMT and SPEED, is depicted in equation **(9)**:

$$\begin{array}{l} \quad\ (.46) \qquad\quad (84.50) \qquad\qquad (.11)(.11)\ (.10) \qquad (.09) \\ Y_t = 2.41\ V_t - 865.74\ X_t + \dfrac{(1+.30B+.22B^2+.28B^3)(1-.61B^{12})}{(1-B^{12})}a_t \end{array} \tag{9}$$

The estimate of lives saved due to the 55 mph NMSL rose from 687 (equation (6)) to 866. A close investigation of the implications of this model will explain how this change came about. Equation (9) explains fatalities as a function of vehicle miles traveled, an intervention variable for speed limit and time series characteristics. As mentioned earlier, VMT is a predominantly increasing series. Thus the implication is that fatalities should also be increasing due to increased exposure. This is graphically portrayed in Figure 10, a forecast of fatalities as a function of VMT only.

FIGURE 10

Forecast Of Fatalities As A Function Of VMT



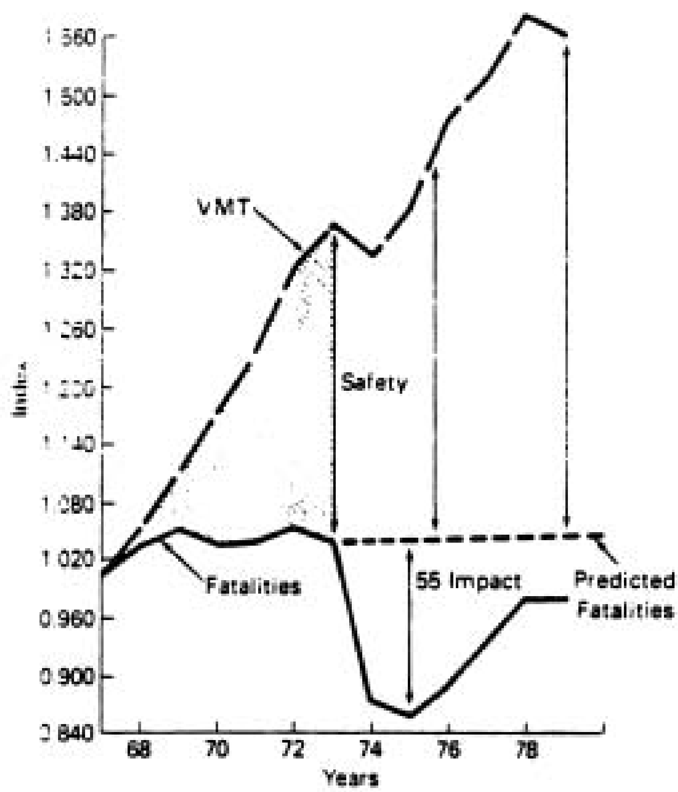
The coefficient (2.41) for VMT in equation (9) can be considered as a fatality rate for the 1970-79 time period. For every change of 100 million vehicle miles traveled on the average a change of 2.41 fatalities can be expected. However, because this fatality rate is calculated as a constant, it does not consider the declining fatality rate that actually occurred and therefore, overstated the number of fatalities due to exposure or VMT. The speed limit dummy variable operates in a decrimenting manner such that the greater the number of fatalities generated by the constant fatality rate, the greater the negative effect would be evidenced by the speed limit dummy variable. As a result of the VMT constant, a higher negative coefficient was calculated to counteract the overstated expected fatalities due to increasing VMT which led to an overstatement of 55 mph NMSL impact.

This observation led to the conclusion that the model with both VMT and SPEED was not adequate in explaining the behavior of fatalities.

As a result of the establishment of the U.S. Department of Transportation, automotive safety standards, driver education and training programs, highway design and construction improvements have had a very positive impact on the quality of travel in terms of safety. When one observes a steadily declining fatality rate (fatalities/100 million VMT) since 1968, it is reasonable to conclude that the introduction of these factors has contributed to this decline. A third variable was introduced to account for the differential changes between VMT and fatalities. This variable represents a measure of safety. An increase in VMT, accompanied by no change in fatalities will cause a reduction in the fatality rate per hundred million VMT, i.e., an increase in safety. Figure 11 is a graph of VMT and fatalities, indexed with 1967 as the base.

