A COMPARATIVE ANALYSIS OF TRUCK ACCIDENTS IN THE STATE OF MICHIGAN

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EXECUTIVE SUMMARY

The report presented here is the result of a study conducted at the Civil Engineering Department of Wayne State University, Detroit, during the period of September 1978 to March 1979. The study was sponsored by the Motor Vehicle Manufacturers Association of the U.S., Inc. and was conducted with the objective of analyzing truck accident experience in the State of Michigan relative to all other motorized vehicles (non-trucks) in the light of the available historical data.

A two stage analysis of the accident and travel data was conducted. In the first stage a comparison of accident data, categorized into three severity schemes (fatal, personal injury and property damage), was conducted between trucks and non-trucks. In the second stage, truck accident data was further classified into three groups, namely: pickups/panels/vans (PPV's), straight trucks (dumps, stakes, etc.) and truck tractors. A comparison of the accident data was made between each truck category and all other non-trucks separately. Also, the accident data for the three truck categories were compared among themselves.

The research approach consisted of collecting historical accident and exposure data for the State of Michigan for these vehicular categories, computing annual accident rates and comparing these rates using appropriate statistical methods. The rates were derived by dividing the number of accidents by the corresponding exposure data as indicated by the number of vehicle miles of travel (VMT). These rates were developed for three types of accidents as well as for all accidents considered together.

The conclusions of the stage 1 analysis are that for fatal and property damage accidents, trucks had a higher rate than non-trucks; for injury accidents trucks had a lower rate; and for all accidents considered together, there is no significant difference between the accident rates. The Stage 2 analysis indicated that in almost all accident categories PPV's and straight trucks had a higher accident rate than non-trucks, while truck tractors had a higher rate for fatal accidents only. In all other severity categories, truck tractors had a lower rate than non-trucks. Further, a comparison among the three truck categories indicated that straight trucks had the highest accident record, followed by PPV's and truck tractors. Truck tractors, however, had a higher accident rate compared to PPV's in the case of fatal accidents.

A number of recommendations for further studies are made in this report. These include, (1) Comparison of truck accidents with passenger cars, (2) A further comparison of severity of injuries between trucks, passenger cars and non-trucks, (3) Comparison of accident data for trucks, passenger cars, and non-trucks, further segregated into roadway types, (4) A similar analysis with data from a comparable state and/or, with nationwide data, (5) A micro-level analysis of a number of sample truck accident records from a smaller study area with emphasis on identification of causative factors such as weather, traffic control, vehicles, drivers, and (6) An in-depth analysis of factors contributing to the general upward trend of truck accidents. These studies, when duly completed, are expected to provide critical insights to safety researchers that could be used to improve the safety aspects of the driver-vehicle-roadway environment.

1. INTRODUCTION

The safety aspects of our transportation systems, consisting of the driver-vehicle-roadway environment, have attracted research attention for a number of years. Considerable research attention has been given toward the improvement of a system that accounts for over 50,000 annual fatalities in this country.

The prime users of roadway facilities in the United States, categorized under motorized vehicles include: passenger cars, trucks, buses, other commercial vehicles, and motorcycles. Of these, passenger vehicles account for the largest share of total travel, followed by trucks. For example, it is estimated that over 75% of total travel by motorized vehicles in the State of Michigan, expressed in vehicle miles of travel (VMT), is generated by passenger vehicles.[1] Trucks account for approximately 15% of total travel with the remaining 10% being attributable to all other motorized vehicles.

The role of trucks in highway accidents has been a subject of research interest for a number of years. Truck related accidents have been considered to account for a sizable portion of all highway accidents. As an example, during the year 1977, a total of 374,751 highway accidents were reported in the State of Michigan of which 84,640 involved trucks (22.5%). While a total of 631,259 motorized vehicles were involved in such accidents, trucks accounted for approximately 91,000 of these vehicles (14%). Lastly, of a total of 1,741 fatal accidents reported in Michigan in 1977, as many as 492 can be considered to be related to trucks (28%).

Questions have been raised by researchers as to the relative role of trucks and all other vehicular categories in the incidence of traffic accidents. There are two different viewpoints expressed by safety experts that need mention in this context. One group proposes that, historically, trucks have been involved in a disproportionately larger number of accidents compared to all other vehicles. The other group contends that there are no significant differences between accidents experienced by these two vehicular categories (namely trucks, and all other vehicles including passenger cars), when the accident data are duly adjusted for their corresponding exposure factors.

The purpose of the research reported here is an objective investigation of this question based upon an analysis of factual data on accident and highway travel, using the State of Michigan as the experimental site. The report represented here is the result of a study conducted at the Civil Engineering Department, Wayne State University, during a six month period from September, 1978 to March, 1979. The study was sponsored by the Motor Vehicle Manufacturers Association of the U.S., Inc. and represents an effort to compare the accident experience of trucks and other vehicular categories, termed as non-trucks in the State of Michigan.

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[1] One Vehicle traveling over a distance of one mile accounts for one VMT of travel. VMT is the most common measure of traffic exposure used in accident analysis.

1.1 Study Objectives

The specific objectives of this study were as follows:

- To examine and review various available data sources related to accidents and traffic exposure for their potential use in future research activities.

- To collect from available data files, inventories and other reports, historical accident and exposure data for trucks, as well as all other motorized vehciles (non-trucks) for the State of Michigan.

- To compare the historical accident data for these vehicular categories (namely trucks vs. non-trucks) in the State of Michigan and to draw conclusions regarding the role of trucks in highway accidents in the State.

- To further classify the truck accident and exposure data into various truck categories and to analyze the accident experiences of these categories, as they are compared among themselves, as well as with all other motorized vehicles (non-trucks).

While the primary prupose of this research was to conduct an analysis of truck accident data, a secondary purpose was to identify various other data sources which may facilitate further research in this general area. An extensive literature survey was conducted as a part of this study; as a result of this search, a number of data sources were identified and reviewed. These are documented at appropriate sections within this report.

1.2 General Methodology

A two stage analysis of the accident and travel data was conducted in this study; as mentioned earlier, the State of Michigan was used as the experimental site. In the first stage, a comparison of accident data (categorized into three severity classifications and corrected for exposure factors) was conducted between all trucks and all other motorized vehicles. The research approach consisted of collecting historical accident and exposure data for the State of Michigan for trucks and non-trucks and comparing these rates using appropriate statistical methods.

Accident rates for both vehicular categories were derived by dividing the number of accidents by the corresponding VMT generated. These rates were developed for all three types of accidents, (fatal/injury/property damage) as well as for all accidents considered together (total). The result of this analysis provides insights regarding the general role of trucks (independent of truck type) in the incidence of accidents.

In the second stage of this analysis, the truck data was further classified into finer groups with the objective of studying in greater detail the truck accident phenomenon. Three categories of trucks were considered:

1) Pickups, Panels and Vans (PPV's)
2) Straight Trucks (dumps, stakes, etc.)
3) Truck Tractors (semi) or Road Tractors

A separate and independent comparison was made between the accident rates for each truck category and the similar rate for all other motorized vehicles. Further, a comparison of the accident data between the three truck categories themselves was made in the second stage analysis. The second-stage analysis provides more insight into the particular type of trucks that may have experienced higher accident rates compared with all other motorized vehicles.

The scope of this study did not include the actual collection of any new field data. Rather the emphasis of this research was to maximize the use of available information with the objective of determining the historical role of trucks in the involvement of highway accidents.

1.3 Collection of Accident Data

The accident data for the analysis were collected from different publications of the Michigan Department of State Police and the U.S. Department of Transportation. The following data sources were used quite extensively for the purpose of this research.

1. Michigan Traffic Accident Facts - Prepared annually by the Michigan Department of State Police (1).[1]

2. Motor Vehicles Accident Tape Layout - Maintained annually by the Michigan Department of State Police.

3. Highway Statistics - Prepared annually by the U.S. Department of Transportation (2).

4. Census of Transportation - Prepared by the U.S. Bureau of the Census every five years (1967 and 1972) (3).

5. Fatalities, Fatal Accidents and Travel - Published annually by the U.S. Department of Transportation (5).

6. American Trucking Trends - Published annually by the American Trucking Association (4).

1.4 Collection of Travel Data

Information on the number of million vehicle miles of travel (VMT) were estimated indirectly from a number of sources. The total VMT data of all motorized vehicles for the entire state were available from the records of the Michigan Department of State Highways and Transportation (MDSH&T). Information on gas tax receipt monies and traffic data collected by the agency

[1] See list of References for details.

as a part of the regular traffic updating procedure constitutes the two primary sources for such VMT data. The VMT data obtained from MDSH&T served as the control total for the State for a given year. These control totals were apportioned into different vehicular categories using approximate estimating techniques. These are duly reported in the next section.

The reports published by the U.S. Bureau of Census on the five year Census of Transportation (Truck Use and Inventory Survey) for the years 1967 and 1972 (3) were also used in this research to conduct an independent check of the reasonableness of the VMT data generated by different estimating techniques. The 1977 census report was not published as of the writing of this report; as such, it was not possible to use the 1977 census report.

1.5 Statistical Analysis

The statistical analysis, termed as 't-tests concerning the difference between the means' was conducted with a view to testing the significance of the difference between mean accident rates of the two vehicular categories to be compared. This was accomplished by developing the accident rates for each year for each 'vehicular category - accident type' combination and comparing these rates following standard statistical procedures. Necessary accident and exposure data were stored in computer files and a computerized statistical package entitled MIDAS developed by the Statistical Research Laboratory, the University of Michigan, was used for comparing the accident rates (7).

A null hypothesis was defined and tested with the accident data as follows:

> Null Hypothesis: There is no significant difference between the mean accident rates as compared between trucks and non-trucks (Stage 1) and between three truck categories and non-trucks (Stage 2).

The hypothesis testing was conducted by computing a particular statistic "t", where "t" is a measure of the difference between the two mean accident rates compared. The calculated "t" value was then compared with an appropriate critical "t" value obtained from standard statistical tables for the corresponding Degrees of Freedom (DF) and confidence interval used. The number of Degrees of Freedom is essentially a function of the sample size and generally equals the number of data points minus 2. A 90 percent level of confidence was used in this analysis. If the calculated "t" value was smaller than the critical "t" value, the hypothesis was accepted. A higher "t" value resulted in the rejection of the null hypothesis. The implication of the acceptance or rejection of the hypothesis is as follows:

1. The acceptance of the null hypothesis would signify that there is no real difference between the accident rates of the two vehicular categories. Whatever small difference might be observed between two data sets, is indeed, attributable to random chance and is not indicative of any real difference.

2. The rejection of the hypothesis would imply that there is a significant difference between the mean accident rates of the two vehicular categories.

2. RESULTS OF STAGE 1 ANALYSIS

The result of the Stage 1 analysis, where a comparison of accident rates for trucks and non-trucks was made with historical data from Michigan is reported in this Chapter. Details of exposure data, accident data and statistical analysis are furnished in the following sections.

2.1 Estimation of Exposure Data

The total amount of travel generated within a given study area is generally estimated by computing the number of "vehicle miles of travel (VMT)", where one vehicle traveling through a distance of one mile will account for one VMT of travel. As a part of Stage 1 analysis of this project, annual VMT data of a number of vehicular categories were calculated for the period between 1963-1977. These are detailed below:

Truck VMT Data: There were two primary sources for calculating truck VMT data, namely: The Highway Statistics (2) and The American Trucking Trends (4). For each of these two sources, total VMT was calculated by multiplying the number of trucks registered in the State of Michigan by the average travel rate in miles per truck, computed from nationwide data. The implicit assumption was that there is no significant difference in the nationwide and statewide travel rates. Since data on travel rate by trucks or non-trucks for the State of Michigan was not available, such an assumption was necessary.

The VMT data generated were compared with a third independent data source, namely, the five-year census data on transportation prepared by the U.S. Bureau of Census (3). The census data was available only for the years 1967 and 1972. As such, it was possible to conduct an independent check of the VMT data derived from Highway Statistics and American Trucking Trends only for the year 1967 and 1972. It must be pointed out that the census data is totally based on information collected through "Truck use and Inventory" survey for the State of Michigan. Furthermore, it was found that the data generated from these three sources were relatively close to each other. The relative closeness of the data from these three independent sources, (namely Highway Statistics, American Trucking Trends, and Census Reports) indicated that the information generated was realistic.

It was also assumed that the travel generated by out-of-state trucks was balanced by travel generated outside the State by vehicles registered within Michigan. No explicit effort was thus made to account for truck travel generated in the State by out-of-state trucks, or discount travel generated by Michigan trucks outside the State boundaries.

Tables 1 and 2 present the data obtained from these sources. Unfortunately, data from American Trucking Trends was not available for periods after 1973. The non-availability of such data was, however, not considered a serious impediment, as the data from these two sources were reasonably close to each other, as evidenced from the last column of the two tables. A decision was made to use the data from Highway Statistics for the analysis of the accident data, as this was most readily available.

TABLE 1. VMT FOR TRUCKS IN MICHIGAN[1]

Year	Average Miles Traveled Per Truck In U.S.	Number Of Trucks Registered In Michigan	Truck Vehicle Mile$_6$ In Mich. x10^6
1963	11,644	429,014	4,995
1964	11,723	454,244	5,325
1965	11,737	482,507	5,663
1966	11,207	496,134	5,560
1967	11,204	533,564	5,978
1968	11,571	569,641	6,591
1969	11,565	602,138	6,963
1970	11,450	637,655	7,301
1971	11,465	673,908	7,726
1972	12,229	731,756	8,948
1973	11,538	790,430	9,119
1974	10,846	850,594	9,225
1975	10,648	903,159	9,616
1976	11,073	961,333	10,644
1977	11,145	1,017,109	11,335

[1] Source: Highway Statistics

TABLE 2. VMT FOR TRUCKS IN MICHIGAN[1]

Year	Trucks Registered In U.S.	VMT For Trucks In U.S. x 10^6	Av. Miles Travel Per Truck In U.S.	Trucks Registered In Michigan	VMT For Trucks In Michigan x 10^6
1963	12,659,102	155,569	12,289	405,865	4,987
1964	13,282,556	164,271	12,367	426,988	5,280
1965	14,026,045	171,436	12,222	458,299	5,601
1966	14,721,307	173,905	11,813	466,638	5,512
1967	15,358,952	181,445	11,813	499,946	5,905
1968	16,104,924	196,651	12,210	531,867	6,494
1969	16,974,011	206,680	12,176	583,262	7,101
1970	17,789,280	214,670	12,067	597,145	7,205
1971	18,841,935	227,037	12,049	635,352	7,655
1972	20,225,504	259,735	12,841	692,559	8,893
1973	22,095,774	270,336	12,234	750,346	9,179

[1]Source: American Trucking Trends

Fig 1. TRUCK REGISTRATION IN MICHIGAN

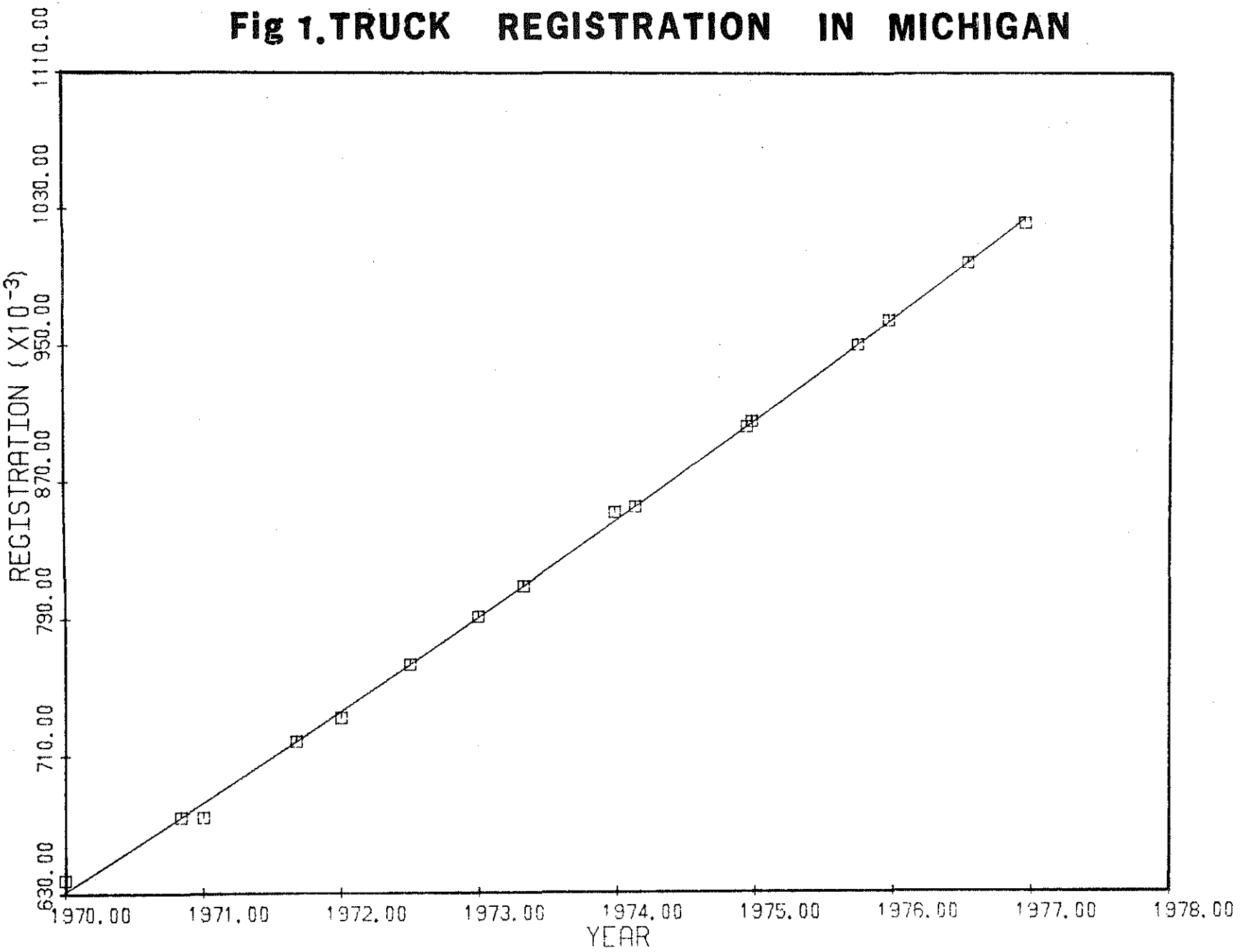
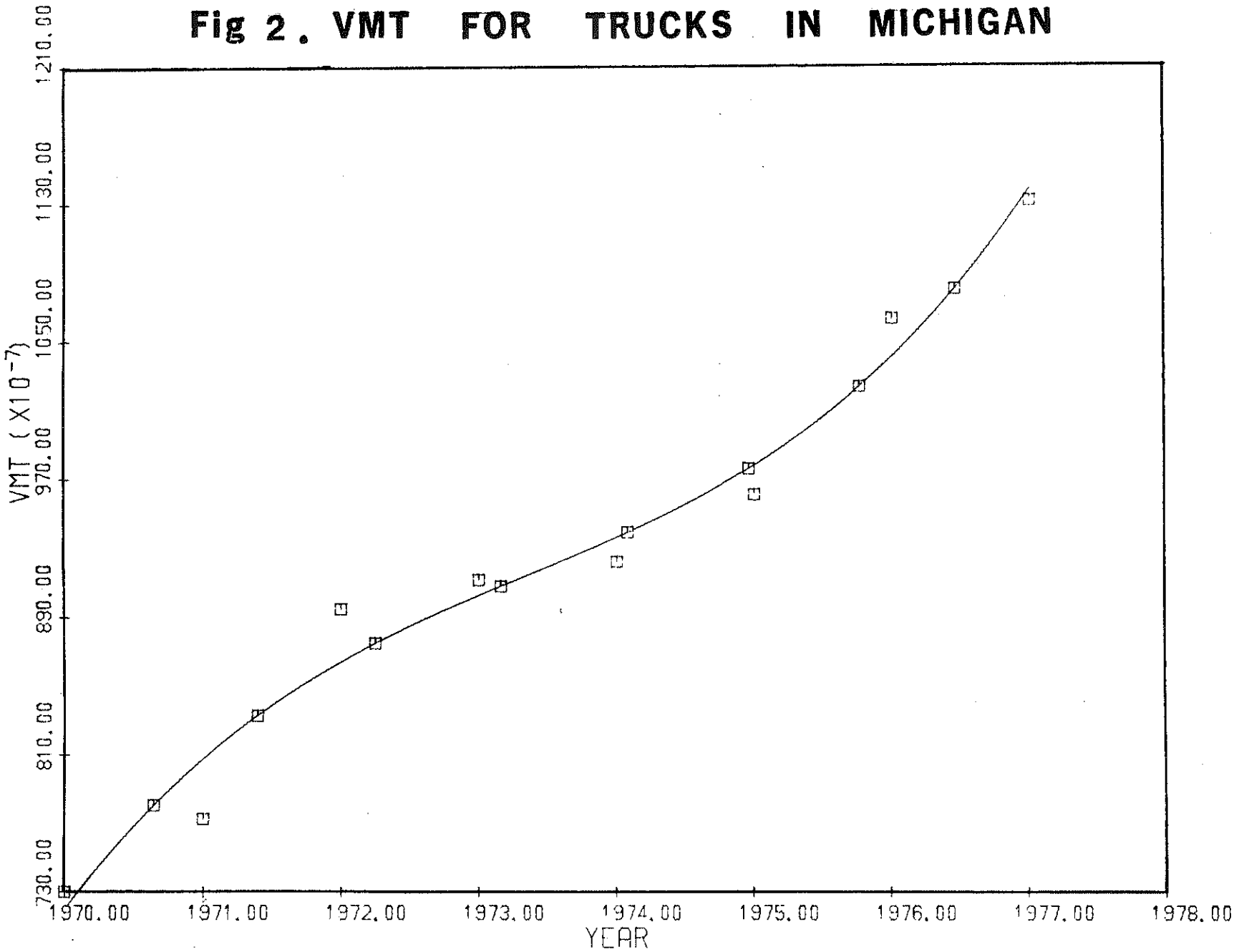


