THE EFFICACY AND
COST-EFFECTIVENESS OF VEHICLE
INSPECTION

A State Specific Analysis Using Time Series Data

By Peter D. Loeb and Benjamin Gilad*

I. INTRODUCTION

Most states in the United States have employed at one time or another a system of inspection of motor vehicles. The procedures used in inspections have varied from state to state as well as over time. However, almost since their inception, there have been serious charges leveled against the efficacy and/or cost-effectiveness of inspections in reducing fatalities, injuries and accidents.

Numerous studies have been conducted to evaluate motor vehicle inspection. These studies, however, have mostly been plagued with statistical or methodological problems which have made their conclusions far from definitive.

Only relatively recently has regression analysis been used, and then only on the basis of cross-sectional data. Thus there have so far been no state-specific studies which have used econometric techniques to test the efficacy of inspection.

The present study employs, for the first time, a time series analysis of the efficacy of inspection in reducing fatalities, injuries and accidents, using New Jersey data. An econometric model is developed to evaluate inspection while accounting for various socio-economic factors, as well as technology and driving-related variables. The results of the econometric study are then used to evaluate a partial benefit/cost analysis of the system of motor vehicle inspection.

Section II provides a short review of the literature in the area. Section III develops an econometric model to evaluate motor vehicle inspection in New Jersey, and Section IV presents a benefit/cost analysis of the system. Section V provides a summary and some concluding comments.

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II. VEHICLE INSPECTION AND HIGHWAY SAFETY — A REVIEW

Previous studies of vehicle inspection and highway safety can be divided into three categories: cross-sectional studies, experimental studies, and time series studies. A review of these studies is presented below.

The cross-sectional studies reviewed (Mayer and Hoult (1963), Buxbaum and Colton (1966), Fuchs and Leveson (1967) and Crain (1980)) made comparisons between states; they differed in the variables included and in the statistical techniques employed. The earliest study, by Mayer and Hoult, grouped states into four categories of inspection, ranging from mandatory state inspection to no inspection, and compared death rates for each of these categories over a 12-year period from 1949 to 1958. The study found an inverse relation between accident death rates and the comprehensiveness of the inspection system. The Buxbaum and Colton study, using 1960 data with a slightly different definition of the death rate and the inspection variables, found similar results. Buxbaum and Colton also included several additional variables not used by Mayer and Hoult, such as population, gasoline consumption per vehicle, number of vehicles, etc. After variable-by-variable comparisons, they still found lower accident rates for states with an inspection programme than for states without one.

The two other studies in this category employed econometric modelling with cross-sectional data, which resulted in somewhat less favourable conclusions. Fuchs and Leveson evaluated accident death rates with models using the following independent variables: age of driver, education, median income, fuel consumption per capita, population density, alcohol consumption per capita, several other socio-economic variables, and a binary variable for inspection. When the inspection variable was the only independent variable, they found a significant negative effect on accident death rates. When more regressors were added to the model, the efficacy of motor vehicle inspection in reducing mortality rates was not statistically significant. The study by Crain used 1974 data and similar socio-economic variables, and did not find a statistically significant effect of periodic inspection on death rates, accident rates or non-fatal injury rates. However, Crain’s study employed five different measures of inspection, and his use of dummy variables to account for type of inspection makes it difficult to interpret his results.

In an experimental study conducted by the U.S. Department of Transportation, NHTSA (1980), the accident rate of vehicles was observed over a 12-month period. The vehicles were grouped into two samples: one consisted of vehicles that underwent (voluntary) inspection, and the other of non-inspected vehicles. The two samples were matched for make, model and year of manufacture. The results showed a statistically significant difference in accident rates, the inspected vehicles having fewer accidents than the non-inspected ones. The results also held when accident rates were adjusted for differences in age and sex. These results, however, should be interpreted with caution, because the non-random sampling procedure used in the study may have biased the selection of drivers in the first sample.

The time series studies conducted in the past have been basically a descriptive comparison of accident rates before and after the introduction of inspection programmes. These studies (State of Nebraska, Department of Motor Vehicles
(1974) and State of Alaska (1974)) compared the percentages before and after the introduction of an inspection programme of all fatal accidents in which vehicle defects played a causative role. Both studies found a decline in these percentages. No attempt was made to formalise the analysis, however, and the circumstances of the accidents were not rigorously examined. Furthermore, the analysis did not include factors other than inspection, and the sample space considered was quite small.

In summary, it seems that various studies of the efficacy of periodic inspection in reducing fatalities, injuries or accidents, give rise to mixed results and no definitive conclusion. The more rigorous studies are cross-sectional only, and somewhat limited in their conclusions. A systematic analysis using time series data and econometric techniques provides a more definitive test for the efficacy of periodic inspection, and is more appropriate as a tool for policy decisions on a state by state basis.