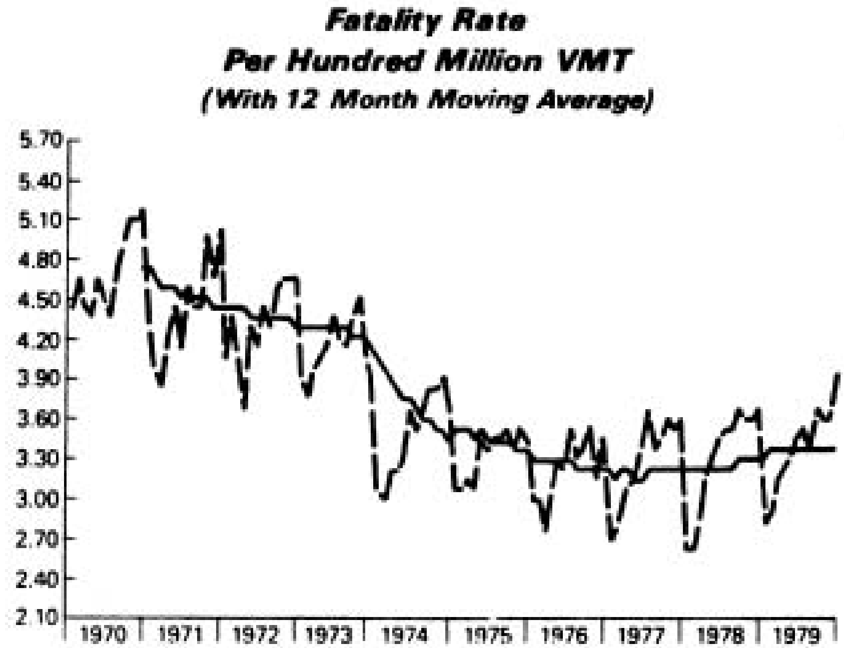
Figure 11

Fatalities and Vehicle Miles Traveled
(1967 = 1.00)



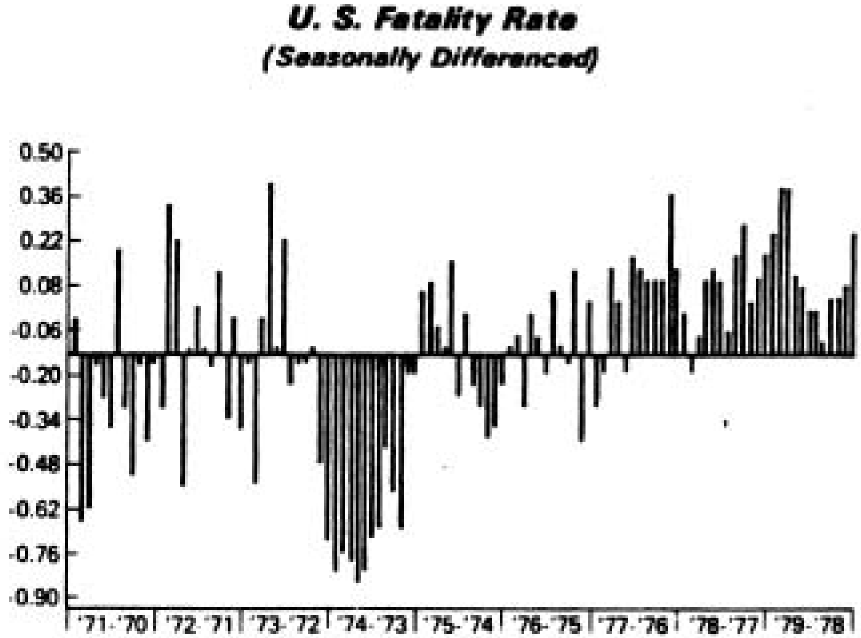
The shaded area from 1967 through 1973 represents the growth in VMT over and above the growth in fatalities, i.e., fatalities forestalled due to an increase in relative safety on the nation's roads (lower probability of a fatality per given VMT). In 1974, the large reduction in fatalities occurred independent from the increased safety on the roads. To illustrate this point, a fatality index projection is shown in Figure 11. It should be noted that the area between the VMT index and the fatality projection index (safety) was still increasing through the late 1970's. Critics of the 55 mph NMSL have proposed that up to 50% of the fatality reduction in 1974 should be attributed to increased safety in the areas of motor vehicle and highway improvements. This does not follow from Figure 11. Figure 11 seems to suggest that most if not all of the reduction in fatalities beginning in 1974 should be attributed to reduced exposure (VMT) in 1974 and the 55 mph NMSL. In addition the safety effect was still increasing. In order to account for this safety effect, a third independent variable in the form of the fatality rate was introduced. A major problem with using the fatality rate as a SAFETY INDEX was that it also included a change to a lower level, presumably caused by the 55 mph NMSL.

FIGURE 12



This change in level and an interruption of the smooth downward trend of the fatality rate can be seen in Figure 12. The 12 month differenced series is depicted in Figure 13, with the now familiar pattern of negative deviations during '74-'73.

FIGURE 13



This was presumed to result from to the 55 mph NMSL, since the series has already been normalized for exposure (mileage). An intervention model was developed for the fatality rate/speed limit relationship, to determine the necessary adjustment to be made for the change in level due to SPEED.

The reduction in the fatality rate in 1974, beyond the expected trend, was estimated to be .575. This estimate (.575) was added to each observation in the fatality rate series beginning in November 1973, to arrive at an adjusted fatality rate called SAFETY for the total period 1970-1979.