Fig 2. VMT FOR TRUCKS IN MICHIGAN



Both Tables 1 and 2 indicate a steady increase in the total truck travel in the State of Michigan during the last 15 years, excepting during the 1973-1974 period, when growth may have been stalled presumably due to the gasoline crisis. Although truck exposure data was compiled for the period starting 1963, the availability of the accident data precluded the analysis for years preceding 1970. Figures 1 and 2 show the truck registration and VMT data for the period between 1970 and 1977[1]. The rising trend in truck travel is quite clear from these two graphs.

Passenger Car VMT Data: The same principle was utilized in developing VMT data for passenger cars for the State of Michigan, using data from Highway Statistics for the period 1963-1977. As Table 3 indicates, during the 1973-1974 period, there was a reduction in passenger car travel in the State, as expected due to the oil embargo. Figures 3 and 4 show the registration and VMT data for passenger cars in the State during the period 1970-1977. The data in Table 3 were used to plot these curves.

Total VMT: Total VMT generated in the State of Michigan, by all motorized vehicles (including trucks, passenger cars, buses , motorcycles, etc.), are computed by the State Highway Department from gasoline tax receipts on a regular basis. This data was directly available from the report entitled, Michigan Traffic Accident Facts, prepared by the Michigan Department of State Police (1).

Table 4 summarized the VMT data compiled for these vehicle categories as described above. The last three columns of Table 4 indicate the VMT data for all motorized vehicles (as available directly from the State Police), for passenger cars (as described in Table 3) and for all other motorized vehicles (except trucks) respectively. Data for all other motorized vehicles was calculated as the simple difference between total VMT and truck VMT as presented in earlier tables.

The first three columns of Table 4 shows the VMT data for trucks only. It must be noted that the truck VMT data from the three different sources[2] are in close agreement with one another. For example, Table 4 shows that during the year 1967 the estimated truck travel in Michigan was 5978, 5905, and 6161 million vehicle miles as calculated from these three sources. These three columns again substantiate the fact that the use of the travel rate for the Highway Statistics did not introduce much error to the analysis.

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[1] A computer software, along with a plotter program was used to develop all curves presented in this report. It is to be noted that for each data point specified, the program internally generates a synthetic data point using the principles of least square. As such, two sets of data points appear in these curves, one the actual point and the other the synthetic point or calculated data point (Ref. GPLOT General Plotting Program, WSU Computing Services Center, 1975).

[2] The 1977 Census Report on Truck Use and Inventory Survey for the State of Michigan was not available as of the writing of this report.

TABLE 3. VMT FOR PASSENGER CARS (PC) IN MICHIGAN[1]

Year	Average Miles Travelled Per PC in U.S.	Registered P.C.'s In Michigan	VMT For P.C.'s in Michigan x 10^6
1963	9,240	3,160,610	29,204
1964	9,286	3,293,526	30,583
1965	9,255	3,496,749	32,362
1966	9,506	3,515,729	33,420
1967	9,531	3,587,441	34,191
1968	9,627	3,734,339	35,950
1969	9,782	3,873,379	37,889
1970	9,978	3,918,113	39,094
1971	10,121	4,052,218	41,012
1972	10,184	4,265,042	43,435
1973	9,992	4,435,673	44,321
1974	9,494	4,536,177	43,066
1975	9,634	4,627,816	44,584
1976	9,733	4,726,259	46,000
1977	9,839	4,954,235	48,744

[1] Source: Highway Statistics

Fig 3. PASSENGER CAR REGISTRATION IN MICHIGAN

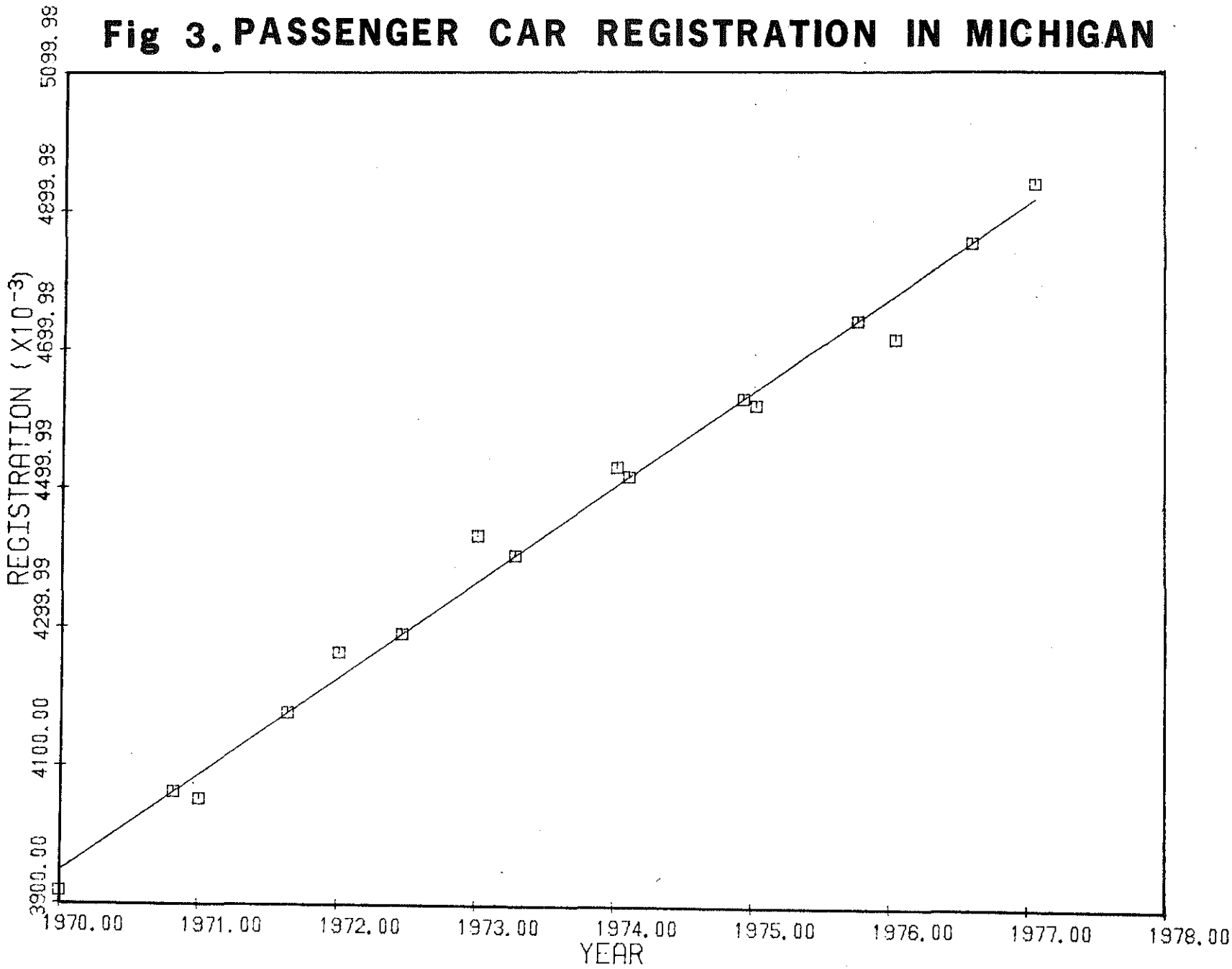

Fig 4. VMT FOR PASSENGER CARS IN MICHIGAN

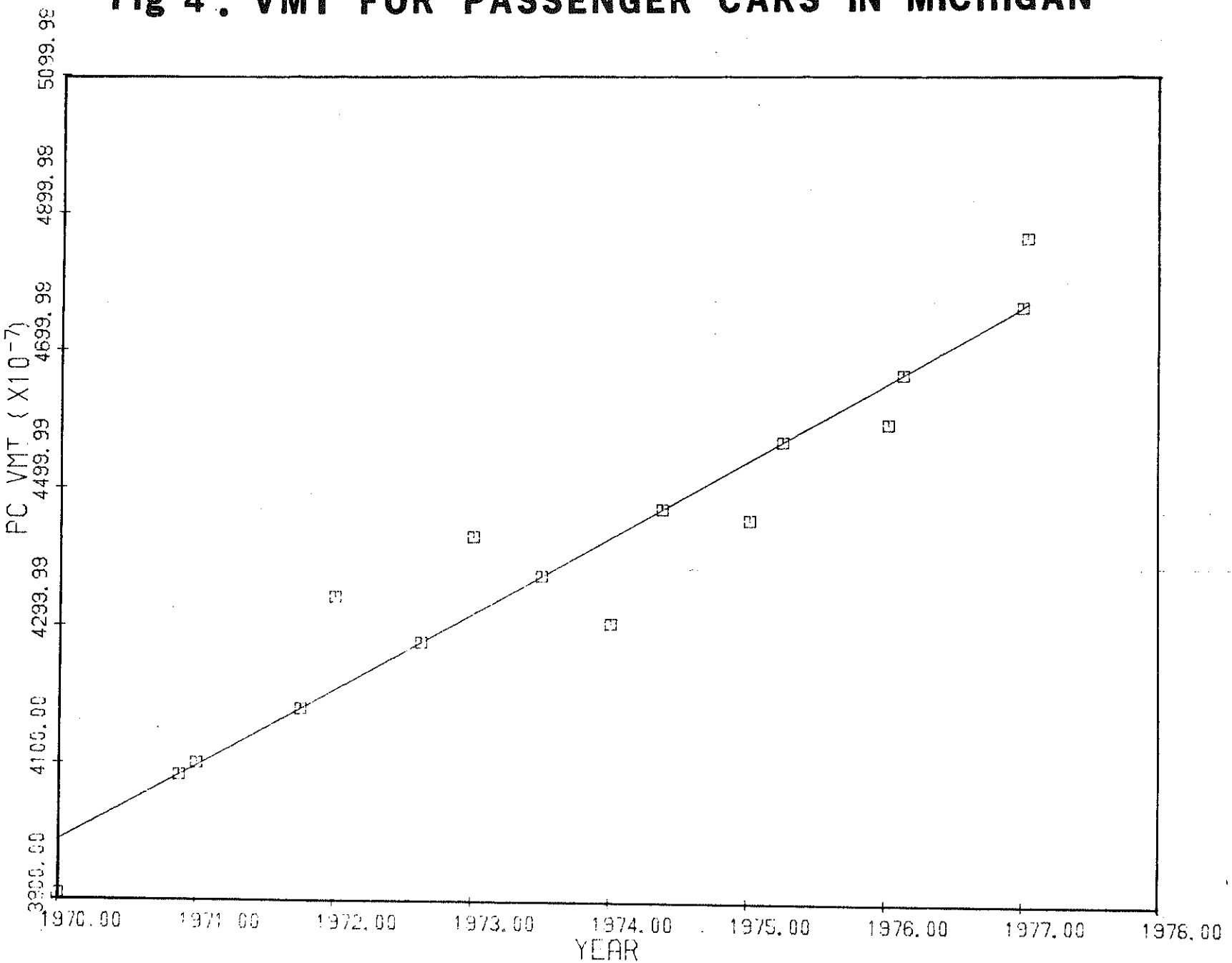

TABLE 4. SUMMARY OF VMT OF TRUCKS AND PASSENGER CARS (PC)

Year	Truck VMT x 10^6			VMT Of All Motorized Vehicles Except Trucks x 10^6	VMT of P.C.'s x 10^6	Total VMT In Mich. x 10^6
	Highway Statistic	American Trucking Association	Census Of Transportation (5 Yearly)			
1963	4,995	4,987		31,460	29,204	36,452.2
1964	5,325	5,280		33,314	30,583	38,617.6
1965	5,663	5,601		35,225	32,362	40,857.4
1966	5,560	5,512		38,403	33,420	43,940.1
1967	5,978	5,905	6,161	39,111	34,191	45,053.6
1968	6,591	6,494		41,504	35,950	48,047.4
1969	6,963	7,101		43,872	37,889	50,904.9
1970	7,301	7,205		45,894	39,094	53,148.1
1971	7,726	7,655		47,848	41,012	55,539.7
1972	8,948	8,893	8,975	48,896	43,435	57,817.1
1973	9,119	9,179		49,328	44,321	58,478.4
1974	9,225	NA[1]		46,522	43,066	55,748.4
1975	9,616	NA[1]		46,644	44,584	56,260.5
1976	10,644	NA[1]		50,993	46,000	61,638.0
1977	11,335	NA[1]	NP[2]	53,518	48,744	64,853.0

[1]NA - Not Available

[2]NP - Not Published as of the Writing of This Report

2.2 Accident Data Analysis

The major source of accident data in this study is the accident data inventory maintained by the Michigan Department of State Police. All reported accidents in the State are recorded in the above inventory file; as such, the data base used in the analysis is considered the most comprehensive.

Accident data was collected in four separate categories, namely, fatal, personal injury (PI), property damage (PD) and total. The number of accidents recorded in a given year was divided by the appropriate VMT to develop accident rates. Rates, rather than frequencies, are generally considered more appropriate representation of accidents, because the exposure factor is duly taken into account in the calculation of rates.

In this analysis, two types of rates were computed. In the first category, the numerator used in computing the rates was the number of vehicles (of the appropriate category) involved in a given type of accident (e.g. fatal, PI, etc.). In the second category, the number of accidents of a specified type in which a truck or a non-truck[1] was involved, was used in the numerator. Further, although rates were computed in these two categories, the statistical analysis conducted to test the relative degree of involvement by trucks in accidents was done only for the second category, i.e., number of accidents (as opposed to number of vehicles). This was done in conformance with standard practices followed in most accident data analysis.

Analysis Based on Number of Vehicles: Tables 5, 6, and 7 respectively, represent the accident data showing the number of trucks, number of passenger cars and number of non-trucks involved in any one of the four accident categories for the years 1966 through 1977. As an example, Table 5 indicates that in the year 1966, a total of 352 trucks were involved in fata accidents. The corresponding numbers in the injury, property damage and total categories are 11,068; 29,400, and 40,828, respectively (indicating the involvement of 11,068 trucks in injury accidents, etc.). These figures, namely the number of vehicles involved in accidents, are to be clearly distinguished from the number of accidents (in which these vehicles were involved) to be presented in the tables which follow.

Table 8 shows the rates derived by dividing the accident data represented in the three preceding tables (i.e., number of vehicles) by the corresponding VMT for the analysis period 1966-1977. Also, included in the bottom of this table is the average rate computed by summing up all the yearly figures and dividing by the number of observations. As an example, Table 8 indicates that, on an average (based on 1966-1977 data) for every 100 million VMT of truck travel, the number of trucks involved in fatal accidents is 5.01. Similarly, for every 100 million VMT of passenger car travel, a total of 5.43 vehicles are involved in fatal accidents. The corresponding figure for all non-trucks is 5.27.

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[1] Any motorized vehicle that is not a truck is considered a non-truck in this study. This includes busses, motorcycles, etc. as well as passanger cars.