III. TIME SERIES MODELS FOR EVALUATING MOTOR VEHICLE INSPECTION IN NEW JERSEY

General Model Specification
The previous econometric models, as stated above, were cross-sectional models as opposed to time series models. As such they were not state specific. We propose to evaluate the effect of motor vehicle inspection on reducing deaths, injuries and accidents, using time series data for New Jersey. Consider, for expository purposes, a model of the form:

\[ D_t = \beta_1 + \beta_2 MVI_t + \sum_{i=3}^{k} \beta_i X_{it} + \epsilon_t \]  

where:
- \( D_t \) is a measure of deaths due to traffic accidents in year \( t \)
- \( MVI_t \) is a binary variable accounting for the existence or non-existence of an inspection system in year \( t \); \( MVI=1 \) for the years an inspection system was in effect, and \( MVI=0 \) otherwise.
- \( X_{it}(i=3,\ldots,k) \) are \( k-2 \) additional socio-economic variables which are independent variables.

The ordinary least squares estimate of \( \beta_2 \) is an estimate of the effect of inspection on mortality. We would expect that \( \beta_2 < 0 \) if inspection is efficacious. Nonetheless, two-tail tests will be reported because they are more conservative.

Various alternative specifications of equations (1) will also be evaluated (for example, natural log models), as was done both by Fuchs and Leveson (1967) and by Crain (1980).

The time series model is state specific, but must account for changes in technology and the like occurring over time, which do not plague cross-sectional studies. A time variable is included in the time series model as a proxy for technological change.

The type of model specified in equation (1) can also be used to evaluate injuries and accidents, which in turn may provide information on loss of property.
The Variables

Time series models were developed for fatalities, accidents and injuries. A potential list of independent variables was compiled, and data were collected for the years 1929-1979 (unless otherwise noted). The final set of variables included: a measure of time (the Gregorian calendar year), maximum highway speed, gasoline consumption, number of licenses revoked for drunken driving, per capita personal income, population (in thousands), number of motor vehicle registrations, number of drivers licensed, vehicle mileage, GNP price deflator, a dummy variable for inspection, a dummy variable for the years of American involvement in World War II, a dummy variable for the year of the Great Depression, total number of accidents reported, number of injuries (from 1932 to 1979), number of traffic deaths and the death rate (per 100 million vehicle miles). A list of the variables and the sources of the data is given in the Appendix, which explains the problems encountered in the data and describes the techniques used to supply missing observations.

The time variable is a proxy for technological change over the years. Since 1929 many engineering advances in automobiles, roads, lighting systems, etc., have been developed, and these may have contributed to a reduction in accidents, fatalities and injuries. Technological change is difficult, if not impossible, to measure. However, technological change progresses over time, so we use time as a proxy for it.\footnote{Models incorporating time in quadratic and other nonlinear forms were also evaluated to allow for the possible non-steady progress of the effect of technology on fatalities. The results are similar to those reported.}

The maximum highway speed is expected to be directly proportional to deaths. As highway speeds increase, an accident is more likely to be serious and to result in a fatality than when speeds are lower. However, the higher maximum speeds have been accompanied by the building of super highways and new designs of access ramps. Thus, though accidents are more likely to be serious at higher maximum highway speeds than at lower ones, there may indeed be fewer accidents.

Gasoline consumption is a measure of driving intensity. We would expect this to be positively related to the dependent variables (fatalities, injuries, accidents).

The number of licences revoked for drunken driving is expected to be negatively related to the dependent variable. As police arrest and courts punish drunken driving with greater rigour, one would expect to find not only that drunken drivers are evicted from our roads, but that a warning is issued to potential drivers who drink that there is a severe punishment for driving under the influence. Both effects would be expected to reduce accidents, fatalities and injuries. Alternatively, we might observe increases in revocations as a result of increased fatalities (possibly reflecting a changing attitude of the courts).\footnote{Additionally, if increased revocations in the current period act as a deterrent to drunken driving, they may result (all else equal) in a reduction of revocations in a future period as fewer drunken drivers travel the roads. The revocations variable lagged one period was examined, as well as its current value, to account for a lagged effect of the deterring process of revocations. The lagged revocations variable was never significant, and so is not reported.}
Per capita personal income is included in the model to account for the economic constraints on individuals to maintain their motor vehicles and/or to maintain a social/economic image. Individuals in higher income brackets can afford more modern and safer cars. Hence, as income per capita increases over time one might expect a reduction in the value of the dependent variables, all else equal. Additionally, income may be related to education, which in turn, is related to the skill of drivers. An increase in drivers' skill over time would result in reduction of fatalities. However, as incomes rise, individuals can afford to drive more readily. As more and more drivers enter the roadways, one might expect an increase in accidents, all else equal.