FIGURE 14

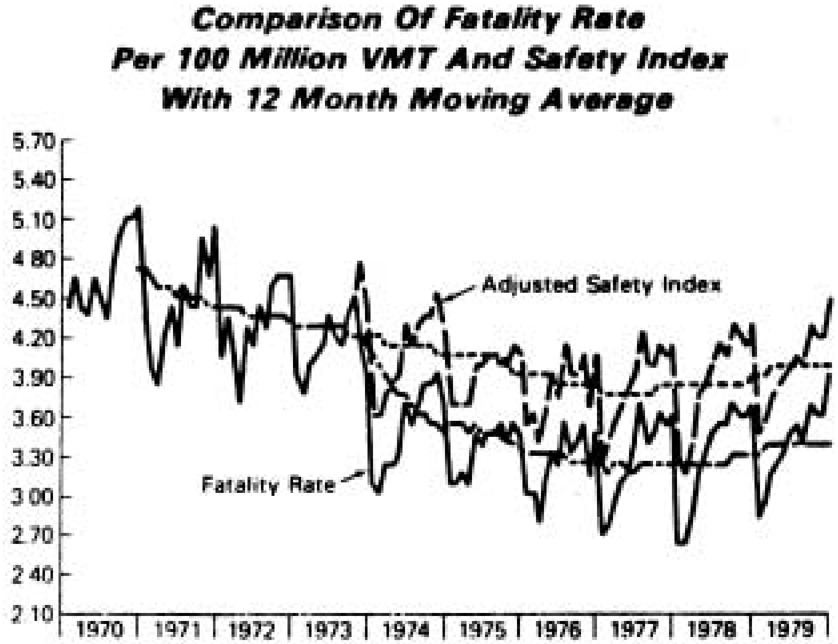
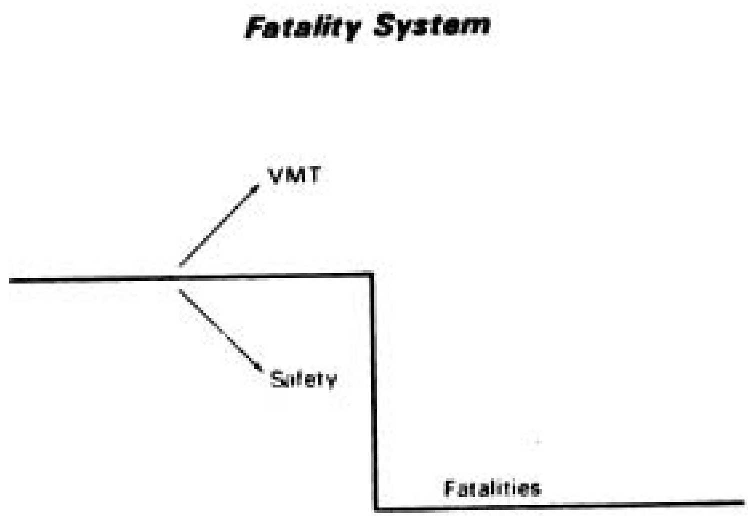


Figure 14 portrays the adjusted safety index projecting what would have occurred had there been no 55 mph NMSL. This series was used in the final evaluation model, to offset the growth in VMT. A schematic of the traffic safety system is presented in Figure 15.

FIGURE 15



VMT and SAFETY operate in opposite directions in order to determine the fatality level.

The final evaluation model, combining fatalities as a function of VMT, SAFETY and SPEED was estimated with the following results:

$$Y_t = \underset{(.13)}{3.52}V_t + \underset{(17.47)}{1060.70}S_t - \underset{(15.71)}{627.65}X_t + \frac{(1+\underset{(.11)}{.42}B+\underset{(.11)}{.29}B^2+\underset{(.10)}{.23}B^3)(1+\underset{(.09)}{.17}B^{12})}{(1-B^{12})}n_t \qquad (10)$$

Thus, the steady state estimate of life savings attributed to the 55 mph NMSL is 627.65 per month (7,532 per year) for 1974-1979. The estimate for 55 mph impact has been reduced to the magnitude of the estimate found in equation (6), the SPEED only model. The necessity of adjusting the estimate of 55 mph impact comes from the fact that this estimate (-627.65) represents a steady state average over the total period rather than a specific estimate for each year. In order to reflect the dynamics of traffic safety, the steady state estimate was adjusted in order to account for variability in noncompliance between years. The analysis which follows uses fatalities by speeding involvement for the years 1975-1979 to adjust this steady state estimate. Note also that the coefficient of VMT has increased to the more conventional magnitude of 3.52.

Indications of Noncompliance with the 55 MPH Speed Limit

A review of the fatalities in Figure 6, shows that there has been an increase in 1977-1979 compared to the 1974 through 1976 level. Many changes in the traffic safety level occurred during the 1977-1979 time frame including increasing noncompliance with the 55 mph NMSL. This section will address these issues in order to obtain the true effect of the 55 mph NMSL during 1976-1979.

An analysis of fatalities was conducted using data from the Fatal Accident Reporting System (FARS) in an effort to adjust the steady state estimates for the effect of the 55 mph NMSL derived in the previous section evaluation model. The reporting of the variable posted speed limit was not 100% complete as can be seen in Table 3.

TABLE 3

Percent Reporting of Posted Speed Limit ; FARS

	KNOWN	UNKNOWN
1975	80.48	19.52
1976	80.42	19.58
1977	84.42	15.58
1978	87.73	12.27
1979	88.43	11.57

It is evident that the percent of known posted speed limit fatalities has been increasing over the years. For the purpose of this analysis, the unknown fatalities were redistributed into posted speed limit categories based on the distribution of the 80-88 percent known fatalities resulting in a two-by-two table.