TABLE 5. NUMBER OF TRUCKS INVOLVED IN ACCIDENTS IN MICHIGAN AND VMT DATA

Year	Type of Accidents				Truck VMT x 10^6
	Fatal	Personal Injury (PI)	Property Damage (PD)	Total	
1966	352	11068	29400	40828	5560
1967	324	11237	29335	40896	5978
1968	360	13502	32377	46239	6591
1969	412	16076	39006	55494	6963
1970	384	15383	36281	52048	7301
1971	392	13502	35841	49735	7726
1972	422	16223	42021	58666	8948
1973	454	17296	45365	63115	9119
1974	365	15879	46052	62296	9225
1975	381	17019	47945	65345	9616
1976	469	20608	58450	79527	10644
1977	532	23744	66818	91094	11335

TABLE 6. NUMBER OF PASSENGER CARS INVOLVED IN ACCIDENTS IN MICHIGAN AND VMT DATA

Year	Type of Accident				Passenger car VMT x 10^6
	Fatal	PI	PD	Total	
1966	2521	159,975	341,027	503523	33,420
1967	2268	149,967	307,430	459665	34,191
1968	2514	156,426	305,386	464326	35,950
1969	2426	172,895	346,561	522102	37,889
1970	2223	162,420	313,628	478271	39,094
1971	2170	153,575	319,782	475527	41,012
1972	2278	170,034	351,260	523572	43,435
1973	2165	159,823	337,815	499803	44,321
1974	1766	133,307	312,864	447937	43,066
1975	1699	139,727	328,048	469474	44,584
1976	1918	152,039	350,751	504708	46,000
1977	1886	154,072	350,962	506920	48,744

TABLE 7. NUMBER OF ALL OTHER MOTORIZED VEHICLES (NON-TRUCKS) INVOLVED IN ACCIDENTS IN MICHIGAN AND VMT DATA

Year	Type Of Accident				Non-Truck VMT x 10^6
	Fatal	P.I.	P.D.	Total	
1966	2668	167353	349727	519748	38403
1967	2427	156219	325036	483682	39111
1968	2697	163358	314250	480305	41504
1969	2853	180718	356047	539618	43872
1970	2431	171472	324339	498242	45894
1971	2399	163888	332888	499175	47848
1972	2555	183582	372909	559046	48896
1973	2455	175038	360299	537792	49328
1974	2056	146516	335287	483859	46522
1975	1944	152163	352005	506112	46644
1976	2136	164380	376062	542578	50993
1977	2143	166568	376454	545165	53518

TABLE 8. ACCIDENT RATES PER VEHICLE MILE OF TRAVEL FOR TRUCKS, PASSENGER CARS (PC), AND NON-TRUCKS (NO. OF VEHICLES INVOLVED/VMT)

Year	Truck Accident Rates				P.C. Accident Rates				Non-Truck Accident Rates			
	Fatal $\times 10^{-8}$	P.I. $\times 10^{-6}$	P.D. $\times 10^{-6}$	Total $\times 10^{-6}$	Fatal $\times 10^{-8}$	P.I. $\times 10^{-6}$	P.D. $\times 10^{-6}$	Total $\times 10^{-6}$	Fatal $\times 10^{-8}$	P.I. $\times 10^{-6}$	P.D. $\times 10^{-6}$	Total $\times 10^{-6}$
1966	6.33	1.99	5.29	7.34	7.54	4.79	10.2	15.1	6.95	4.36	9.11	13.5
1967	5.42	1.88	4.91	6.84	6.63	4.39	8.99	13.4	6.20	3.99	8.31	12.4
1968	5.46	2.05	4.91	7.01	6.99	4.35	8.49	12.9	6.50	3.94	7.57	11.6
1969	5.92	2.31	5.60	7.97	6.98	4.56	9.15	13.8	6.50	4.12	8.12	12.3
1970	5.26	2.11	4.97	7.13	5.69	4.15	8.02	12.2	5.30	3.74	7.10	11.0
1971	5.07	1.75	4.64	6.44	5.29	3.74	7.79	11.6	5.01	3.42	6.96	10.4
1972	4.72	1.82	4.70	6.55	5.24	3.91	8.08	12.0	5.22	3.75	7.63	11.4
1973	4.98	1.90	4.94	6.92	4.88	3.61	7.62	11.3	4.98	3.55	7.30	10.9
1974	3.96	1.72	4.99	6.75	4.10	3.09	7.26	10.4	4.42	3.15	7.21	10.4
1975	3.96	1.77	4.99	6.79	3.81	3.13	7.36	10.5	4.17	3.26	7.55	10.8
1976	4.41	1.94	5.49	7.47	4.17	3.30	7.62	11.0	4.19	3.22	7.37	10.6
1977	4.69	2.09	5.89	8.04	3.87	3.16	7.20	10.4	4.00	3.11	7.03	10.2
Yearly Average	5.01	1.94	5.11	7.10	5.43	3.85	8.15	12.05	5.27	3.63	7.60	11.29

Analysis Based Upon Number of Accidents: Tables 9 and 10 represent data on number of accidents in which trucks and non-trucks were involved in any one of the four accident categories[1] along with the corresponding VMT data. The availability of accident data in this case precluded the analysis to be extended prior to 1970. Table 9 indicates that during the year 1970, there were a total of 363 fatal accidents in which at least one truck was involved. Similarly, Table 10 indicated that during the same year, a total of 1,500 fatal accidents occurred that did not involve any truck. It must be noted that these numbers are mutually exclusive and the sum of these two figures represent the total number of fatal accidents in the State in which at least one motorized vehicle was involved during the year 1970.

The accident rates derived by dividing the number of accidents by the corresponding VMT are presented in Table 11. The overall average is also shown in the last row of this table. This table indicates that for the analysis period between 1970 through 1977, for every 100 million vehicle miles of truck travel, there was an average of 4.305 fatal accidents. Similarly, for every 100 million vehicle miles of travel by non-trucks (i.e., all other motorized vehicles) an average of 2.90 fatal accidents occurred. All other numbers in Table 11 are to be interpreted similarly.

These historical trends in accident occurrence rates were plotted using data from Table 11 and are shown in Figure 5 through 12. Data for trucks and non-trucks appear successively in these figures for each of the four accident categories. Figures 5 and 6 show that for fatal accidents there is a gradual decreasing trend for both of these vehicular categories. In each of the other three accident categories, the historical trend for truck accidents is towards as increasing pattern, whereas for the non-truck category it is toward the decreasing pattern. An analysis of causal factors for the rising trends in truck accidents and the identification of possible means of stalling such a trend is clearly a subject of further research.

Results of the statistical "t" test of means using data from Table 11 are shown in Table 12. For each of the four accident categories, a test was conducted at the 90 percent level of confidence, as to whether there is enough validity to the hypothesis of no difference between the two accident rates. As explained in the earlier chapter, the acceptance of the null hypothesis is indicative of no difference, and the rejection of the same implies the existence of a significant difference. Further, in case of the rejection of the hypothesis (namely the existence of a difference), a positive sign of the value of t calculated figure indicates that trucks have a higher accident rate; a negative sign indicates otherwise.

Table 12 indicates the results of the test, including mean rates for each accident category, the calculated value as well as the critical "t" value. In instances where $t_{calculated}$ was less than $t_{critical}$, the hypothesis

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[1] Similar analysis with passenger car data was beyond the scope of this analysis. The available data base, however, permits the computation of similar figures for passenger cars through estimating techniques.

TABLE 9. NUMBER OF TRUCK ACCIDENTS AND VMT DATA

Year	Type of Accidents				Truck VMT X 10^6
	Fatal	PI	PD	Total	
1970	363	9,620	22,935	32,918	7,301
1971	354	11,183	29,884	41,421	7,726
1972	390	15,245	39,792	55,427	8,948
1973	420	16,146	42,874	59,440	9,119
1974	345	14,837	43,408	58,590	9,225
1975	363	15,932	45,108	61,403	9,616
1976	433	19,125	54,801	74,359	10,644
1977	492	21,939	62,209	84,640	11,335

TABLE 10. NUMBER OF NON-TRUCK ACCIDENTS AND VMT DATA

Year	Type of Accidents				Non-Truck VMT X 10^6
	Fatal	P.I.	P.D.	Total	
1970	1,500	92,258	187,039	280,797	45,894
1971	1,536	89,264	181,794	272,594	47,848
1972	1,607	98,428	204,283	304,318	48,896
1973	1,529	94,139	195,756	291,424	49,328
1974	1,306	80,536	184,331	266,173	46,522
1975	1,248	82,305	188,604	272,157	46,644
1976	1,297	87,938	202,006	291,241	50,993
1977	1,249	87,670	201,192	290,111	53,518

TABLE 11. ACCIDENT RATES FOR TRUCKS AND NON-TRUCKS

(NO. OF ACCIDENTS/VMT)

Year	Truck Accident Rates				Non-Truck Accident Rates			
	Fatal $\times 10^{-8}$	PI $\times 10^{-6}$	PD $\times 10^{-6}$	Total $\times 10^{-6}$	Fatal $\times 10^{-8}$	PI $\times 10^{-6}$	PD $\times 10^{-6}$	Total $\times 10^{-6}$
1970	4.97	1.31	3.14	4.51	3.27	2.01	4.07	6.12
1971	4.58	1.45	3.87	5.36	3.21	1.86	3.80	5.70
1972	4.36	1.70	4.45	6.19	3.29	2.01	4.18	6.22
1973	4.61	1.77	4.71	6.52	3.09	1.91	3.97	5.91
1974	3.74	1.61	4.70	6.35	2.81	1.73	3.96	5.72
1975	3.77	1.66	4.69	6.38	2.67	1.76	4.04	5.83
1976	4.07	1.80	5.15	6.99	2.54	1.72	3.96	5.71
1977	4.34	1.93	5.49	7.47	2.33	1.64	3.76	5.42
Yearly Average	4.305	1.65	4.25	6.22	2.90	1.83	3.97	5.83