The population variable is expected to be positively correlated with accidents, fatalities and injuries. The larger the population, the greater the number of potential victims for automobile accidents.

The number of vehicles registered, drivers licensed, and vehicle mileage are all measures of driving intensity and are expected to be positively related to the dependent variable. Only one of these three measures is included per model, since they are highly correlated with one another, and their contemporaneous linear inclusion in the model might lead to multicollinearity.

The GNP deflator was used to deflate the nominal income data to constant dollars, using 1972 as the base year.

A dummy variable (that is, a binary variable) was employed for measuring the effect of inspection. The binary variable takes the value of zero for years when inspection was not in practice (1929-1937) and the value of one for years when inspection was in force (1938-1979). We expect, a priori, that inspection will have a negative effect on the dependent variable. Dummy variables for the years of American involvement in World War II and for the Great Depression years were investigated also. World War II had a drastic impact on the production of automobiles for domestic consumption. Furthermore, the war effort reduced the availability of gasoline for pleasure driving and reduced the number of potential drivers, as many men were in the armed forces. The dummy variable for the Great Depression takes into account the effect of massive economic turmoil on motor-vehicle-related accidents, injuries and fatalities.

The dependent variables of this study were based on data for: fatalities, number of accidents reported, number of injuries, and the death rate (per 100 million vehicle miles).

All these data, other than the GNP deflator, may be considered specific for New Jersey.

The independent variables will explain changes in the dependent variable over time. Inclusion of the relevant independent variables in a model designed to be structurally correct (with all classical assumptions upheld) will result in unbiased

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3 Additional dummy variables were employed to measure the influence of truck inspection and motorcycle inspection. Additionally, inspection was measured as the number of inspections per year (0–2). These variables do not add significantly to this study, and they are not included. Interested readers may obtain these results from the authors.
estimates. Hence, in the analysis which follows, it is assumed that the final models evaluated are properly specified, that is, that they conform with classical assumptions.

Regression results on the fatality models — time series data

Ordinary Least Squares estimates were obtained for many variants of a measure of fatalities as a function of various independent variables. The OLS estimates suffered from serial correlation and were corrected by a Cochrane-Orcutt procedure.

Table 1 provides a list of definitions of variables, and Table 2 a set of regressions, using the level of fatalities as a function of various independent variables. It is interesting to note that the coefficient associated with the dummy variable for inspection is always negative and significant. It is also of great interest that the absolute value of this coefficient is relatively stable across model specifications. The $R^2$ figures indicate the percentage variation of fatalities, explained by the regressions as being between 0.9134 and 0.9332.

We have chosen equation 3 as the optimal model on the basis of the traditional criteria of: $R^2$, $t$-tests, signs of coefficients consistent with a priori expectations, apparent avoidance of serial correlation, and containing variables suggested by theory. An additional criterion was to select the model indicating the most conservative effect of inspection.

Equation 3 suggests: (1) a significant reduction of fatalities over time — a measure of technology or technological change; (2) a significant positive influence of income on fatalities; (3) a significant positive influence of population on fatalities; (4) a significant positive influence of registrations on fatalities; (5) a significant negative effect of inspection on fatalities; (6) a significant negative effect of the war years on fatalities. Thus the dummy variable for inspection indicates that fatalities are reduced by 304 deaths as a result of inspection. This was the most conservative estimate obtained from the models in Table 2. The coefficient obtained is significantly different from zero at the 1% significance level.

In order to add additional confidence to the finding that inspection reduces fatalities, a Chow-Test was performed after homoscedasticity had been verified by a Goldfeld-Quandt Test. The Chow-Test evaluates whether the coefficients in the model are stable over the entire period. If the universe from which we sample changes over time, we would expect the estimated coefficients to reflect this. We therefore investigated whether a model using the first nine observations (1929-1937) came from the same population as for the more recent period (1938-1979). The Chow-Test as applied to equation 3 (devoid of the dummy for inspection) rejects the hypothesis that the coefficients are stable over time.