The determination of speeding involvement in a fatality presented somewhat of a different problem. The selection process was based upon three data elements reported to FARS:

(1) Posted speed limit,

(2) Pre-crash traveling speed, and

(3) Too fast for conditions.*

If the pre-crash traveling speed of any vehicle in a fatal accident exceeded the posted speed limit by at least 5 mph, those fatalities were defined to be speeding involved. In the absence of either posted or traveling speed, too fast for conditions was the determining factor. Tables 4A through 4E depict the output from the algorithm.

TABLE 4A
FATALITIES VS. POSTED SPEED LIMIT AND SPEEDING INVOLVEMENT 1975

SPDINVOL POSTED

FREQUENCY / PERCENT / ROW PCT / COL PCT	LESS THAN 55	55MPH ROADS	UNKNOWN	TOTAL
NO SPEEDING INVO	11416 25.64 37.69 68.23	12640 28.39 41.72 66.18	6236 14.01 20.58 71.75	30294 68.04
SPEEDING INVOLVE	5317 11.94 37.36 31.77	6459 14.51 45.39 33.82	2455 5.51 17.25 28.25	14231 31.96
TOTAL	16735 37.59	19099 42.90	8691 19.52	44525 100.00

* Too fast for conditions is driver factor 44 in FARS.

TABLE 4B
FATALITIES VS. POSTED SPEED LIMIT AND SPEEDING INVOLVEMENT 1976

SPDINVOL POSTED

FREQUENCY PERCENT ROW PCT COL PCT	LESS THAN 55	55MPH ROADS	UNKNOWN	TOTAL
NO SPEEDING INVO	11734 25.78 38.08 68.38	12755 28.02 41.39 65.58	6328 13.90 20.53 71.01	30817 67.70
SPEEDING INVOLVE	5427 11.92 36.90 31.62	6695 14.71 45.53 34.42	2584 5.68 17.57 28.99	14706 32.30
TOTAL	17161 37.70	19450 42.73	8912 19.58	45523 100.00

TABLE 4C
FATALITIES VS. POSTED SPEED LIMIT AND SPEEDING INVOLVEMENT 1977

SPDINVOL POSTED

FREQUENCY PERCENT ROW PCT COL PCT	LESS THAN 55	55MPH ROADS	UNKNOWN	TOTAL
NO SPEEDING INVO	12530 26.17 39.11 66.65	14284 29.83 44.59 66.07	5220 10.90 16.30 69.99	32034 66.91
SPEEDING INVOLVE	6264 13.09 39.57 33.35	7337 15.32 46.31 33.93	2238 4.67 14.13 30.01	15844 33.09
TOTAL	19799 39.26	21621 45.16	7458 15.58	47878 100.00

TABLE 4D
FATALITIES VS. POSTED SPEED LIMIT AND SPEEDING INVOLVEMENT 1978

SPDINVOL POSTED

FREQUENCY PERCENT ROW PCT COL PCT	LESS THAN 55	55MPH ROADS	UNKNOWN	TOTAL
NO SPEEDING INVO	13792 27.40 40.52 67.93	15987 31.76 46.97 67.02	4258 8.46 12.51 68.97	34037 67.63
SPEEDING INVOLVE	6510 12.93 39.96 32.07	7867 15.63 48.28 32.98	1916 3.81 11.76 31.03	16293 32.37
TOTAL	20302 40.34	23854 47.40	6174 12.27	50330 100.00

TABLE 4E
FATALITIES VS. POSTED SPEED LIMIT AND SPEEDING INVOLVEMENT 1979

SPDINVOL POSTED

FREQUENCY PERCENT ROW PCT COL PCT	LESS THAN 55	55MPH ROADS	UNKNOWN	TOTAL
NO SPEEDING INVO	14374 28.17 41.71 67.29	15672 30.72 45.48 65.97	4414 8.65 12.81 74.76	34460 67.54
SPEEDING INVOLVE	6988 13.70 42.19 32.71	8085 15.85 48.81 34.03	1490 2.92 9.00 25.24	16563 32.46
TOTAL	21362 41.87	23757 46.56	5904 11.57	51023 100.00

Several observations are worth noting:

(1) The percent of speeding involved fatalities for all posted speed limits has remained relatively constant across the years (31.96 -- 32.30 -- 33.09 -- 32.37 -- 32.46);

(2) The same is true for percent speeding involved within 55 and less than 55 posted roads; and

(3) The percent unknown posted speed limit has been gradually declining.

The redistribution of unknown posted speed limit fatalities yield the following results in Table 5.

TABLE 5

Fatalities due to speeding involvement by posted speed limit

	Non-55	Change	55	Change
1975	6,425		7,806	
1976	6,584	+159	8,122	+316
1977	7,300	+716	8,544	+422
1978	7,378	+ 78	8,915	+371
1979	7,679	+301	8,884	- 31

Using the estimate for lives saved due to the 55 mph NMSL in formula **(10)**, 627.65, yields an annual reduction of approximately 7,532 lives saved per year. This estimate can be adjusted by using the fatality changes on 55 mph roads from Table 5 for 1976-1979 to arrive at the benefits in Table 6 below.