Fig 5. FATAL ACCIDENT RATE FOR TRUCKS

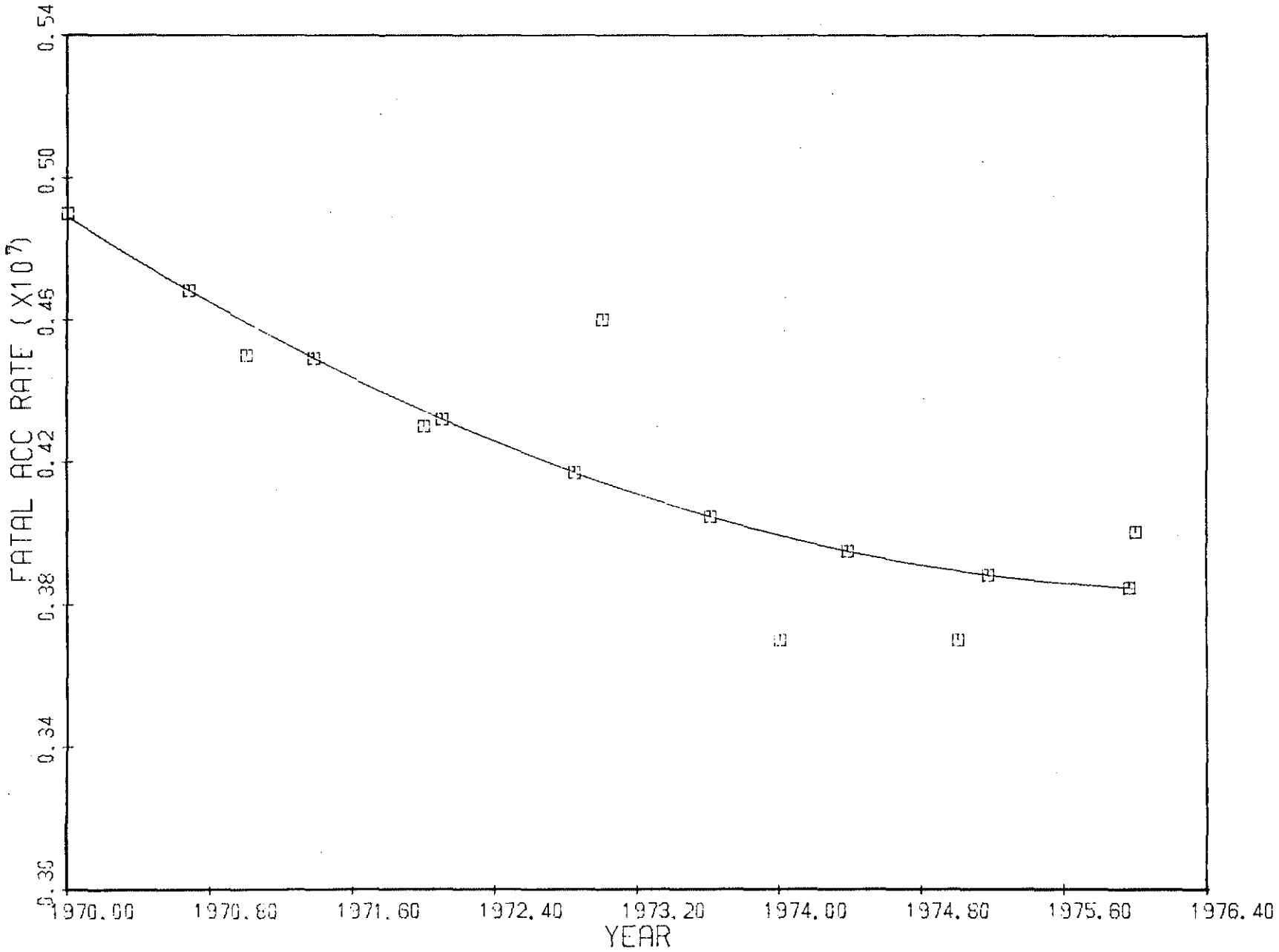

Fig 6 . FATAL ACCIDENT RATE FOR NON-TRUCKS

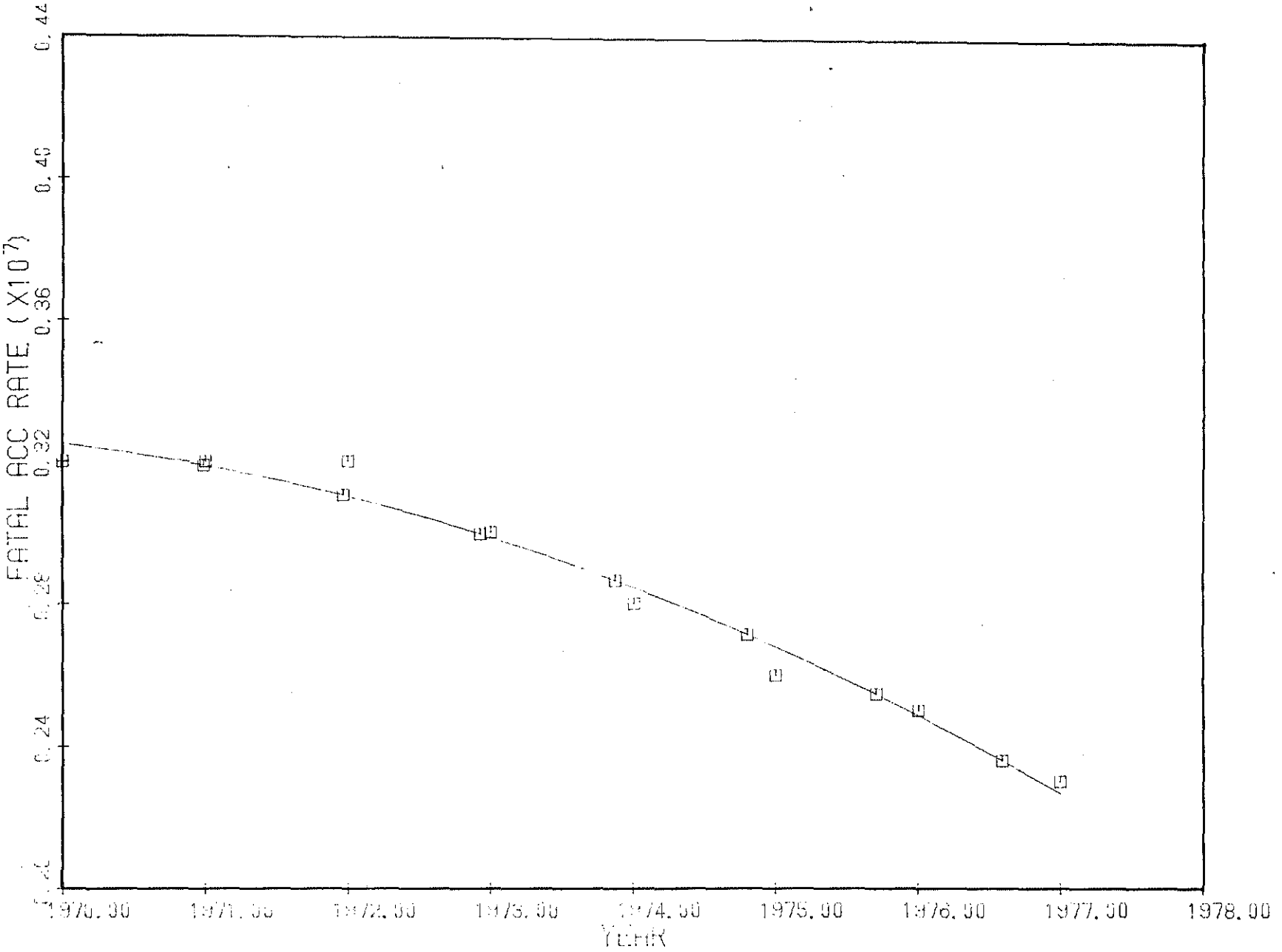

Fig 7. PI ACCIDENT RATE FOR TRUCKS

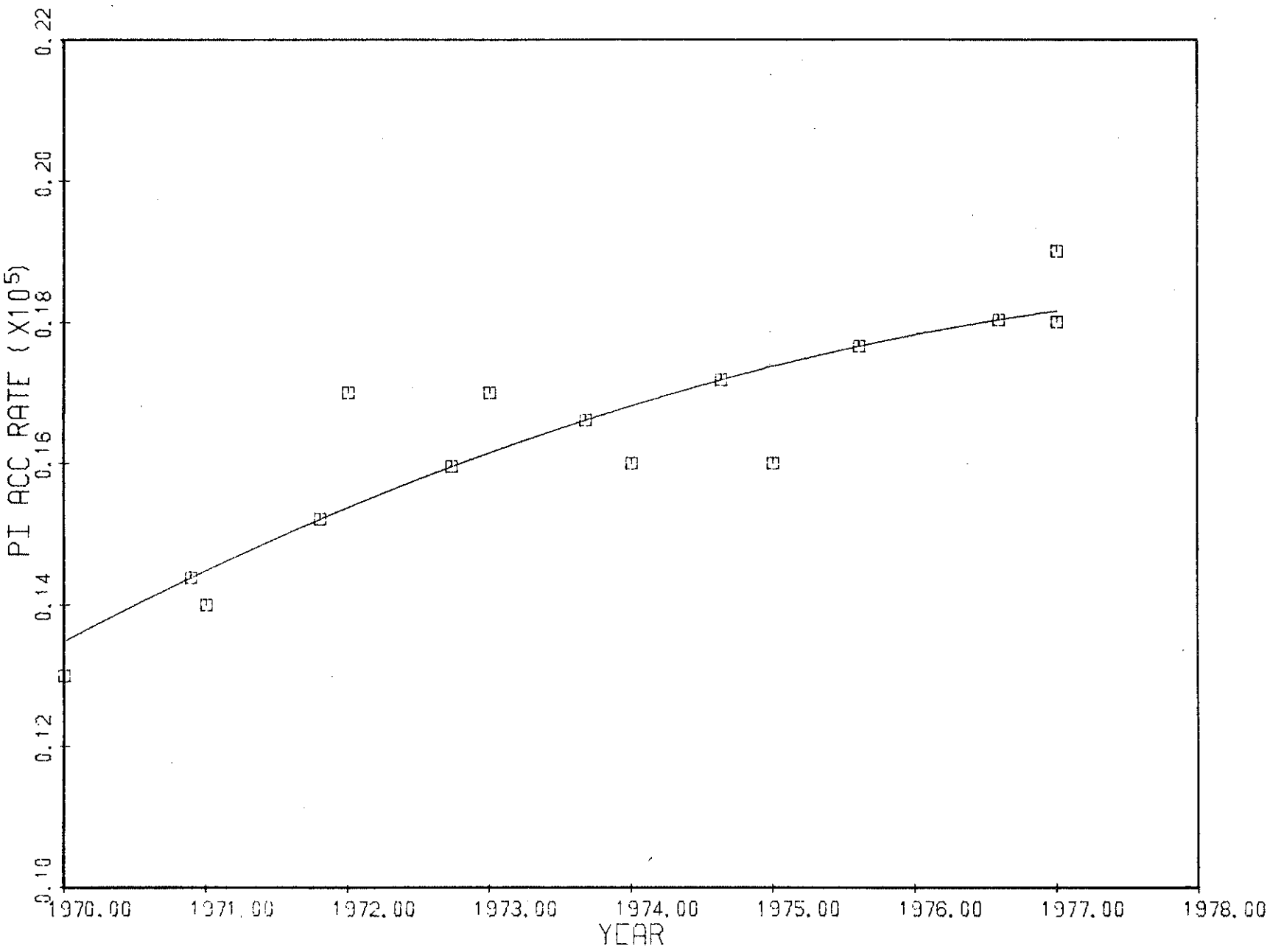

Fig 8. PI ACCIDENT RATE FOR NON-TRUCKS

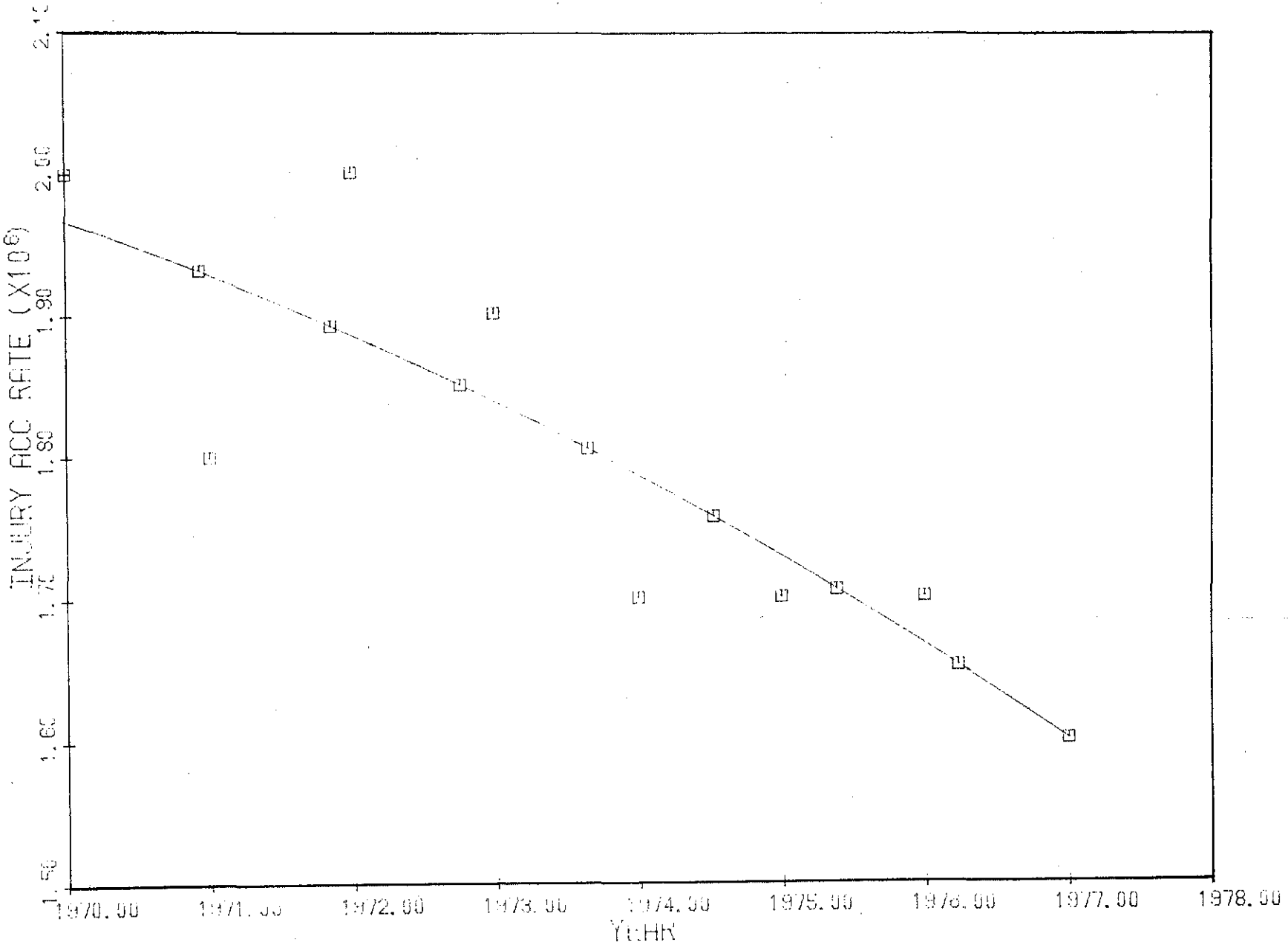

Fig 9. PD ACCIDENT RATE FOR TRUCKS

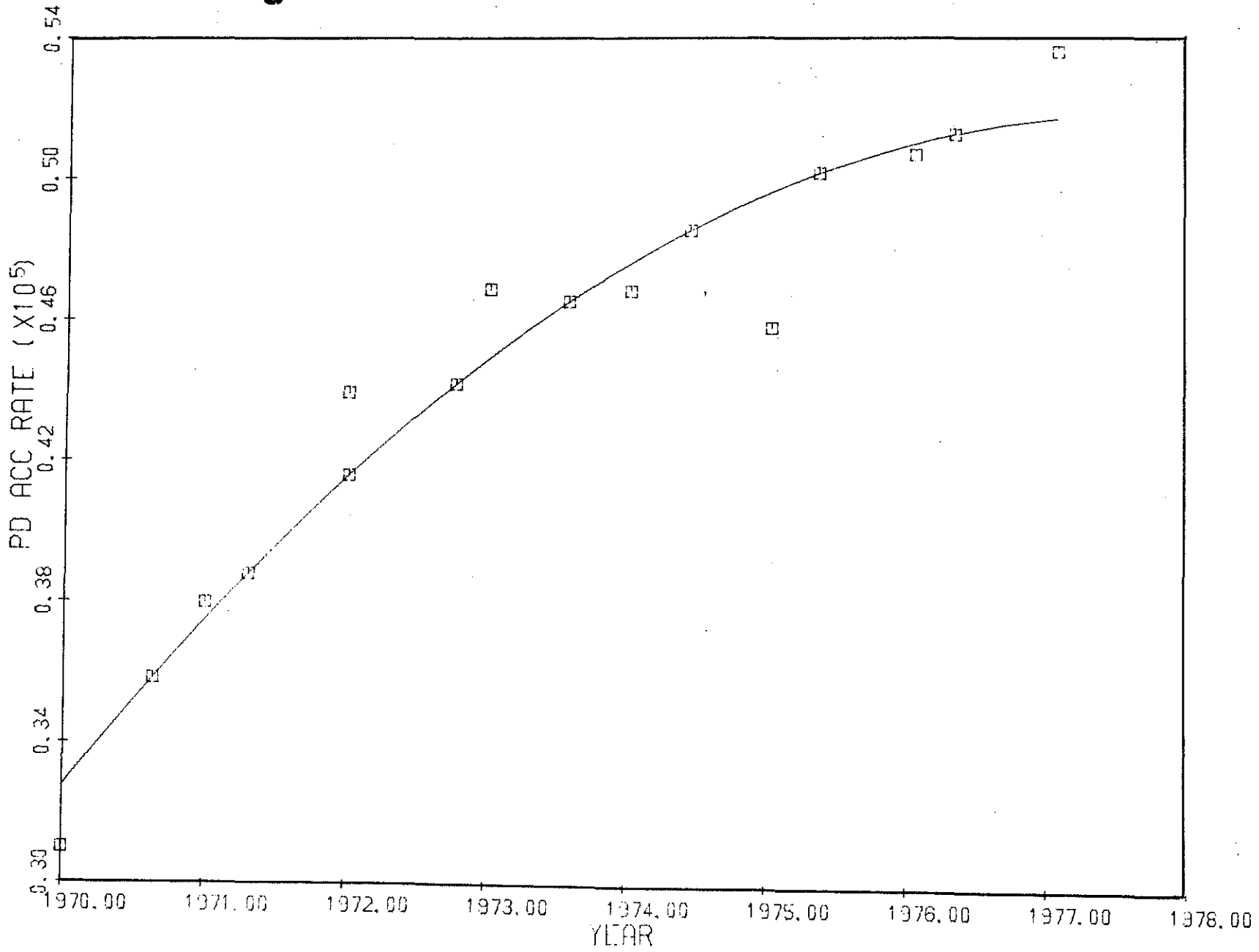

Fig 10. PD ACCIDENT RATE FOR NON-TRUCKS

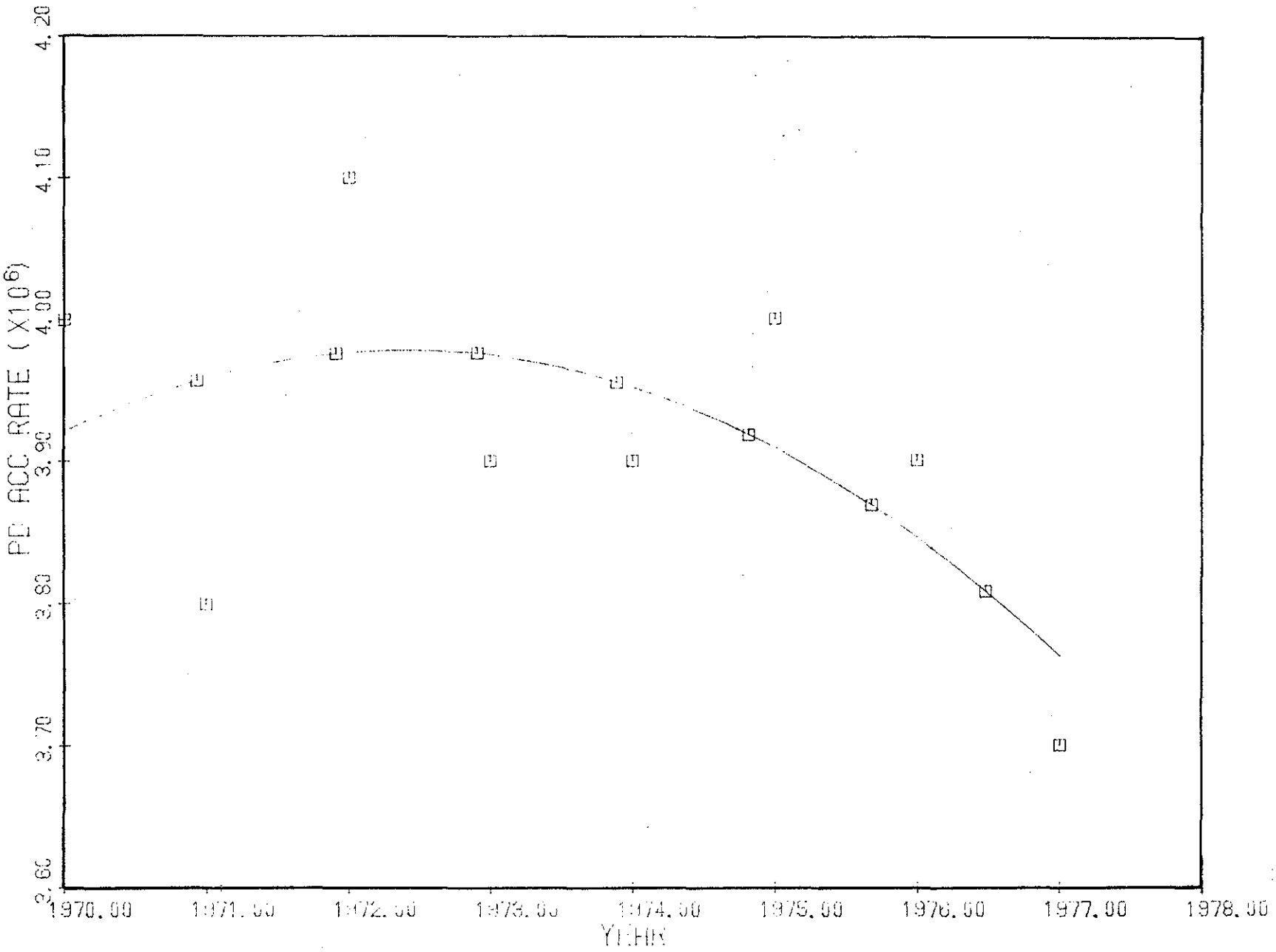

Fig 11.TOTAL ACCIDENT RATE FOR TRUCKS

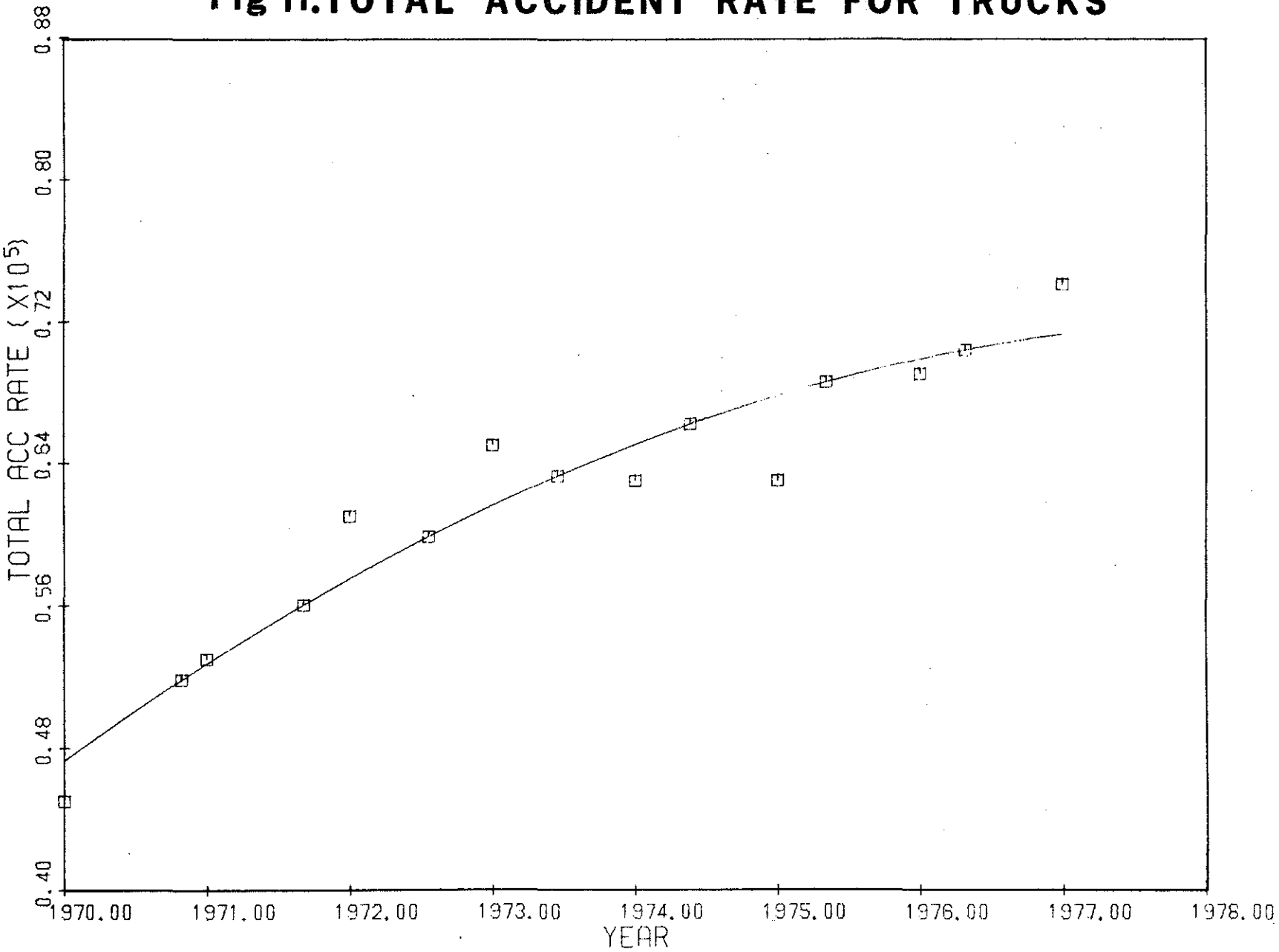

Fig 12.TOTAL ACCIDENT RATE FOR NON-TRUCKS

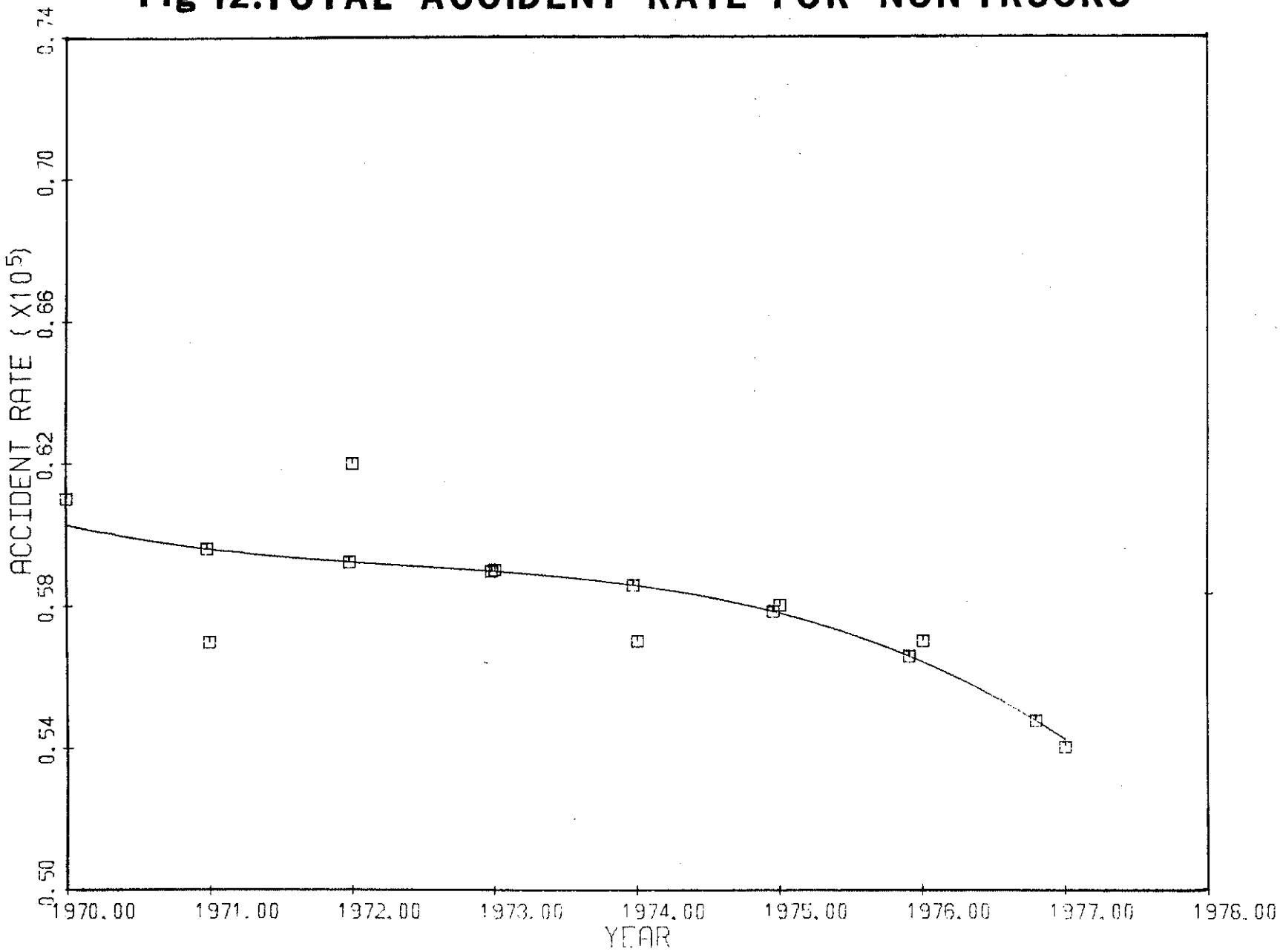

TABLE 12. COMPARISON OF ACCIDENT EXPERIENCE BETWEEN TRUCKS AND NON-TRUCKS (BASED ON NO. OF ACCIDENTS/VMT)

Accident Type	Mean Accident Rate	Test	$t_{Calculated}$	$t_{Critical}$	DF [1]	Conclusion
Total Accident	6.2212 5.8287	Truck vs Non-Trucks	1.1604	1.761	14	Accept Ho (No Difference)
Fatal Accident	4.3050 2.9012	Truck vs Non-Trucks	7.0623	1.761	14	Reject Ho (Trucks Higher)
PI Accident	1.6537 1.8300	Truck vs Non-Trucks	-2.0594	1.761	14	Reject Ho (Trucks lower)
PD Accident	4.5250 3.9675	Truck vs Non-Trucks	2.1128	1.761	14	Reject Ho (Trucks higher)

Ho - There is no difference between accident rates of compared classes
Accept Ho - No difference
Reject Ho - Difference exists

[1] DF = Degrees of Freedom (function of sample size)

was accepted, implying no difference between the two rates. In the event $t_{calculated}$ exceeded $t_{critical}$, the null hypothesis was to be rejected, indicating the existence of a real difference. It should be noted that in case of rejection, the $t_{calculated}$ value takes on both positive and negative signs in Table 12, indicating that the truck accident rates are higher and lower (than non-trucks) in these respective cases.

It is evident from Table 12 that for fatal and PD accidents, trucks had a statistically higher rate, for injury accidents trucks were lower and for all accidents considered together (total), there were no significant differences. The overall implication of this table can be summarized as follows: When all accidents involving trucks and non-trucks are considered together; there does not appear to be any significant difference in the accident rates of these two vehicular categories. For fatal accidents, truck rates are definitely higher (note that the $t_{calculated}$ value of 7.062 is considerably higher than that of $t_{critical}$ of 1.761). For the other two accident categories, the accident experiences are reasonably close to each other, although the statistical tests place trucks lower in one case and higher in the other. The small difference between $t_{calculated}$ and $t_{critical}$ values in these two cases provides support for such a conclusion.

3. RESULTS OF STAGE 2 ANALYSIS

In Stage 2 of the study, the truck data collected and analyzed in the earlier stage was further classified into three categories. The classification was accomplished in a manner that would permit the use of the available accident exposure and data. During discussion with State Police officials, it was found that three categories of trucks were recorded in the accident inventory as follows:

1. Pickups, Panels and Vans (PPV's)
2. Straight Trucks (stakes, dumps, etc.)
3. Truck Tractors (semi) or Road Tractors

It was thus necessary to categorize the exposure (VMT) data also into the same three classification schemes. The Stage 2 analysis was conducted for the period between 1972-1977, as accident data by the three different truck categories was not available prior to 1972. Further, as of the preparation of this report, the 1978 accident data was not released. The analysis period covered in Stage 2 analysis is thus shorter than that for Stage 1 analysis as dictated by the availability of data. Results of the Stage 2 analysis are presented below.

3.1 Estimation of VMT Data by Truck Categories

The procedure applied for estimating VMT generated by the three truck categories is essentially similar to the one used in the Stage 1 analysis in calculating total truck VMT. Truck vehicle registration data was obtained from the Michigan Department of State Highways and Transportation (MDSH&T). These data were then multiplied by the annual average travel mileage rate (average miles traveled per year) for each vehicular category, as obtained from Highway Statistics based upon nationwide data.

It must be pointed out that the VMT for the three truck categories as estimated by the above mentioned procedure, when added together will fall somewhat short of the total truck VMT reported within Stage 1. This is because of the fact that a number of miscellaneous truck categories were also instrumental in generating a small amount of travel in the state that is not accounted for in the Stage 2 analysis.

Pickups, Panels and Vans (PPV's): Table 13 shows the VMT data for the period between 1972 and 1977 for the first category of trucks, namely pickups, panels and vans (PPV's). Although registration data for pickups/panels and vans could be obtained separately, accident data was available only in combined form. As such, it was necessary to consider these three truck subcategories together in the analysis. Further, the average annual travel rate data for PPV's could not be obtained separately from Highway Statistics. As such, the travel rate for this truck category was assumed to be the same for all other single-unit trucks. It is possible that because of this assumption, the VMT of PPV's is slightly underestimated; this may have the effect of slightly overestimating the accident rate. This part of the analysis is thus to be treated somewhat on the conservative side.

TABLE 13. VMT FOR PICKUPS, PANELS AND VANS

Year	Aver. Miles Per Singel Unit Truck in U.S.	No. of Pickup & Panel Trucks Registeted in MI	No. of Registered Vans In MI	Total Registration	VMT x 10^6
1972	10,525	419,839	78,502	498,341	5,245
1973	9,868	471,580	88,234	559,814	5,524
1974	8,985	502,370	97,614	599,984	5,390
1975	8,882	531,176	108,886	640,062	5,685
1976	9,355	573,450	122,801	696,251	6,513
1977	9,400	618,722	129,297	748,019	7,013

TABLE 14. VMT FOR DUMP AND STAKE TRUCKS, ETC.

Year	Aver. Mile Traveled per Single Unit Truck in U.S.	No. of Dump & Stake Trucks Registered in MI	VMT x 10^6
1972	10,525	56,495	594.6
1973	9,868	59,739	589.5
1974	8,985	59,839	537.6
1975	8,882	58,764	521.9
1976	9,355	59,842	559.9
1977	9,400	58,919	553.8

TABLE 15. VMT FOR TRUCK TRACTORS IN MICHIGAN

Year	Aver. Mile Traveled per Truck Tractor in U.S.	No. of Truck Tractors Registered in MI	VMT x 10^6
1972	47,084	29,591	1,393
1973	46,716	32,559	1,521
1974	51,968	33,571	1,744
1975	49,125	32,239	1,583
1976	48,366	33,365	1,613
1977	50,206	35,522	1,784

Table 13 clearly indicates a reduction in the VMT during the year 1974, compared to the previous years, although there was an increase in vehicle registration during the same period. This reduction in VMT is anticipated, in view of the general reduction in all motorized travel across the nation, presumably because of the oil embargo during this period.

Stake and Dump Trucks: Table 14 shows the registration and VMT data for the second truck category, namely stake and dump trucks. As this table indicates, the reduction of VMT after 1973 is even more pronounced for this truck category compared to PPV's. Since the same unit travel rate for PPV's and stake and dump trucks was used, the same note of conservative analysis for this category of truck, and for PPV's is true here. It appears from the data presented that the registration of stake and dump trucks has stabilized, as indicated by the relatively low yearly fluctuation in the number of vehicles registered.

Truck Tractors: Table 15 indicated registration and VMT data for the third type of truck category, i.e., truck tractors in the State for the period 1972-1977. Since the average travel rate by truck tractors is significantly higher (almost five-fold) than the single-unit trucks, it is clear that truck tractors generate considerably higher travel in terms of VMT, although the registration data shows the opposite trend.

3.2 Accident Data Collection by Truck Categories