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4 The maximum speed variable, when included in the models, had estimated coefficients which were not significant, so those results are not reported.
TABLE 1
Definitions of Variables

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T$</td>
<td>Time (1929-1979)</td>
</tr>
<tr>
<td>$RY_t$</td>
<td>Real per capita personal income in year $t$, i.e., ( \frac{\text{per capita personal income}_t}{\text{GNP price deflator}_t} )</td>
</tr>
<tr>
<td>$DDR_t$</td>
<td>Number of licences revoked for drunken driving in year $t$</td>
</tr>
<tr>
<td>$POP_t$</td>
<td>Population in year $t$</td>
</tr>
<tr>
<td>$REG_t$</td>
<td>Number of motor vehicles registered in year $t$</td>
</tr>
<tr>
<td>$D$</td>
<td>Dummy variable accounting for periods of inspection. The dummy variable takes on the value of one (1) for years in which inspection occurred and zero (0) otherwise.</td>
</tr>
<tr>
<td>$WW2$</td>
<td>Dummy variable accounting for direct American involvement in World War II. $WW2 = 1$ for years of American participation, 0 otherwise.</td>
</tr>
<tr>
<td>$GDEP$</td>
<td>Dummy variable denoting years of the Great Depression. $GDEP = 1$ during depression years, 0 otherwise.</td>
</tr>
<tr>
<td>$MILPDL$</td>
<td>Ratio of vehicle mileage to drivers licensed. This is a proxy for intensity of driving per potential driver.</td>
</tr>
<tr>
<td>$REGPDL$</td>
<td>Ratio of registrations to drivers licensed. This is a proxy of intensity of vehicle use.</td>
</tr>
<tr>
<td>$GASC$</td>
<td>Gasoline consumption (in gallons).</td>
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</table>

We also evaluated additional models having different dependent variables and structural forms. Models were estimated in terms of deaths per capita and deaths per 100 million vehicle miles, and natural log models with respect to deaths and deaths per capita where all non-binary variables were in natural log form. The results with regard to the dummy variable for inspection were consistently negative and significant. The magnitude of the coefficients associated with this dummy variable was stable for all variations of the model, by consistent measure
### TABLE 2

Regression Results of the Determinants of Fatalities\(^a, b\)

<table>
<thead>
<tr>
<th>Equation</th>
<th>Constant</th>
<th>T</th>
<th>RY</th>
<th>DDR</th>
<th>POP</th>
<th>REG</th>
<th>D</th>
<th>WW2</th>
<th>GDEP</th>
<th>MILPDL</th>
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<td>92.82</td>
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</tbody>
</table>

\(^a\) All models are estimated by the Cochrane-Orcutt procedure for the period 1929-1979.

\(^b\) Numbers in parentheses indicate t-statistics associated with the estimated coefficients.

\(*\), **, *** Indicate significance at the 99, 98 and 95% confidence intervals, respectively.

Equations are read horizontally, and differ from one another according to the variables included.
of the dependent variable. However, the results reported in Table 2 for the level of fatalities were, by and large, the most conservative estimates of the effect of inspection.5

Regression results on the injury models — time series data
Various models were estimated in order to evaluate the influence of inspection on injuries in New Jersey for the period 1932 to 1979. The results in general were that the coefficients associated with the inspection variable were negative, but not significant (at the α = 0.05 level).

Further, a few specifications resulted in positive coefficients. However, these were never significantly different from zero at reasonable α-levels.

No optimal model could be obtained for injuries while we used the same criteria as for the fatality equations. If these criteria are modified, or if one is willing to accept a model based on a smaller sample, significant negative coefficients result.

Several possible reasons must be postulated for the insignificant effect of inspection on injuries. The inspection process may be efficacious in discovering and correcting major safety violations in vehicles, but not minor ones. Also, the inspection process may serve as an educational device affecting drivers' attitudes towards the maintenance of vital safety factors in their vehicles, thereby reducing fatal accidents.

Regression results on the accident models — time series data
Table 3 presents the regression results on the level of accidents. Except in the case of equations 2 and 3, we can reject the null hypothesis that the coefficient associated with $D$ is equal to zero at the 0.02 or 0.01 level in favour of the two-tail alternative that the coefficient is not equal to zero. In the case of equations 2 and 3, the null hypothesis that the coefficient is equal to zero can be rejected at the 0.05 level in favour of a one-tail alternative hypothesis that the coefficient is less than zero.

Choice of an optimal model is more difficult in the case of accidents than in the case of fatalities. All models had $R^2$ statistics greater than 0.93, varying from 0.9371 to 0.9462. This indicates that the various models explained between 93.71 and 94.62 per cent of the variation in the dependent variable.

The inclusion of $GASC$ in the model resulted in the decline of the $t$-statistic associated with $T$ (equation 1 vs 2). The correlation coefficient associated with $T$ and $GASC$ is 0.979, indicating that multicollinearity may exist here. Equation 2 is thus omitted from the set of potential optimal models.