TABLE 6
Lives saved due to 55 mph NMSL

1974	7,532
1975	7,532
1976	7,216
1977	6,794
1978	6,423
1979	6,454
Total	41,951

It should be noted that no reductions to the 55 mph impact should be made to account for fatality increases either on roads posted less than 55 mph or on 55 mph roads where speeding was not a contributing factor. Therefore, for the six year period 1974-1979, almost 42,000 lives have been saved due to the slower, more uniform speeds resulting from the 55 mph NMSL.

Analysis of Speed and Speed Changes

Adjustment to model estimates for changes in noncompliance were derived by analyzing changes in speeding involvement in fatal accidents. In order to corroborate these estimates, speed data was analyzed. When the 55 mph NMSL was imposed, its effect should have been reflected in the speed statistics derived from the FHWA speed monitoring system. This system's data was used to analyze these speed changes over time. Annual speed certification data for FY 1968-1979 was obtained. The average speed and 85th percentile speed for the U.S. were used to determine:

1. If a considerable reduction in speed occurred timely to the imposition of the 55 mph NMSL; and

2. If any changes in speeds can be shown for 1976-1979, coinciding with changes in fatalities/fatality rate.

These two determinations, tied to comparable trends in fatalities, injuries, fatality rates and injury rates serve as a basis for validation of the estimate of the number of lives saved due to the 55 mph NMSL.

Trends in speed monitoring data for 1968-1979 were used to determine if the behavior of average speed and 85th percentile speed coincided with the imposition of the 55 mph NMSL. Speed measurement data is obtained by FHWA from the States. For the years 1968-1975 speed data was reported on a FY basis to FHWA and represented measured speeds for all free flowing vehicles on main rural roads only. For FY 1976-1979 speed data was reported quarterly to FHWA as part of the 55 mph speed limit monitoring program. Data for these years represent measures of speeds of free-flowing vehicles on "straight, level segments of a State's highway system having a posted or allowable speed of 55 mph," **15/** i.e., not restricted to main rural roads. Therefore, the annual figures were obtained for 1976-1979 by averaging the quarterly data and are somewhat different from the pre-1976 data. Some caution should be taken since pre-1976 data represents speeds on "main rural roads" and post-1976 data represents speeds on "55 mph highways."

Annual data for 1968-1978 was obtained for:

- o average speed
- o 85th percentile speed
- o total fatalities
- o total injuries
- o injury rate
- o Interstate fatalities
- o Interstate injuries
- o Interstate fatality rates
- o Interstate injury rate

The rates in Table 7 are fatalities and injuries per 100 million VMT. Data for fatalities, injuries and rates were obtained from the FHWA publication "Fatal and Injury Accident Rates" for 1975 **16/** and 1976 **17/**. Data for 1977-1978 was estimated by FHWA based on trends in fatalities, injuries and VMT for earlier years.

In order to make the speed data trends comparable to the trends for fatalities and injuries, indices were calculated using 1973 as the base year (100) to reflect changes of the pre- and post-period imposition of the 55 mph NMSL. Table 7 shows the data adjusted to reflect 1973 as the base year along with the original data.

Based on Table 7 data, the following observations can be made:

- o Average speeds, 85th percentile speeds, the U.S. fatality rate and the Interstate fatality rate declined in 1974-1976, began to increase in 1977.

- o Total fatalities and Interstate fatalities declined in 1974-1975, began to increase in 1976.

- Total fatalities, fatality rate, Interstate fatalities, Interstate fatality rate, and Interstate injury rate exhibited a substantial drop (greater than ten percent) in 1974 from 1973 levels. The drop in average speeds was approximately five percent, for 85th percentile speeds, it was approximately 2 percent.

Table 8 shows the distribution of fatalities by highway systems for 1973-1977. In 1974, the Interstate and Federal Aid Primary systems showed the largest percent decreases in fatalities from the previous year. These systems would be where the 55 mph NMSL would have the most impact. For 1975, all systems except Federal Aid Secondary and Urban (FAS/U) continued decreases over the previous year. The increase in fatalities for FAS/U could be attributable in part to the anticipated FHWA highway system realignment 17/ which reclassified highways using functional criteria (usage characteristics) instead of administrative criteria (funding characteristics). The Interstate and Federal Aid Primary systems showed percent increases in fatalities for both 1976 and 1977. The largest percent increase in fatalities in 1977 was on the highway system almost exclusively 55 mph, i.e., the Interstate system with a 17 percent increase.