As explained earlier in this report, the prime source of all accident data used in this study was the accident data inventory file maintained by the Michigan Department of State Police. For this part of the analysis accident data was available on the number of trucks (by each of the three categories) involved in any one of the four accident types (i.e. fatal, personal injury, property damage and total). Similar information on number of accidents was not directly available, but was estimated indirectly using available data. In the following section these results are presented; first, through the development of rates based upon the number of vehicles and next considering rates based upon the number of accidents. Also, as in the case of the Stage 1 analysis, the statistical test is presented only for the latter case, namely, comparison of rates based upon the number of accidents. Again, this decision was largely predicated upon standard practices in accident data analysis.

Analysis Based Upon Number of Vehicles: Table 16, 17, and 18 present the accident data showing the number of PPV's, stakes and dumps, and truck tractors, respectively, that were involved in any one of the four accident categories, along with the corresponding VMT data. As an example, Table 16 indicates that during the year 1972, there were a total of 223 PPV's involved in fatal accidents. Similarly Tables 17 and 18 show that the numbers of

TABLE 16. NUMBER OF PICKUPS, PANELS AND VANS INVOLVED IN ACCIDENTS IN MICHIGAN

Year	Type of Accident				VMT x 10^6
	Fatal	PI	PD	Total	
1972	223	9,726	23,878	33,827	5,245
1973	208	10,186	25,469	35,863	5,524
1974	186	9,568	26,789	36,543	5,390
1975	216	10,305	28,678	39,199	5,685
1976	274	13,457	37,525	51,256	6,513
1977	316	15,984	43,712	60,012	7,013

TABLE 17. NUMBER OF DUMP STAKE TRUCKS, ETC. INVOLVED IN ACCIDENTS IN MICHIGAN

Year	Type of Accident				VMT x 10^6
	Fatal	PI	PD	Total	
1972	97	3,986	10,955	15,038	594.6
1973	115	4,473	12,402	16,990	589.5
1974	82	4,506	13,418	18,006	537.6
1975	100	5,158	14,607	19,865	521.9
1976	102	5,178	15,486	20,748	559.9
1977	105	5,458	16,511	22,074	553.8

TABLE 18. NUMBER OF TRUCK TRACTORS INVOLVED IN ACCIDENTS IN MICHIGAN

Year	Type of Accident				VMT x 10^6
	Fatal	PI	PD	Total	
1972	101	2,051	5,939	8,091	1,393
1973	122	2,305	6,677	9,104	1,521
1974	94	1,875	5,773	7,742	1,744
1975	66	1,665	4,976	6,707	1,583
1976	86	2,124	6,026	8,236	1,613
1977	110	2,358	7,046	9,514	1,784

stakes and dumps, and truck tractors involved in fatal accidents during the same year were 97 and 101 respectively. These numbers must be clearly distinguished from the number of accidents in which the above truck categories were involved, as described later in this section.

Tabel 19 shows the accident rates obtained by dividing the number of trucks by the corresponding VMT for each truck category and each accident type. As an example, this table indicates that during the year 1972 for every hundred million VMT generated by PPV's, a total of 4.25 vehicles (of the same category) were involved in fatal accidents. The corresponding number for stakes and dumps, and for truck tractors are 16.3 and 7.25 respectively.

It is quite evident from an inspection of this table that the involvement rate of stake and dump trucks is the highest in all accidents, followed by PPV's and truck tractors. When a comparison is made between PPV's and truck tractors, the involvement rate by the latter category is higher in the case of fatal accidents. In the case of the personal injury and property damage type accidents, the involvement rate by the former category is higher.

3.3 Analysis Based Upon Number of Accidents

It was mentioned earlier that data on the number of accidents in which each of the three types of trucks was involved, were not available directly. As such, indirect estimating techniques were used to derive these figures. It was assumed that the average number of trucks involved in a given accident category and in a given year did not vary between truck types. This average figure was computed for each accident type for each of the analysis years from data collected in Stage 1 (Tables 5 and 9). The number of accidents for each truck category was obtained by dividing the number of corresponding trucks involved in accidents (as presented in Tables 16, 17, and 18) by the average figures obtained.

The average figures for each year used in the analysis and derived from Tables 5 and 9 are presented in Table 20. For example, from Tables 5 and 9, it can be seen that in the year 1972, there was a total of 390 fatal truck accidents, in which 422 trucks were involved. This implied that approximately 1.08 trucks were involved for every fatal truck accident. The figure 1.08 appears in the appropriate column in Table 20. It was then assumed that on an average, the same number of trucks (for all truck categories) was involved for the corresponding "accident type-year combination". This assumption is considered quite realistic in view of the fact that most truck accidents involve one truck and another non-truck (the case of two car accident being the most common one). A review of the figures in Table 20 shows that the numbers are quite close to one another varying between 1.06 to 1.08. This indicates that the involvement rate of trucks does not greatly vary with time and accident type. The closeness of these numbers generally support the above mentioned assumption.

The average numbers thus derived and represented in Table 20 were used to estimate the number of corresponding accidents for each truck category and represented in Tables 21, 22, and 23, for PPV's, stakes and dumps and

TABLE 19. ACCIDENT RATES OF THREE TRUCK CATEGORIES (NO. OF VEHICLES INVOLVED/VMT)

Year	Pickups, Panels & Vans				Dump, Stake, Etc.				Truck Tractor			
	Fatal $\times 10^{-8}$	PI $\times 10^{-6}$	PD $\times 10^{-6}$	Total $\times 10^{-6}$	Fatal $\times 10^{-8}$	PI $\times 10^{-6}$	PD $\times 10^{-6}$	Total $\times 10^{-6}$	Fatal $\times 10^{-8}$	PI $\times 10^{-6}$	PD $\times 10^{-6}$	Total $\times 10^{-6}$
1972	4.25	1.85	4.55	6.45	16.3	6.70	18.4	25.3	7.25	1.47	4.26	5.81
1973	3.76	1.84	4.61	6.49	19.5	7.59	21.0	28.8'	8.02	1.51	4.39	5.98
1974	3.45	1.77	4.97	6.78	15.2	8.38	24.9	33.5	5.39	1.07	3.31	4.44
1975	3.80	1.81	5.04	6.89	19.1	9.88	27.9	38.0	4.17	1.05	3.14	4.24
1976	4.21	2.06	5.76	7.87	18.2	9.25	27.6	37.0	5.33	1.32	3.73	5.11
1977	4.49	2.27	7.22	8.53	18.9	9.85	29.8	39.8	6.17	1.32	3.95	5.33
Average	3.99	1.93	5.19	7.17	17.87	8.61	24.9	33.1	6.05	1.29	3.796	5.1517

TABLE 20. AVERAGE NO. OF TRUCKS INVOLVED IN EACH TYPE OF TRUCK ACCIDENT

Year	Accident Type			Total
	Fatal	P.I.	P.D.	
1972	1.08	1.06	1.06	1.06
1973	1.08	1.07	1.06	1.06
1974	1.06	1.07	1.06	1.06
1975	1.05	1.07	1.06	1.06
1976	1.08	1.08	1.07	1.07
1977	1.08	1.08	1.07	1.07

TABLE 21. NUMBER OF ACCIDENTS INVOLVING PICKUPS, PANELS AND VANS

Year	Type of Accident				VMT x 10^6
	Fatal	PI	PD	Total	
1972	207	9,176	22,527	31,910	5,245
1973	193	9,520	24,027	33,740	5,524
1974	176	8,942	25,273	34,391	5,590
1975	206	9,631	27,055	36,892	5,605
1976	254	12,461	35,071	47,786	6,513
1977	293	14,800	40,853	56,088	7,013

TABLE 22. NUMBER OF ACCIDENTS INVOLVING DUMPS, STAKE TRUCKS, ETC. IN MICHIGAN

Year	Type of Accident				VMT x 10^6
	Fatal	PI	PD	Total	
1972	90	3,761	10,335	14,186	594.6
1973	107	4,181	11,700	15,988	589.5
1974	87	4,212	12,659	16,949	537.6
1975	96	4,821	13,781	18,698	521.9
1975	95	4,795	14,457	19,347	559.9
1977	98	5,054	15,431	20,630	553.8

TABLE 23. NUMBER OF ACCIDENTS INVOLVING TRUCK TRACTORS

Year	Type of Accident				VMT x 10^6
	Fatal	PI	PD	Total	
1972	94	1,935	5,603	7,632	1,393
1973	113	2,155	6,300	8,568	1,521
1974	89	1,753	5,447	7,289	1,744
1975	63	1,557	4,695	6,315	1,583
1976	80	1,967	5,632	7,679	1,613
1977	102	2,183	6,585	8,892	1,784

truck tractors, respectively. For example, Table 21 indicates that during the year 1972, there were a total of 207 fatal accidents, in which at least one PPV was involved. The number 207 is the result of dividing 223 (the number of PPV's involved in fatal accidents as seen in Table 16) by the number 1.08, as explained above and presented in Table 20. All the numbers in the last three tables were derived in a similar manner.