5The models for fatalities and accidents were evaluated without the dummy variable for inspection. As one would expect, the $R^2$ of the models including the dummy variable were always higher than for the associated models without the dummy, all else equal. Furthermore, the $R^2$ was always higher for the models with the dummy variable than for those omitting it, indicating a greater explanatory power of the models when the dummy variable is included.
### TABLE 3

**Regression Results of the Determinants of Accidents**

<table>
<thead>
<tr>
<th>Equation</th>
<th>Constant</th>
<th>RY</th>
<th>POP</th>
<th>D</th>
<th>T</th>
<th>GASC</th>
<th>REGPD</th>
<th>MILPD</th>
<th>$R^2/F$</th>
<th>DW</th>
<th>Estimation Technique</th>
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<td>1</td>
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<td>-5.31</td>
<td>13.97</td>
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<td>3.73</td>
<td>-24290.1</td>
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<td>9387</td>
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</tbody>
</table>

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**a** All models are estimated for the period 1929-1979.

**b** Numbers in parentheses indicate t-statistics associated with the estimated coefficients.

**c** CORC indicates that the equation was estimated by the Cochrane-Orcutt procedure, and OLS indicates estimation by Ordinary Least Squares.

* *, **, *** Indicate significance at the 99, 98 and 95% confidence intervals, respectively.

Equations are read horizontally and differ from one another according to the variables included.
The coefficients associated with \textit{REGPDL} and \textit{MILPDL} were never significantly different from zero; therefore equations 3, 4 and 5 are dropped from consideration.

Of the remaining equations (1, 6, 7), equation 6 has coefficients all of which are significantly different from zero at the 0.01 level. The inclusion of the population variable in equation 7 reduces the absolute value of the estimated coefficients and \textit{t}-statistics vis-a-vis equation 6. Since we expect population and real income to be important variables, their omission may result in biased estimates. Hence, equation 1 is chosen as the optimal model. The absolute value of the coefficient associated with \textit{D} in equation 1 is slightly larger than that in equation 7, and substantially smaller than that of equation 6. Hence, it provides a reasonably conservative estimate of the impact of inspection on accidents (based on the equations evaluated), that is, a reduction of 37,910 accidents per year.

IV. COST AND BENEFITS ASSOCIATED WITH MOTOR VEHICLE INSPECTION IN NEW JERSEY — A PARTIAL ANALYSIS

Section III provided statistical evidence of the efficacy of motor vehicle inspection. This is particularly noticeable in the consistent time series estimates on reduction of fatalities. The economic argument for periodic inspection, however, should be based on a benefit/cost analysis. This section applies the results of the model to a partial list of benefits and calculates a benefit/cost ratio. The analysis is performed with 1981 as a reference year.

Benefits

Deaths and injuries related to motor vehicles impose specific financial costs on individuals and society, including:

1. Reduction of potential output of society due to deaths.
2. Reduction of potential output of society while injured individuals are incapacitated.
3. Cost of medical, legal and insurance services (which otherwise would not have been expended) rendered to the victims and families of victims of accidents.
4. Property destroyed by accidents.
5. Lost income of families and friends of accident victims while they are tending and ministering to the victims (or themselves) instead of using their energies in alternative production processes.
6. Costs to society from pollution (air and noise) which may result in diseases as well as wasteful (inefficient) consumption of fuel.
7. Costs of enforcement activities related to the investigation of accidents.
8. Costs of activities of the Fatal Accident Review Board.
9. Costs of internal motor vehicle administrative activities.

Some of the above costs are not measurable (for example, pain and suffering),
and some are not measured in various studies because of lack of data. Nevertheless, the avoidance of these costs through motor vehicle inspection amounts to benefits due to the inspection system.  

Costs
A partial list of costs associated with inspection includes:

1. Direct cost of inspection.  
2. Cost to the driver of spending time in having a vehicle inspected (including travel time), as opposed to allocating that time to an alternative endeavour (opportunity cost).  
3. Additional repairs which would not have been made if it were not for inspection.  
4. Value of time expended in repairing the vehicle (including travel time).  
5. Cost in time and direct payment for reinspection.

Calculation of benefits
1. Benefits due to avoidance of deaths
The present value of the income stream lost by victims of fatal accidents has been estimated by Hartunian, Smart and Thompson (1980), hereafter called HST. They evaluate the present value of motor vehicle fatalities in 1975, using a 6 per cent discount rate and adjusting for sex and age grouping. Using their result, we calculate that the average present value of forgone earnings is $160,640 per victim. We assume that the national average is representative of New Jersey.