TABLE 7
ORIGINAL DATA

Year	Average Speed	U.S. Fatalities	Fatality Rate	U.S. Injuries	Injury Rate	Interstate Fatalities	Interstate Fatality Rate	Interstate Injuries	Interstate Injury Rate	85th Percentil Speed
1978	56.3	51,200	3.39	3,199,992	211.64	3,823	1.47	166,601	63.98	62.0
1977	55.9	48,800	3.31	3,020,000	204.51	3,694	1.45	160,610	63.16	61.6
1976	55.6	46,434	3.30	2,844,488	201.86	3,511	1.38	152,093	59.82	61.3
1975	55.8	45,500	3.42	2,808,323	211.25	3,282	1.43	141,530	61.55	63.7
1974	57.6	46,078	3.59	2,653,527	206.67	3,323	1.55	128,352	60.04	63.7
1973	60.3	55,113	4.19	2,835,664	215.44	4,942	2.29	168,034	77.99	64.7
1972	64.9	55,704	4.40	2,794,599	220.98	4,827	2.42	166,177	83.30	73.0
1971	60.6	53,761	4.54	2,691,055	227.38	4,651	2.59	152,875	85.09	73.2
1970	59.2	53,672	4.82	2,758,061	247.56	4,328	2.69	140,777	87.41	72.7
1969	61.7	55,032	5.16	2,708,607	254.06	4,210	2.90	131,426	90.56	69.3
1968	60.4	53,831	5.28	2,727,866	267.51	3,765	2.98	115,762	91.68	68.9

INDICES
USING 1973 AS BASE

1978	93.37	92.90	80.91	112.85	98.34	77.36	64.19	99.15	82.04	95.83
1977	92.70	88.55	79.00	106.50	94.93	74.75	63.32	95.58	80.98	95.21
1976	92.21	84.25	78.76	100.31	93.70	71.04	60.26	90.51	76.70	94.75
1975	92.54	82.56	81.62	99.04	98.06	66.41	62.45	84.23	78.92	98.45
1974	95.52	83.61	85.68	93.58	95.93	67.24	67.69	76.39	76.98	98.45
1973	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1972	107.63	101.07	105.01	98.55	102.57	97.67	105.68	98.89	106.81	112.83
1971	100.50	97.55	108.35	94.90	105.54	94.11	113.10	90.98	109.10	113.14
1970	98.18	97.39	115.04	97.26	114.91	87.58	117.47	83.78	112.08	112.36
1969	102.32	99.85	123.15	95.52	117.93	85.19	126.64	78.21	116.12	107.11
1968	100.17	97.67	126.01	96.20	124.17	76.18	130.13	68.89	117.55	106.49

TABLE 8
Distributions of Fatalities by Highway System, 1973-1977

YEAR	HIGHWAY SYSTEM*				
	Interstate	Other FA Primary	FA Secondary and Urban	Non FA	Year Totals
1977	4,113 +17%	17,276 +7%	14,351 -3%	13,163 +10%	48,903 +5%
1976	3,513 +7%	16,226 +7%	14,704 -5%	11,991 +4%	46,434 +2%
1975	3,282 -1%	15,243 -4%	15,425 +6%	11,550 -6%	45,500 -1%
1974	3,323 -33%	15,792 -22%	14,621 -10%	12,342 -10%	46,078 -16%
1973	4,942	20,264	16,253	13,654	55,113
SYSTEM TOTALS (5-yr.)	19,173	84,801	75,354	62,700	242,028

*Each cell gives number of fatalities and percent change from previous year.

The distributions of fatalities by highway system were analyzed using the chi square test statistic 18/. The calculated chi square value with 12 degrees of freedom was 527.7. The magnitude of the calculated value, which is statistically significant, is due in part to the magnitude of the values in the table. However, by observing the largest contributions to the chi square value, it can be seen where the greatest differences in the fatality distributions lie.

For the highway systems, the Interstate and FAS/U fatalities made the largest contributions to the chi square statistic. This was due to 1973 Interstate fatalities being much greater than following years. The contribution from FAS/U is due to the increase in fatalities for 1975 over 1974, again, probably attributable to the system realignment. For the year totals, the largest contributions to the chi square value were for 1975, which had the lowest fatality total of the five years, and for 1973, the highest fatality total for the five years.

This comparison of the fatality distributions by highway system demonstrates that beginning with 1974 there was a considerable drop in the fatality level. In addition, the greatest reductions in fatalities for 1974 occurred on those highway systems which would be most impacted by the 55 mph NMSL -- the Interstate and other Federal Aid Primary Systems. Also, the increase in fatalities in 1977 is most evident in the change in fatalities on the Interstate --again the highway system most impacted by the 55 mph NMSL and consequently most affected by increasing noncompliance.

These characteristics of the fatality distributions by highway system can be matched to similar behavior in the various speed measures.

Table 9 contains the distribution of average speed for the 50 States for FY 1976-1979. In FY 1976, approximately two years after imposition of the 55 mph NMSL, 59% of the States had an average speed of less than 56.0 mph. In FY 1977 40% of the States had an average speed of less than 56.0 mph. For FY 1978, this percentage decreased to 30% of the States. For FY 1979, the percentage increased to 54% of the States.

TABLE 9
Average Speed

	Distribution of States			
Range/Mph	**FY 1976**	**FY 1977**	**FY 1978**	**FY 1979**
50.0-50.9	2%	2%	0%	0%
51.0-51.9	2	0	2	2
52.0-52.9	6	4	4	2
53.0-53.9	10	4	4	6
54.0-54.9	10	10	6	14
55.0-55.9	22	18	14	28
56.0-56.9	6	28	40	26
57.0-57.9	28	18	12	16
58.0-58.9	4	10	16	4
59.0-59.9	2	4	2	0
60.0-60.9	0	0	0	0
61.0-61.9	1	0	0	0
Percent of States less than 56.0 mph	59%	40%	30%	54%

These proportions were tested for year to year differences using the parametric test (t test) for differences in proportions 18/ and compared to the normal distribution critical value for 5% level of significance. There was a significant difference in the proportion of States for FY 1976 vs. FY 1977. No other differences were significant.