The accident rates derived by dividing the number of accidents (by truck categories and accident types), by the corresponding VMT are represented in Table 24. Table 24 is essentially the counterpart of Table 19, the only difference being that in Table 24, the estimated number of accidents were used in the numerator to compute the rates (as opposed to the number of vehicles in Table 19). The general trends observed in Table 19 are also true in Table 24. In all types of accidents, the dumps/stakes have the highest rate. For fatal accidents, truck tractors have a higher accident rate than PPV's. In the other two accident categories, the PPV's have a higher rate. The historical accident data for the three truck categories are represented in graphical form for each of the four accident types in Figures 13 through 24. As in the case of the trend data presented in Stage 1 analysis (Figures 7, 9, and 11, in particular), the general upward trend in accident experience by differenct truck categories is quite obvious from these figures. An analysis of specific causal factors in these trends, in the face of a general downward trend of accident rates by all other motorized vehicles (Figures 4, 6, 8, and 12) is clearly a subject of more detailed research effort.

3.4 Statistical Comparison of Accident Data

The data generated in Table 24 was the basis for a statistical comparison as reported in this section. Essentially, two sets of comparisons were made. In the first set, the rates for each truck category and accident type were compared with the corresponding rate for all other motorized vehicles (non-trucks). It may be recalled that in the Stage 1 analysis, the same data base for non-trucks was also used for comparing accident rates of all trucks considered together. In the second set, accident rates for different truck categories were compared among themselves. The results of such comparisons are presented below.

Comparison with Non-Truck Accident Rates: The statistical procedure used in Stage 2 analysis is similar to the one used in Stage 1. The acceptance or rejection of the null hypothesis is to be interpreted as being indicative of a no difference or difference between the two accident rates, respectively. Further, in case of rejection of the hypothesis, a positive value of $t_{calculated}$ indicated that truck accident rates were higher and a negative value indicated that trucks were lower.

Results of comparing accident rates for PPV's stake/dumps and truck tractors (Table 24) with all other non-trucks (Table 11) are presented in Table 25, 26, and 27, respectively. While the entries in these three tables

TABLE 24. ACCIDENT RATES OF THREE TRUCK CATEGORIES (NO. OF ACCIDENT/VMT)

Year	Pickups, Panels & Vans				Dump, Stake, etc.				Truck Tractor			
	Fatal $\times 10^{-8}$	PI $\times 10^{-6}$	PD $\times 10^{-6}$	Total $\times 10^{-6}$	Fatal $\times 10^{-8}$	PI $\times 10^{-6}$	PD $\times 10^{-6}$	Total $\times 10^{-6}$	Fatal $\times 10^{-8}$	PI $\times 10^{-6}$	PD $\times 10^{-6}$	Total $\times 10^{-6}$
1972	3.95	1.75	4.29	6.08	15.1	6.32	17.4	23.8	6.74	1.39	4.02	5.48
1973	3.49	1.72	4.35	6.11	18.1	7.19	19.8	27.1	7.43	1.42	4.14	5.63
1974	3.26	1.66	4.69	6.38	14.5	7.83	23.5	31.5	5.10	1.00	3.12	4.17
1975	3.62	1.69	4.76	6.49	18.3	9.24	26.4	35.8	3.97	.98	2.96	3.98
1976	3.90	1.91	5.38	7.33	16.9	8.56	25.8	34.5	4.96	1.21	3.49	4.76
1977	4.17	2.10	5.81	7.98	17.7	9.12	27.8	37.2	5.72	1.22	3.69	4.98
Average	3.73	1.8050	4.88	6.728	16.766	8.04	23.45	31.65	5.65	1.20	3.57	4.83