2. Benefits due to avoidance of damage to property
The HST study does not provide estimates of damage to property. However, the U. S. Department of Transportation, NHTSA (1976), estimates the average cost of damage to property per accident in 1975 as $519 when the accident entailed only damage to property. This figure includes: damage to the vehicle, insurance

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6 The estimates of benefits due to inspection in this study pertain to avoidance of real resource costs and net output losses associated with accidents and fatalities. Jones-Lee (1976) has suggested that the total benefit associated with saving a life should include an additional element — the average value of human life in itself. This latter benefit is equivalent under certain conditions to the population average of the marginal value of a decrease in risk, both direct and indirect (see Jones-Lee, section 5 IX). The estimated magnitude of this variable, according to Jones-Lee, is several times larger than the figure based on real resource cost and net output loss alone (p. 150). To this extent, our estimate is an underestimate of the true benefits of inspection. We thank an anonymous referee who brought this point to our attention.

7 This cost includes the opportunity cost of the use of the inspection facility.

8 See HST for definitions and assumptions. Their analysis takes into account the costs of insurance administration and legal and court costs, as well as the traditional direct and indirect costs which they enumerate.

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administration, legal and court costs, police accident investigation, and traffic delay. Fatalities and injuries also involve damage to property. Hence, the weighted average of costs would be higher than reported above. So $519 is a conservative figure.

Furthermore, we find that, for the period 1974-1980, 63 per cent of all accidents resulted in damage to property only. Our regression results suggest that accidents are reduced by 37,910. Assuming that 63 per cent of these accidents would have resulted in damage to property, we can estimate the value of property damage avoided, keeping in mind that this figure underestimates the true cost to society from property damage.

Table 4 provides the present value of selected accident costs in their nominal 1975 terms as well as in their CPI-adjusted 1981 values. The total present value figure comes to $103,467,670.

Given the list of potential benefits which were omitted, as denoted in Table 4, it is important that the reader be cognisant of the downward bias of this partial benefit figure.

Calculation of benefits based on alternative studies
Two additional estimates on 1975 accident costs were compiled by the National Safety Council (NSC) and the U. S. Department of Transportation, National Highway Traffic Safety Administration (NHTSA). These estimates differ from the HTS study in methodology employed and benefits included. Hence, caution should be exercised in making comparisons across the studies.

Table 5 provides the results of these studies together with the 1981 up-date of the figures by the consumer price index. It also provides the estimated present value of the selected benefits, based on the regression results of the previous section and the NSC and NHTSA estimates.

As can be seen from Tables 4 and 5, the estimates of benefits differ when different studies are used to provide cost data on fatalities and property damage.

Calculation of Costs
1. Cost of operating inspection facilities by State agencies (SE)
New Jersey’s Division of Motor Vehicles reports an expenditure of $14,514,474 for 1981. We assume away problems associated with amortisation. That this assumption is not heroic is indicated by U. S. Department of Transportation, NHTSA (1975), where it was found that costs are dominated by operating costs.

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9 This estimate is based on the ratio of the number of accidents resulting in property damage only to the total number of accidents. Data were provided by New Jersey DMV from Department of Transportation Reports.

10 See Henn (1981) on this. New Jersey’s DMV data do not include amortisation or rental price of capital information directly.

TABLE 4

Present Value (PV) of Benefits (partial list) *

<table>
<thead>
<tr>
<th>Event</th>
<th>PV per event (1975)</th>
<th>PV per event (1981)a</th>
<th>Regression coefficient</th>
<th>Probability associated with coefficient† for PV calculation purposes</th>
<th>PV of event (1981)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalitiesb</td>
<td>$160,640</td>
<td>$271,454</td>
<td>304</td>
<td>1</td>
<td>82,522,016</td>
</tr>
<tr>
<td>Property damagec</td>
<td>519</td>
<td>877</td>
<td>37,910</td>
<td>0.63</td>
<td>20,945,654</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$103,467,670</td>
</tr>
</tbody>
</table>

*The following benefits were not included in the analysis because reliable data and/or models were not available:
Reduction of fatalities and morbidity due to a reduction in air pollution.
Reduction of property damage due to a reduction in accidents involving fatalities and injuries.
Reduction of enforcement activities associated with accidents resulting in fatalities and injuries.
Reduction of Fatal Accident Review Board activities.
Reduction of internal motor vehicle administrative activities.
Reduction in gasoline/fuel usage.
Avoidance of pain and suffering.