Table 10 shows the distribution of 85th percentile speed for the States for FY 1976-1979. In FY 1976, 44% of the States had 85th percentile speeds of less than 61.0 mph. For FY 1977 this proportion of States was 34%, decreased to 30% for FY 1978, and increased to 46% for FY 1979. These proportions were also tested for year to year differences at 5% level of significance. There was a significant difference between the proportion of States with 85th percentile speeds of less than 61.0 mph for FY 1978 vs. FY 1979. No other differences were significant.

TABLE 10
85th Percentile Speed

Range/Mph	FY 1976	FY 1977	FY 1978	FY 1979
	Distribution of States			
57.0-57.9	2%	2%	2%	2%
58.0-58.9	12	2	0	2
59.0-59.9	12	18	20	18
60.0-60.9	18	12	12	24
61.0-61.9	16	28	20	28
62.0-62.9	20	12	24	14
63.0-63.9	8	18	12	4
64.0-64.9	4	0	4	4
65.0-65.9	8	6	4	2
66.0-66.9	0	2	0	2
67.0-67.9	0	0	2	0
Percent of States less than 61.0 mph	44%	34%	30%	46%

Table 11 shows the distribution of States for percent exceeding 55 mph for FY 1976-1979. The proportion of States with 50% of the vehicles and above exceeding 55 mph was 64% in FY 1976, increased to 78% in FY 1977, to 84% in FY 1978, and decreased to 70% in FY 1979. Therefore in FY 1977 and FY 1978, a larger number of States had compliance levels of 50% or lower. These proportions were tested for year to year differences. The difference in the proportions for FY 1978 vs. FY 1979 was significant at the 5% level of significance.

TABLE 11
Percent Exceeding 55 MPH*

Range/Mph	FY 1976	FY 1977	FY 1978	FY 1979
	Distribution of States			
Below 30%	4.0%	2.0%	0.0%	2.0%
30-39%	8.0	4.0	8.0	6.0
40-49%	24.0	16.0	8.0	22.0
50-59%	24.0	38.0	38.0	40.0
60-69%	34.0	30.0	36.0	28.0
70-79%	4.0	10.0	10.0	2.0
80-89%	2.0	10.0	0.0	0.0

*Compiled from FHWA Speed Summaries for the 50 State for FY 1976-79.

During 1976-1978, a large proportion of States experienced increases in their average speed, 85th percentile speed, fatalities, and fatality rates. Table 12 shows those States with increases for 1976-1978 (fatality rate data not available for 1979).

TABLE 12
1976 vs. 1978

	No. of States with		
	No Change	Increase	Decrease
Average Speed	4	32	14
85th Percentile Speed	9	27	14
Fatalities	12	32	6
Fatality Rates	8	24	18

From 1976-1978, 32 States' average speed increased, 27 States' 85th percentile speed increased, 32 States' fatalities increased, and 24 States' fatality rate increased.

Tables 13A-13D show those States that experienced increases in average speed and 85th percentile speed with increases in fatalities and fatality rates for 1976-1978. In Table 13A, 21 States experienced both an increase in their average speed and an increase in fatalities. In Table 13B, 17 States experienced and increase in average speed and the fatality rate. In Table 13C, 17 States had increases in 85th percentile speed and fatalities. In Table 13D, 15 States had increases in both 85th percentile speed and the fatality rate.

TABLE 13A
AVERAGE SPEED

FATALITIES		No Change	Increase	Decrease	**Total**
	No Change	0	8	4	12
	Increase	3	21	8	32
	Decrease	1	3	2	6
	Total	4	32	14	**50**

TABLE 13B
AVERAGE SPEED

FATALITY RATE	No Change	Increase	Decrease	**Total**
No Change	1	5	2	8
Increase	1	17	6	24
Decrease	2	10	6	18
Total	4	32	14	**50**

TABLE 13C
85TH PERCENTILE SPEED

FATALITIES	No Change	Increase	Decrease	**Total**
No Change	2	7	3	12
Increase	6	17	9	32
Decrease	1	3	2	6
Total	9	27	14	**50**

TABLE 13D
85TH PERCENTILE SPEED

FATALITY RATE	No Change	Increase	Decrease	**Total**
No Change	1	4	3	8
Increase	3	15	6	24
Decrease	5	8	5	18
Total	9	27	14	**50**

In addition to a large proportion of States (32/50) experiencing an increase in the average speed, a large proportion of States has also experienced an increase in the percentage of vehicles exceeding 55 mph, i.e., a decrease in the percent compliance. The average percent compliance was obtained by averaging the quarterly values for each State.

The range and median of the average speed distributions and the 85th percentile speed distributions for FY 1976 - FY 1979 are shown below. The median of average speed values increased in FY 1977 and FY 1978, decreased for FY 1979. A similar result occurred with the 85th percentile speed.