Fig 13. FATAL ACCIDENT RATE FOR PICKUP, PANEL AND VAN

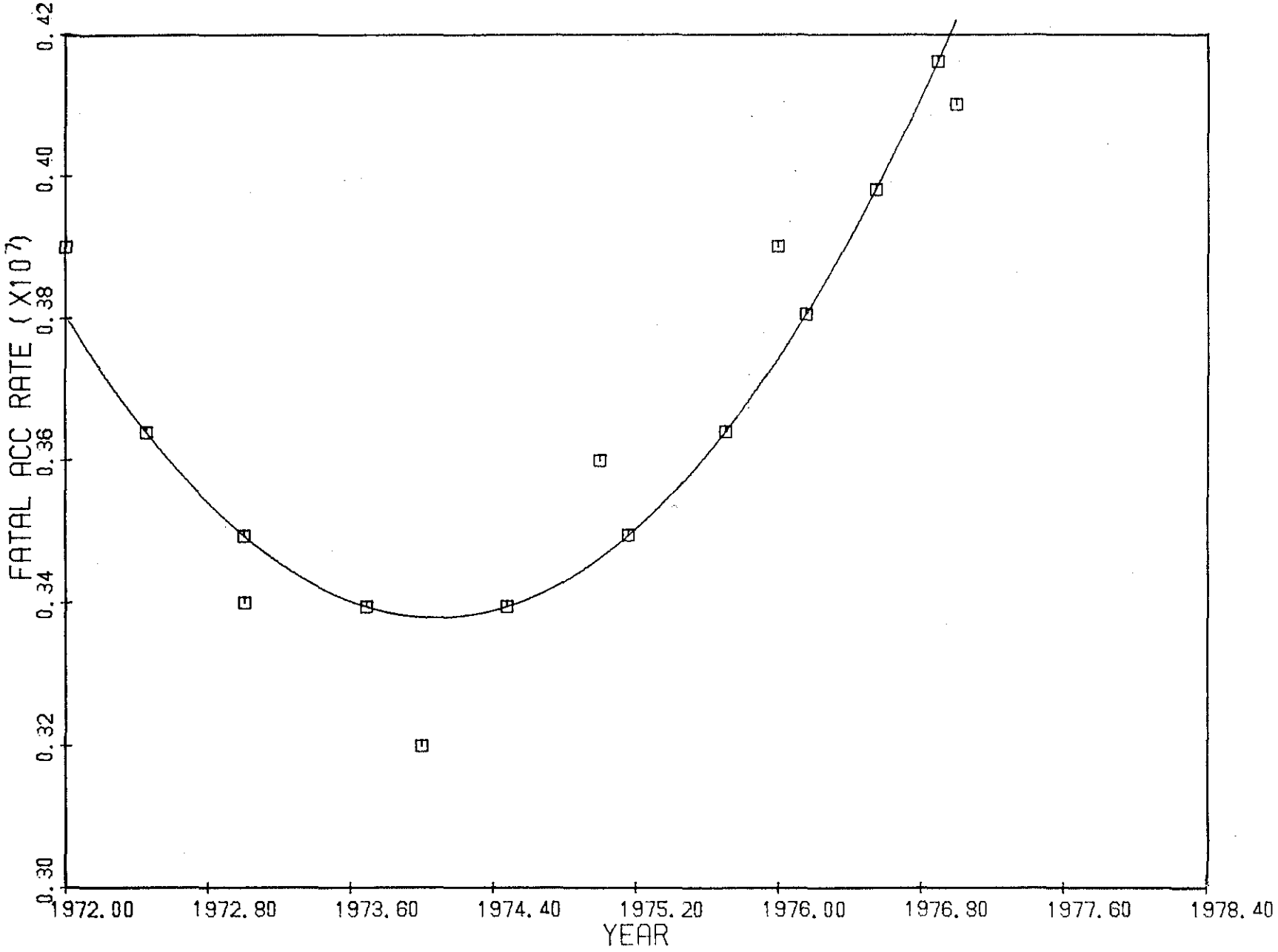

Fig 14. PI ACCIDENT RATE FOR PICKUP, PANEL & VAN

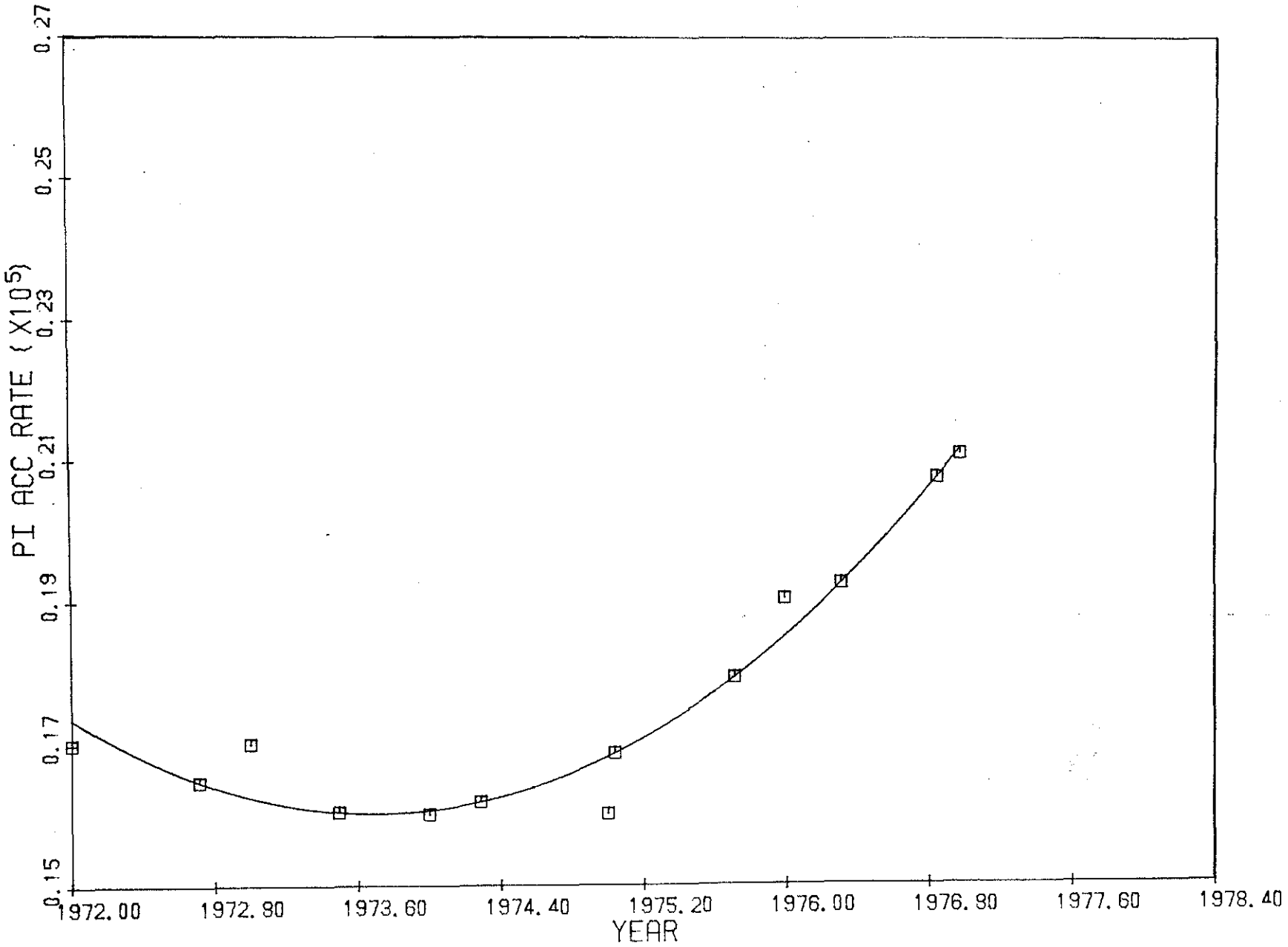

Fig 15. PD ACCIDENT RATE FOR PICKUP, PANEL & AND VAN

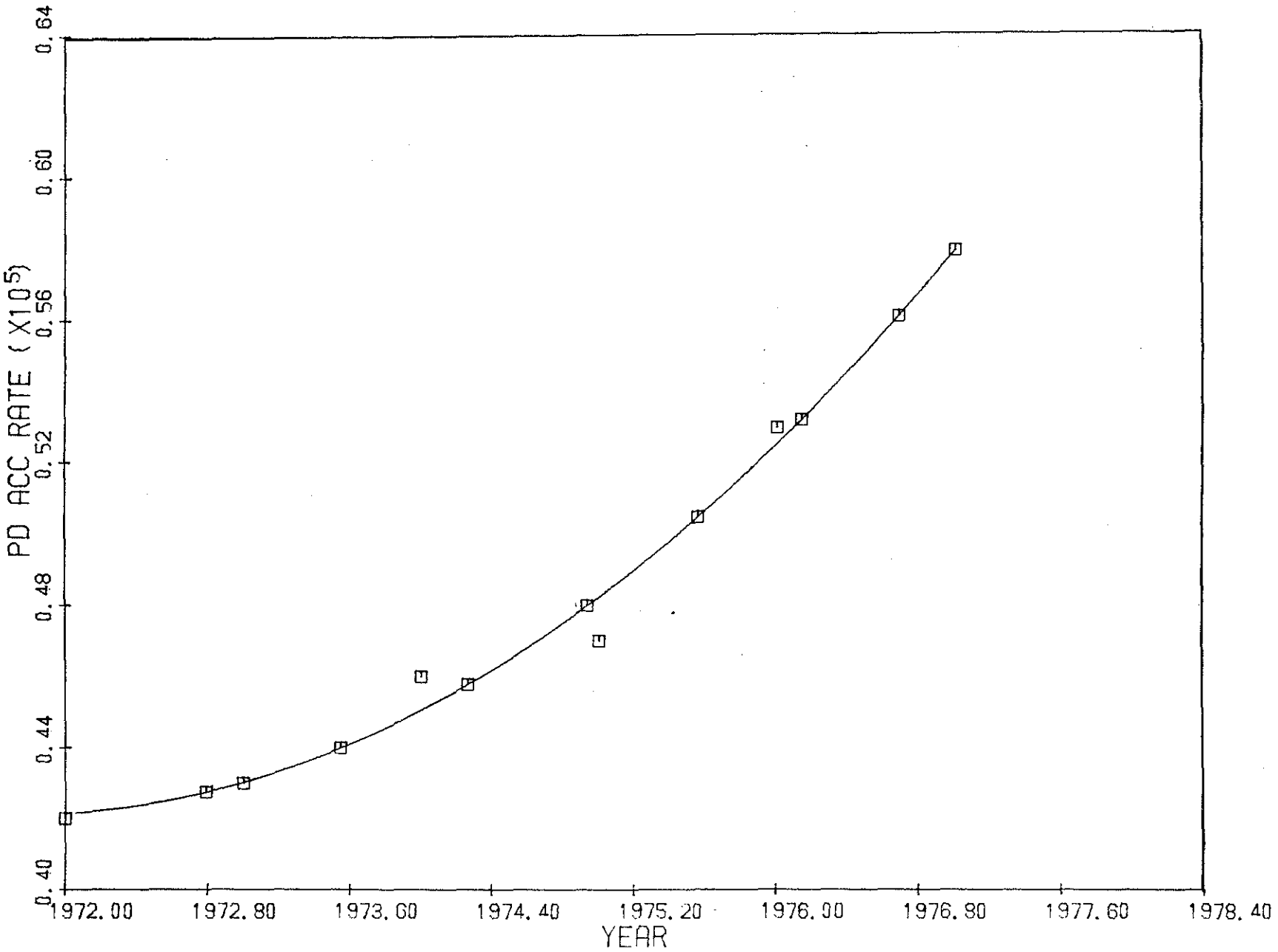

Fig 16. TOTAL ACCIDENT RATE FOR PICKUP, PANEL AND VAN

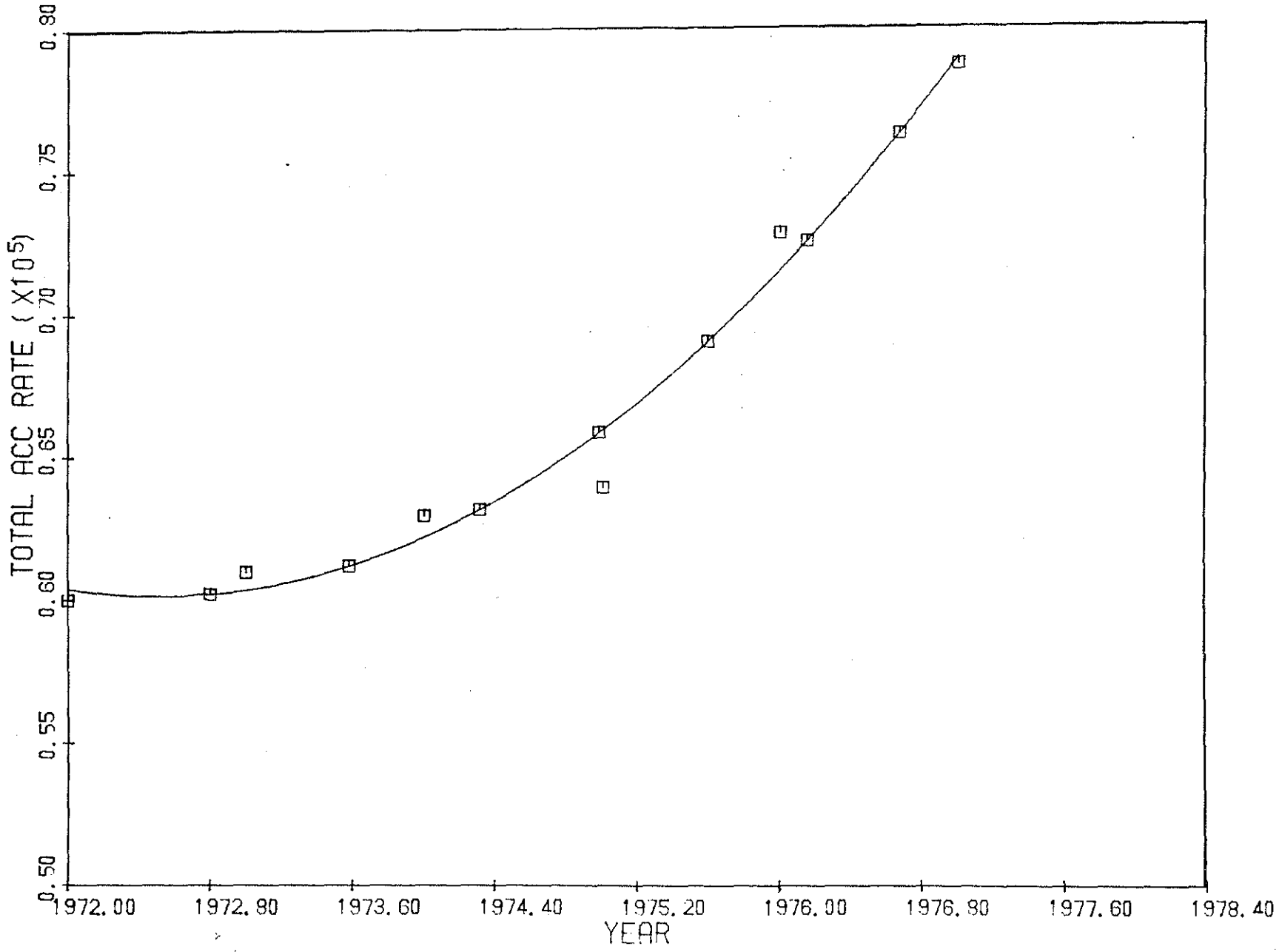

Fig 17. FATAL ACCIDENT RATE FOR DUMP AND STAKE

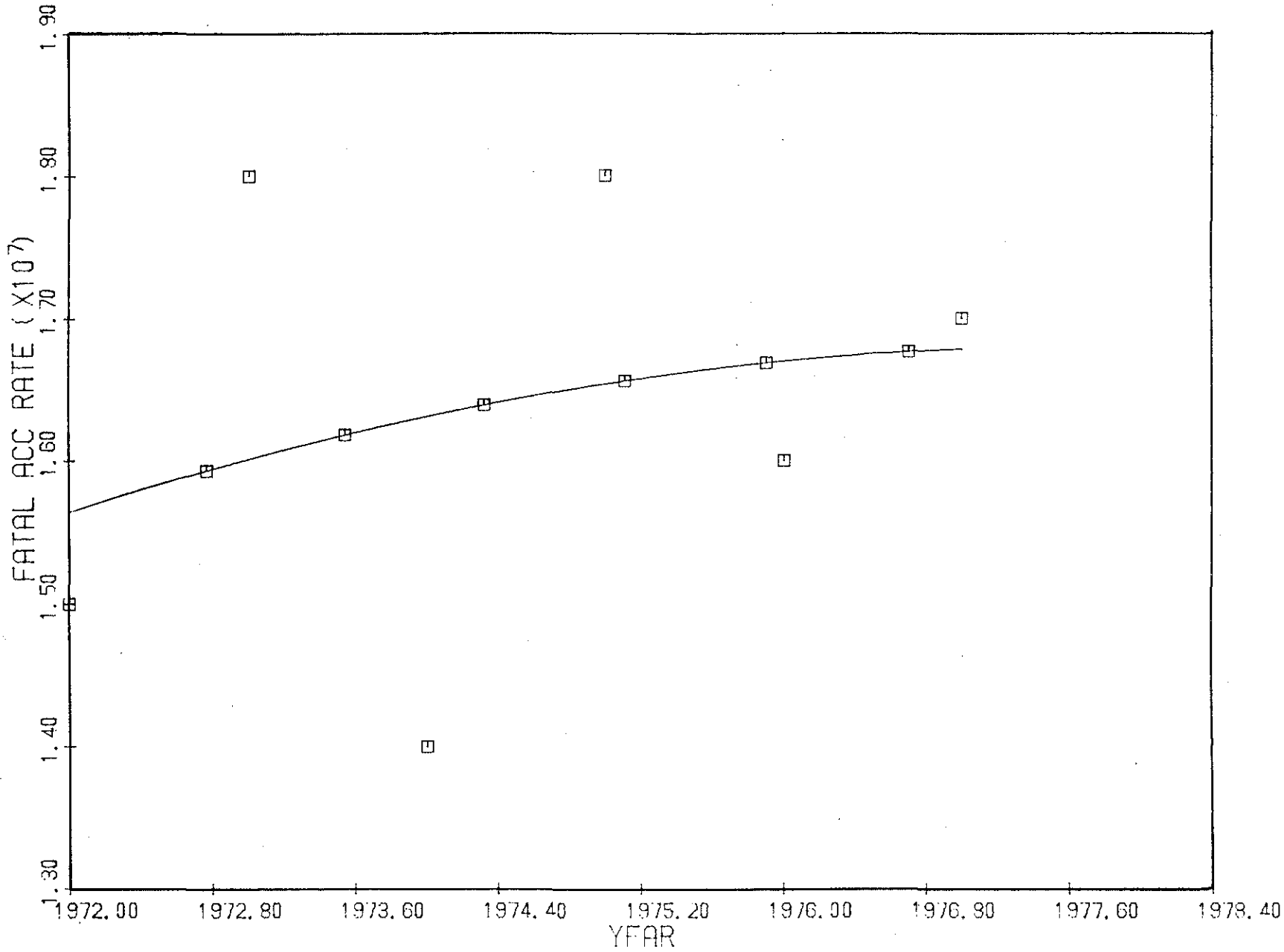

Fig 18. PI ACCIDENT RATE FOR DUMP AND STAKE

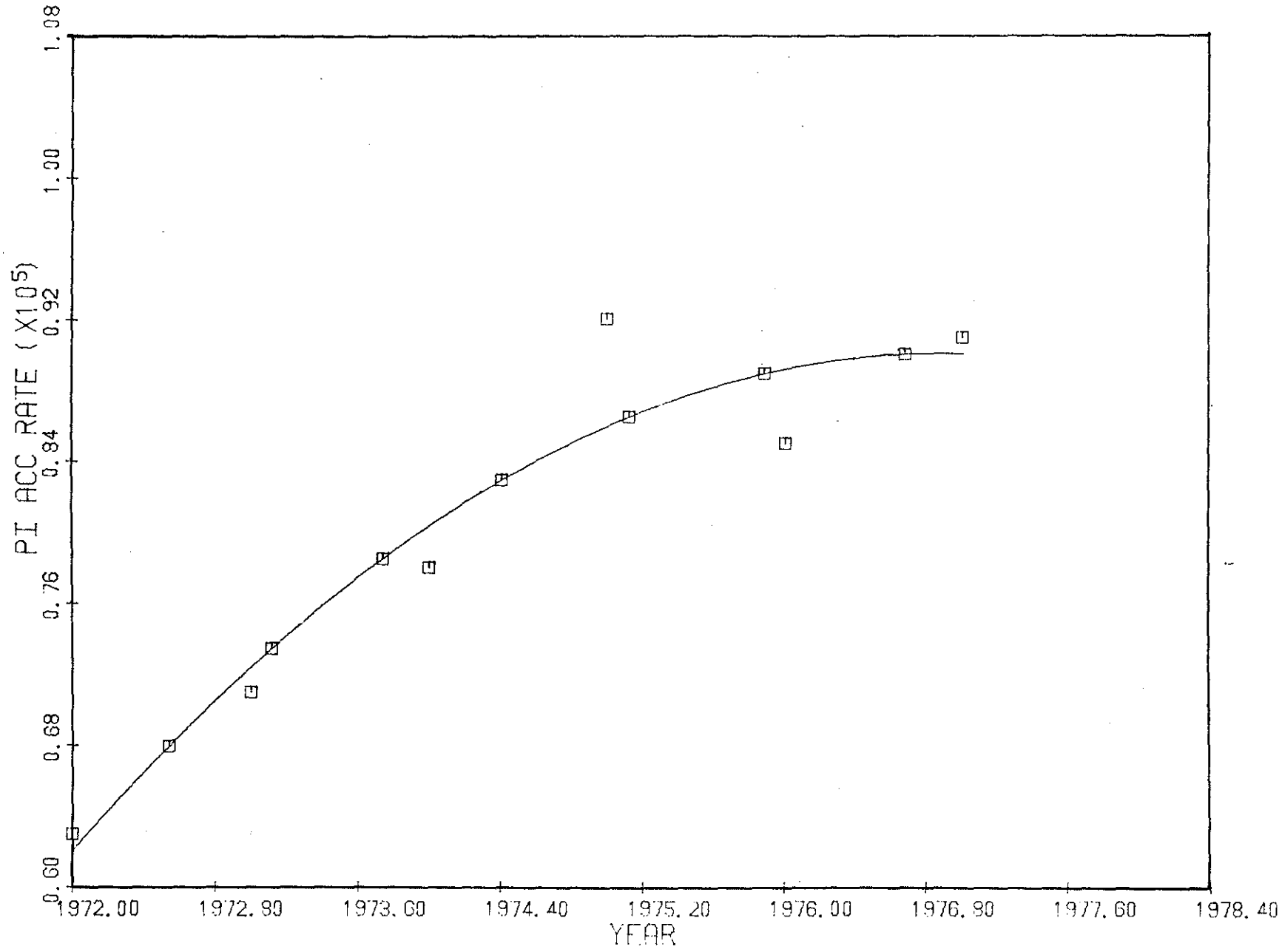

Fig 19. PD ACCIDENT RATE FOR DUMP AND STAKE

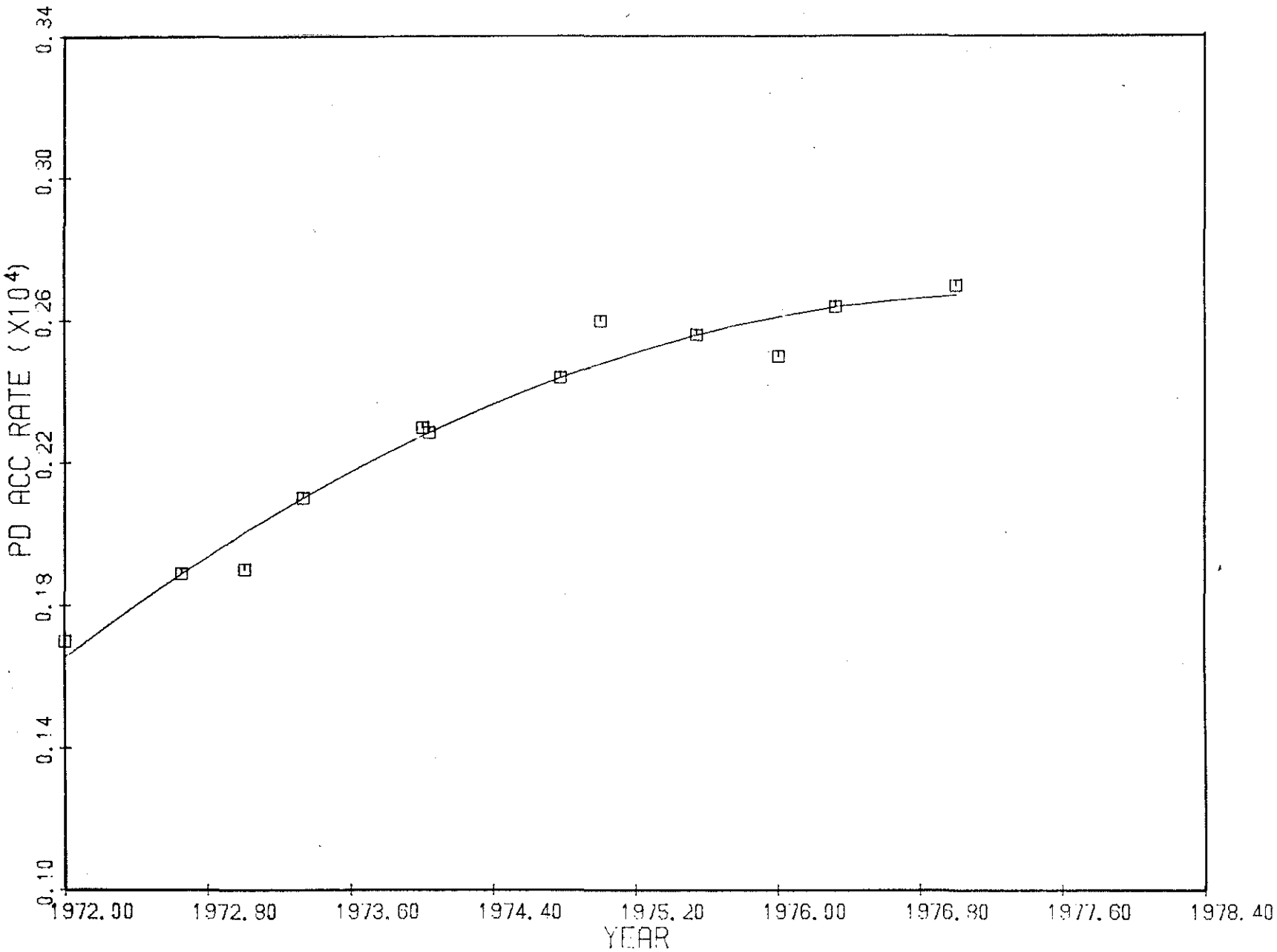

Fig 20.TOTAL ACCIDENT RATE FOR DUMP AND STAKE

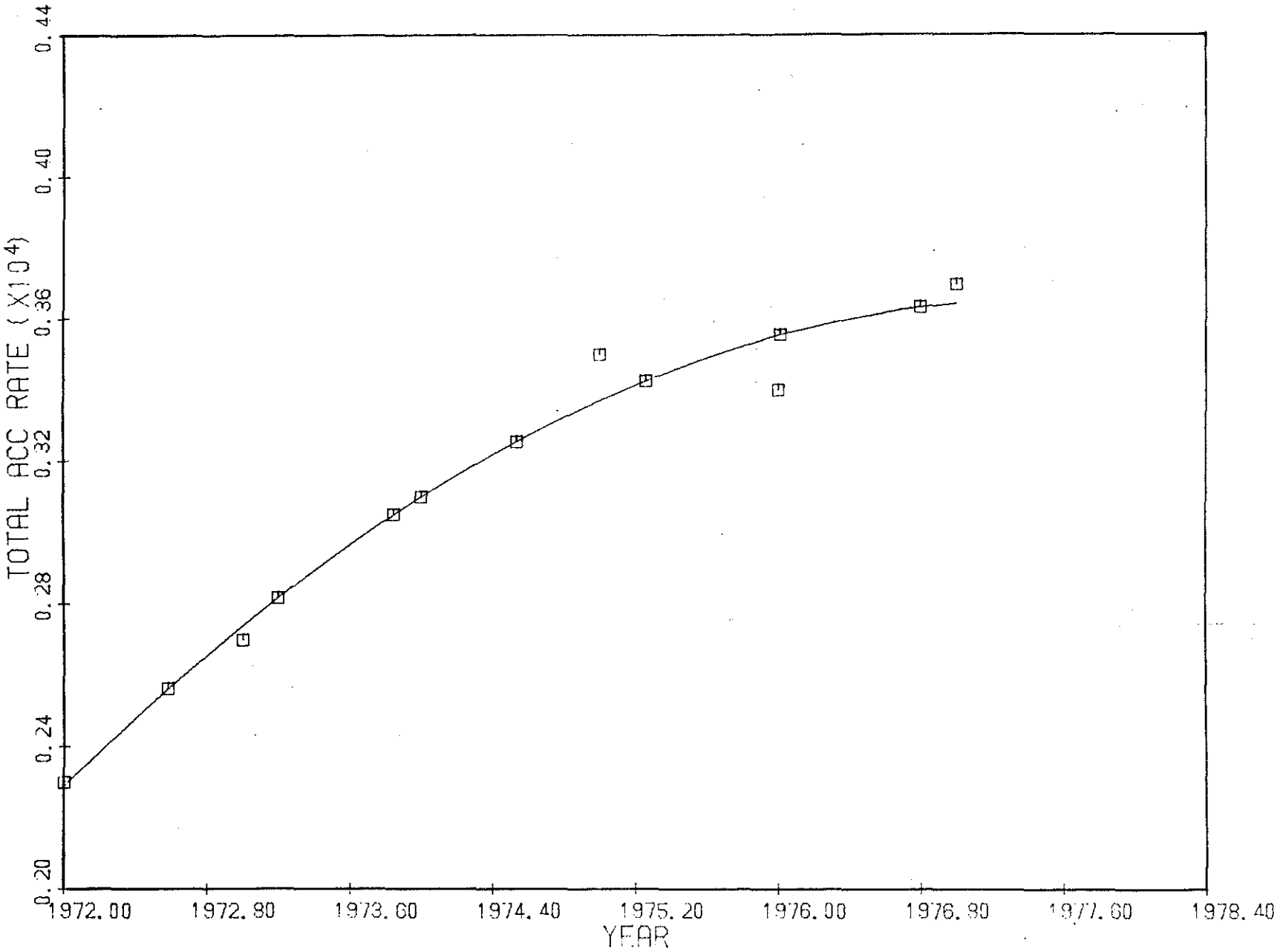

Fig 21. PI ACCIDENT RATE FOR TRUCK TRACTOR

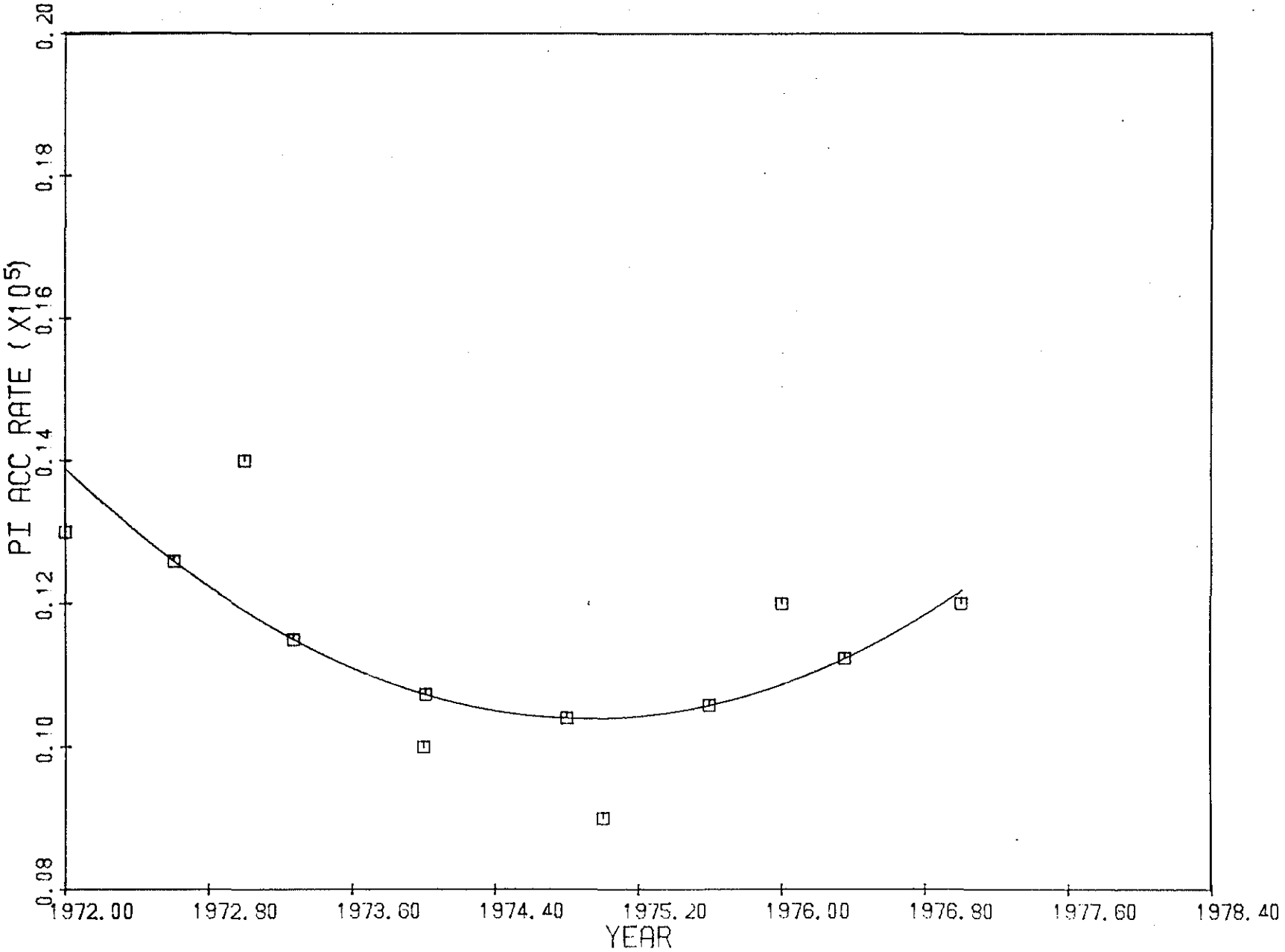

Fig 22.PD ACCIDENT RATE FOR TRUCK TRACTOR

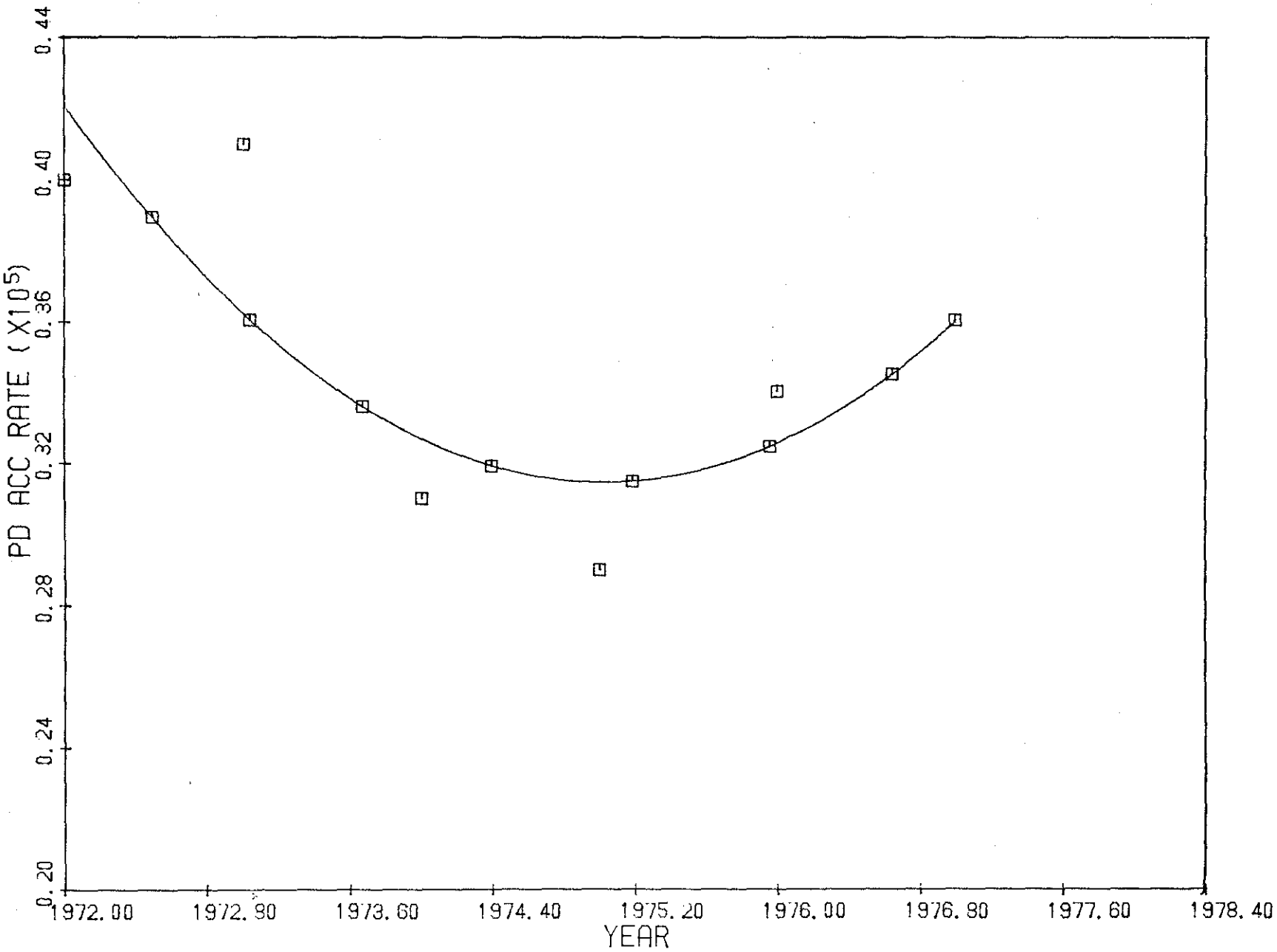

Fig 23.TOTAL ACCIDENT RATE FOR TRUCK TRACTOR

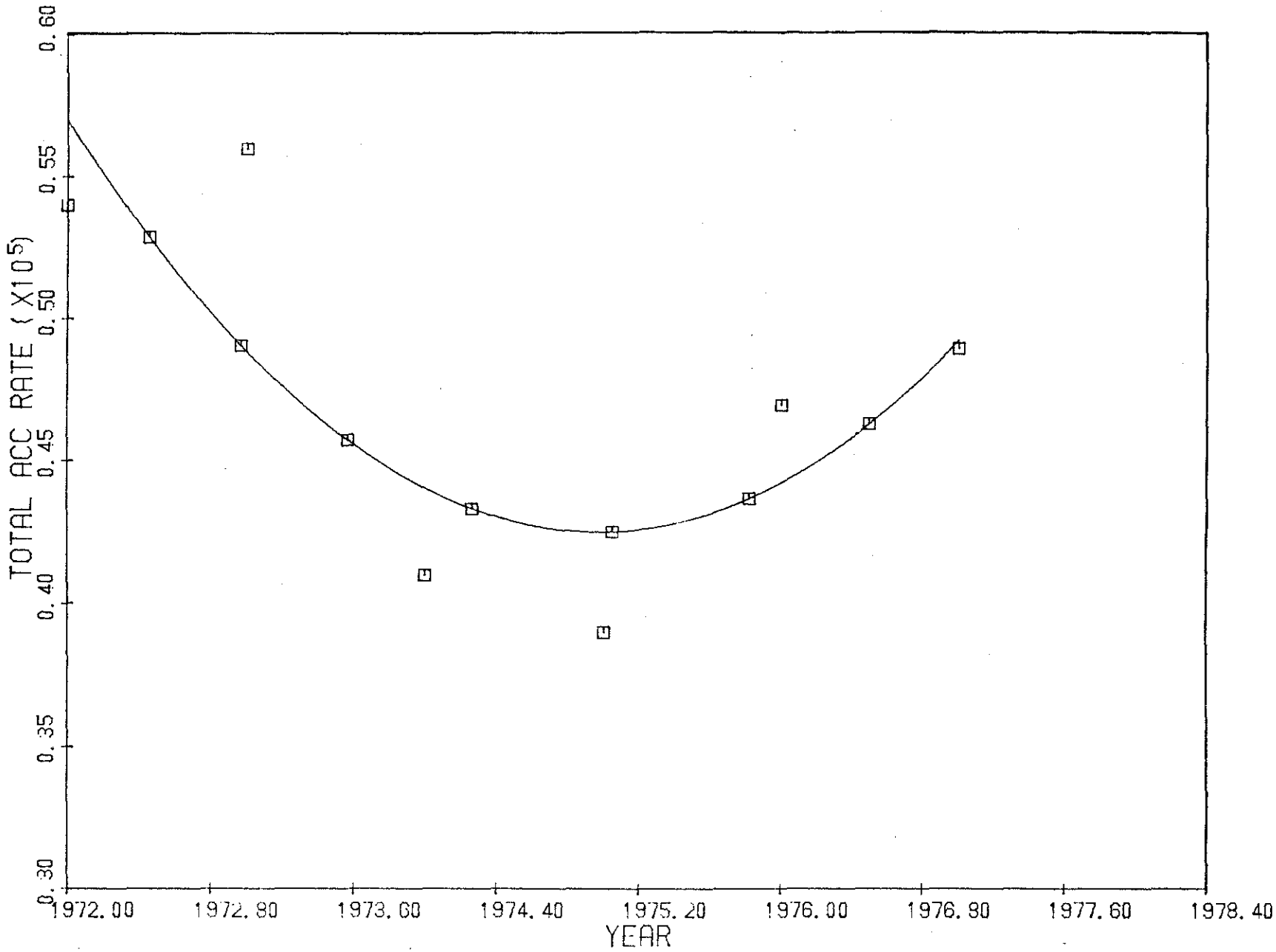

Fig 24. FATAL ACCIDENT RATE FOR TRUCK TRACTOR

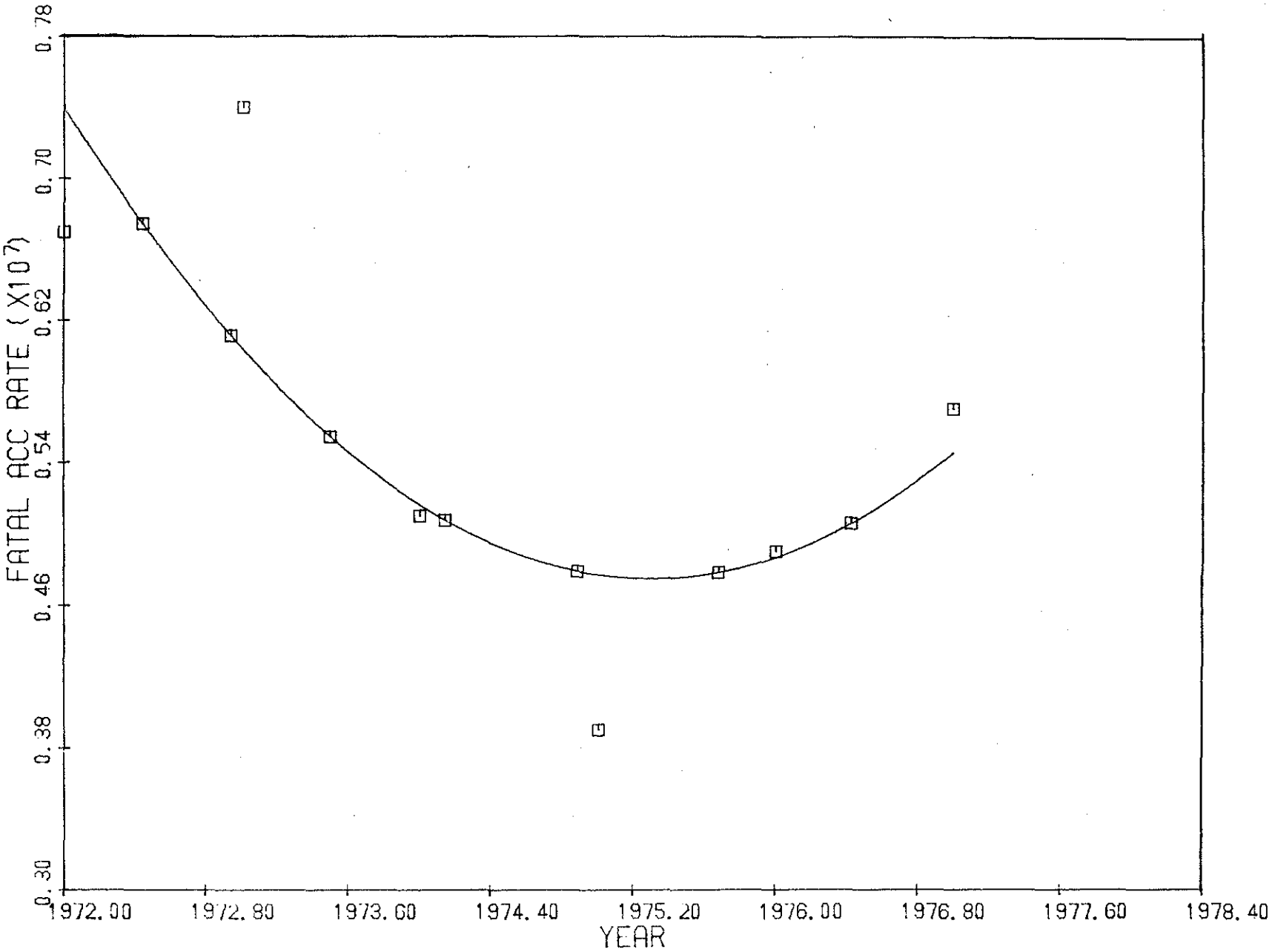

TABLE 25. COMPARISON OF ACCIDENT EXPERIENCE
BETWEEN PICKUPS, PANELS & VANS AND NON-TRUCKS
(BASED ON NO. OF ACCIDENT/VMT)

Accident Type	Mean Rate	Test	$t_{Calculated}$	$t_{Critical}$	DF	Conclusion
Fatal Accident	3.7317 2.7883	PPV's vs Nontrucks	4.7357	1.812	10	Reject Ho (PPV's Higher)
PI Accident	1.8050 1.7950	PPV's vs Nontrucks	.11249	1.812	10	Accept Ho (No Difference)
PD Accident	4.8800 3.9783	PPV's vs Nontrucks	3.5949	1.812	10	Reject Ho (PPV's Higher)
Total Accident	6.7283 5.8017	PPV's vs Nontrucks	2.8121	1.812	10	Reject Ho (PPV's Higher)

Ho - There is no difference between accident rates of compared classes
Accept Ho - No difference
Reject Ho - Difference exists

TABLE 26. COMPARISON OF ACCIDENT EXPERIENCE BETWEEN DUMPS & STAKES, ETC. AND NON-TRUCKS BASED ON NO. OF ACCIDENT/VMT

Accident Type	Mean Rate	Test	$t_{Calculated}$	$t_{Critical}$	DF	Conclusion
Fatal Accident	16.767 2.7883	Dumps & Stakes vs Nontrucks	20.790	1.812	10	Reject Ho (Dumps & Stakes Higher)