†Property damage is evaluated from the regression on accidents and the estimate that 63% of all accidents involved property damage (only).

aInflated by the CPI
bBased on HST (1980)
cBased on U.S. Department of Transportation, NHTSA (1976).
### TABLE 5

*Alternative Calculations of Present Value (PV) of Benefits*

<table>
<thead>
<tr>
<th>Event</th>
<th>PV per event (1975)</th>
<th>PV per event (1981)</th>
<th>Regression coefficient</th>
<th>Probability associated with coefficient† for PV calculation purposes</th>
<th>Total PV of event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NSC</td>
<td>NHTSA</td>
<td>NSC</td>
<td>NHTSA</td>
<td>NSC</td>
</tr>
<tr>
<td>Fatalities</td>
<td>$110,000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$287,175&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$185,881&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$485,276&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$56,507,824</td>
</tr>
<tr>
<td>Property damage†</td>
<td>570</td>
<td>519</td>
<td>963</td>
<td>877</td>
<td>22,999,618</td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$79,507,442</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$168,469,558</td>
</tr>
</tbody>
</table>

*The following benefits were not included in the analysis because reliable data and/or models were not available:
- Reduction of fatalities and morbidity due to a reduction in air pollution.
- Reduction in gasoline fuel usage.
- Reduction in internal motor vehicle administrative activities.
- Avoidance of pain and suffering.*

†Property damage is evaluated using the regression on accidents and the estimate that 63% of all accidents involved property damage (only).

<sup>a</sup>Inflated via the CPI

<sup>b</sup>These figures include property damage, traffic delay, and accident investigation, which are not included in the HST estimates.
The Department of Environmental Protection reports another $600,000 in expenditures devoted to inspection. So the state expenditure for 1981 denoted as SE was $15,114,474.

2. **Opportunity cost associated with time spent bringing vehicles for inspection (OCTR)**
The opportunity cost associated with time expended bringing vehicles for inspection (that is, for travel) is estimated as:

\[
OCTR = REG \times TR \times WRATE
\]

where:
- \(OCTR\) = opportunity cost associated with travel time in 1981
- \(REG\) = number of cars inspected in 1981
- \(TR\) = average duration involved in travel time
- \(WRATE\) = average wage rate

Palmini and Rossi (1980) provide estimates of \(TR\) of 1.02 hours and \(WRATE\) of $5.92 in 1977. Inflating the wage rate by the consumer price index results in a wage rate of $8.88 for 1981. \(REG = 4,891,642\) in 1981. Hence,

\[
OCTR = 4,891,642 \times (1.02)(8.88) = 44,306,536
\]

3. **Opportunity cost associated with time spent waiting during the inspection process (OCW)**
The opportunity cost associated with waiting time may be calculated by the formula:

\[
OCW = WT \times WRATE \times REG
\]

where:
- \(WT\) = average waiting time = 9 minutes = 0.15 hours

\[
OCW = 0.15(8.88)(4,891,642) = 6,515,667
\]

4. **Vehicle usage costs for the inspection process (VHC)**
Vehicle usage costs are estimated as:

\[
VHC = REG \times VC \times MI
\]

where:
- \(REG\) = cars inspected
- \(VC\) = cost per mile of operating an automobile
- \(MI\) = average round trip to inspection station

\(VC\) and \(MI\) are reported by Palmini and Rossi (1980) as $0.18 per mile and 20 miles respectively. Hence,

\[
VHC = 4,891,642 \times (0.18)(20) = 17,609,911
\]

---

12 We are grateful to Mr. Daniel Cowperthwait of the New Jersey Department of Environmental Protection (DEP) for this information.

13 If time expended for inspection purposes is leisure time, the cost figures presented overestimate the true cost of inspection.

14 Data from New Jersey’s DMV.

15 Data supplied by New Jersey’s DMV.
Repair Costs
Repair costs and the associated benefits of repairs for items which, but for inspection, would not have been repaired, are not included in this analysis, because there is no consensus of opinion on whether inspection increases or decreases repair costs.  

Overall costs
The overall costs are estimated as the sum of the above, that is:

<p>| | |</p>
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<tr>
<td>1. SE</td>
<td>15,114,474</td>
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<tr>
<td>2. OCTR</td>
<td>44,306,536</td>
</tr>
<tr>
<td>3. OCW</td>
<td>6,515,667</td>
</tr>
<tr>
<td>4. VHC</td>
<td>17,609,911</td>
</tr>
<tr>
<td>Total cost (partial list)</td>
<td>83,546,588</td>
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</table>

Summary of costs and benefits — a partial analysis
On the basis of the HST estimates, our partial list of the benefits of inspection is $103,467,670, as compared to a partial list of costs of inspection of $83,546,588 for 1981. The ratio of the benefits to costs is approximately 1.24. If the partial lists of benefits and costs is representative of total benefits and costs, it appears that inspection is cost effective.

On the basis of the U. S. Department of Transportation, NHTSA estimates, our partial list of benefits due to inspection is $168,469,558, and therefore the ratio of benefits to costs is approximately 2.02. If the NSC estimate of benefits of $79,507,442 is used, the ratio drops to approximately 0.95.