TABLE 14

Ranges of Speed Measures (MPH)

	FY 1976	FY 1977	FY 1978	FY 1979
		Average Speed		
Minimum	50.0	50.6	51.4	51.1
Median	55.9	56.4	56.6	55.8
Maximum	61.0	59.3	59.7	58.7
		85th Percentile Speed		
Minimum	57.8	57.2	57.7	57.8
Median	61.5	61.7	61.8	61.1
Maximum	65.9	66.0	67.2	66.2

From these observations of the distributions of the speed measures for the States it can be seen that the increases in average speed, percent exceeding 55 mph, and 85th percentile speeds were concurrent with increases in fatalities.

Table 15 shows the distributions of average percent compliance for FY 1974-1979. The median of the distribution of the States' percent compliance decreased in FY 1975, increased in FY 1976, and decreased in FY 1977 and 1978. However, it appears that more States are in the ranges of 30% to 49% compliance, beginning with FY 1977. There appears to be a shift downward in compliance levels as evidenced by the larger compliance intervals (50% compliance and above) having fewer States.

TABLE 15
AVERAGE PERCENT COMPLIANCE
FY 1974-1979

Interval	FY 1974*	FY 1975**	FY 1976	FY 1977	FY 1978	FY 1979
Below 30%	7.3%	13.7%	6%	8%	10%	2%
30-39%	26.8	24.1	30	30	36	26
40-49%	17.0	28.0	28	38	36	40
50-59%	22.0	20.6	22	12	10	22
60-69%	17.0	6.8	10	8	6	8
70-79%	7.3	3.4	4	2	2	2
80% and Above	2.6	3.4	0	0	0	0
Minimum	20%	18%	18%	23%	23%	28%
Median	49.5%	42.5%	45.5%	42%	41.5%	45%
Maximum	90%	82%	72%	72%	70%	72%

* Data from 40 States.
**Data from 29 States.

Tables 16A and 16B show those States that experienced decreases in percent compliance and increases in fatalities/fatality rates for 1976-1978. Twenty-two States that experienced a decrease in the compliance level (i.e., an increase in the percent of vehicles exceeding 55 mph) also experienced an increase in fatalities.

Seventeen States experienced a decrease in the compliance level and an increase in the fatality rate 1976-1978. Therefore, the shift downward in the States' compliance levels appears to be associated with increases in fatalities and fatality rates.

TABLE 16A
% Compliance

FATALITIES	No Change	Increase	Decrease	Total
No Change	0	4	8	12
Increase	0	10	22	32
Decrease	0	3	3	6
Total	0	17	33	**50**

TABLE 16B
% Compliance

FATALITY RATE	No Change	Increase	Decrease	Total
No Change	0	3	5	8
Increase	0	7	17	24
Decrease	0	7	11	18
Total	0	17	33	**50**

CONCLUSIONS

The analysis of the impact of the 55 mph NMSL has been conducted in three phases. Initially, the global model was developed as a starting point to assess the magnitude of the effect of the reduced speed limit during 1974-1979. This pointed to the following conclusions:

- o The introduction of safety improvements for the vehicle, driver and the environment has been generally effective in maintaining the level of fatalities, offsetting the expected increases due to increased exposure (VMT).

- The initial impact of the 55 mph NMSL was fairly constant for the years 1974-1975.

- During the period 1976-1979 there was significant upward growth in fatalities, as compared to 1974-1975.

The second phase of the analysis was an investigation of what factors contributed to the increase in fatalities in 1977-1978. This led to an analysis of fatalities due to speeding involvement by posted speed limit roads. From this analysis, adjustments were made to the evaluation model estimates, to account for the effect of noncompliance. The reconciliation of these factors appears in Table 17.

TABLE 17

MODEL RECONCILIATION (lives saved)

	1974	1975	1976	1977	1978	1979
55 mph NMSL	7,532	7,532	7,532	7,532	7,532	7,532
Noncompliance with 55			-316	-738	-1,109	-1,078
Total lives saved due to 55 mph NMSL	—	—	7,216	6,794	6,423	6,454

Based on the analytic formulation on page 23, a 95% confidence interval for 55 mph impact on monthly fatalities in 1974-1975 would yield (597,658). The value 627.65 per month or an annual 7,532 in Table 17 represents the best estimate of the 55 mph NMSL impact on the reduction in fatalities. It should be remembered that the adjustments made in phase II and reflected in Table 17 are the result of the analysis of fatalities by speeding involvement and posted speed limit from FARS.

The third phase consisted of analyzing the speed monitoring data to investigate 55 mph compliance over time. This analysis showed that:

- Between 1977-1978 there was a shift downward in compliance levels for the individual States.

- The average speed and the 85th percentile speed, after reaching a low in 1976 began to rise in 1977.

- From 1976-1978, 32 States' average speed increased.

- From 1976-1978, 27 States' 85th percentile speed increased.

- From 1976-1978, 22 States experienced a decrease in compliance level <u>and</u> an increase in fatalities.

The results of the phase three analysis appear to validate the model adjustments derived in phase two.

In conclusion, the 55 mph NMSL is one of the most effective countermeasures to have been used in reducing fatalities. The effect of the 55 mph NMSL on fatalities depends heavily upon the compliance level present on the Nation's roads.

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