The benefit/cost ratio takes on values between 0.95 and 2.02 according to the estimate of benefits. Since many benefits are not included in these estimates (for example, benefits of reduction in pollution), it is most probable that a benefit/cost ratio including the omitted benefits would be greater than 1. Furthermore, the HTS procedure is well documented and methodologically elegant. This cannot be readily said for the NSC and NHTSA reports. Therefore we have also more confidence in the estimated benefit/cost ratio based on the HTS study.

V. CONCLUSIONS
This study has presented a wide array of findings concerning some of the benefits and costs of motor vehicle inspection, with particular attention to the safety benefits and costs of the motor vehicle inspection system in the State of New Jersey.

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The study of the cost-effectiveness of the New Jersey inspection programme indicates that vehicle inspection in New Jersey significantly reduces the number of highway fatalities. The time series regression analysis reported in Section III shows that vehicle inspection in New Jersey reduces highway fatalities by 304 deaths per year. This result is obtained when other changes that also might affect fatalities are taken into account in the analysis. Though inspection appears to make a significant reduction in the number of highway fatalities, the models investigated do not show that it significantly reduces the number of highway injuries. Finally, the analysis indicates that inspection in New Jersey significantly reduces the number of highway accidents by 37,910 accidents per year.

Previous research on the effects of vehicle inspection on highway safety was reviewed in Section II. In general, the results of the earlier research do not show the kind of significant reductions in fatalities and accidents due to inspection that are indicated by the findings from the present study. However, the earlier econometric studies were based on cross-section data, as opposed to the time series results reported here.

A calculation of most of the costs associated with the New Jersey inspection programme, including the cost of operating the programme and costs incurred by drivers in undergoing inspection, resulted in a final figure of $83,546,588. A calculation of the partial list of benefits associated with the programme, as measured by the value of benefits connected with the avoidance of deaths and property damage, resulted in a final figure of $103,467,670 when the estimated figures from HST (1980) are used. The ratio of partial benefits to costs is approximately 1.24. This suggests that the New Jersey inspection system is cost-effective. It should be noted that the benefits measured in monetary terms are limited to those connected with the avoidance of deaths and property damage. Other benefits that might accrue from vehicle inspection (such as reduction in pollution) have not been included in the computation of the benefit/cost ratio. The value derived for that ratio is thus on the conservative side.

It would be interesting to determine, by using the methodology employed in this study, whether inspection would result in significant reductions in fatalities, injuries and accidents in other states. The difficulties associated with data collection should be weighed against the benefits of state-specific studies, especially during times of financial pressure when intensive efforts are being made to reduce the expenditures of state governments.

APPENDIX

Data Sources and Adjustments

We indicate below sources for series used in reported regressions.

Data on motor vehicle registrations, drivers licensed, vehicle mileage, traffic deaths, N. J. death rate per 100 million vehicle miles, and years when a state vehicle inspection was in force are found in New Jersey State Department of Law and Public Safety (1979).
Efficacy & Cost Effectiveness of Vehicle Inspection

P. D. Loeb & B. Gilad

Data on per capita personal income are from Supplement to Survey of Current Business, September 1956, for the years 1929-1947, and from U. S. Department of Commerce, Bureau of Economic Analysis, for the years 1948-1979.

Numbers of revocations for drunk driving were available for 1918-1958 from the annual reports of the New Jersey Division of Motor Vehicles, and for 1971-1981 from New Jersey Division of Motor Vehicles, Bureau of Driver Improvement. The data for missing years were estimated by means of a geometric mean to estimate growth rates when linear, exponential and moving average time series models had failed to extrapolate accurately.


Data on gasoline consumption (1929-1950) are from annual reports of the N. J. Division of Motor Vehicles. For 1953-1979 the data were provided by the Division of Motor Vehicles. Missing data for the years 1951 and 1952 were estimated by evaluating the growth rate of the appropriate portion of the series.

Data on numbers of injuries (1932-1979) are from: New Jersey Division of Motor Vehicles Annual Reports and Traffic Safety Service Summary of Motor Vehicle Traffic Accidents; U. S. Department of Transportation, Bureau of Accident Records, Summary of Vehicle Traffic Accidents; and the N. J. Department of Motor Vehicles, Division of Traffic Control and Regulation.

Data on numbers of accidents reported are from the N. J. Division of Motor Vehicles, Annual Reports (1916-1958), N. J. Traffic Accident Facts (1959-1966), and N. J. Department of Transportation Reports (1967-1980). Data were missing for the years 1930-1931 and 1952. The missing data for the earlier period were estimated from a geometric growth rate, and the 1952 observation was estimated as the mean of the values for 1951 and 1953.


REFERENCES


New Jersey State Department of Law and Public Safety, Division of Motor Vehicles: Annual Reports, various issues.