PI Accident	8.0267 1.7950	Dumps & Stakes vs Nontrucks	13.016	1.812	10	Reject Ho (Dumps & Stakes Higher)
PD Accident	23.450 3.9783	Dumps & Stakes vs Nontrucks	11.695	1.812	10	Reject Ho (Dumps & Stakes Higher)
Total Accident	31.650 5.8017	Dumps & Stakes vs Nontrucks	12.015	1.812	10	Reject Ho (Dumps & Stakes Higher)

Ho - There is no difference between accident rates of compared classes
Accept Ho - No difference
Reject Ho - Difference exists

TABLE 26A COMPARISON OF ACCIDENT EXPERIENCE BETWEEN DUMPS & STAKES, ETC. AND NON-TRUCKS BASED ON NO. OF ACCIDENT/VMT (REVISED VMT DATA

Accident Type	Mean Rate	Test	$t_{Calculated}$	$t_{Critical}$	DF	Conclusion
Fatal Accident	12.94 2.7883	Dumps & Stakes vs Nontrucks	15.229	1.812	10	Reject Ho (Dumps & Stakes Higher)
PI Accident	6.08 1.7950	Dumps & Stakes vs Nontrucks	8.950	1.812	10	Reject Ho (Dumps & Stakes Higher)
PD Accident	17.78 3.9783	Dumps & Stakes vs Nontrucks	8.290	1.812	10	Reject Ho (Dumps & Stakes Higher)
Total Accident	24.00 5.8017	Dumps & Stakes vs Nontrucks	8.459	1.812	10	Reject Ho (Dumps & Stakes Higher)

Ho - There is no difference between accident rates of compared classes
Accept Ho - No difference
Reject Ho - Difference exists

TABLE 27. COMPARISON OF ACCIDENT EXPERIENCE BETWEEN TRUCK TRACTORS AND NON-TRUCKS BASED ON NO. OF ACCIDENT/VMT

Accident Type	Mean Rate	Test	$t_{Calculated}$	$t_{Critical}$	DF	Conclusion
Fatal Accident	5.6533 2.7883	Truck Tractors vs Nontrucks	5.3537	1.812	10	Reject Ho (Truck Tractor Higher)
PI Accident	1.2033 1.7950	Truck Tractors vs Nontrucks	-6.2613	1.812	10	Reject Ho (Truck Tractor Lower)
PD Accident	3.5700 3.9783	Truck Tractors vs Nontrucks	-2.0285	1.812	10	Reject Ho (Truck Tractor Lower)
Total Accident	4.8333 5.8017	Truck Tractors vs Nontrucks	-3.2917	1.812	10	Reject Ho (Truck Tractor Lower)

Ho - There is no difference between accident rates of compared classes
Accept Ho - No difference
Reject Ho - Difference exists

are quite self-explanatory, a number of general observations are in order. Tables 25 and 26 clearly show that, excepting for personal injury accidents for PPV's, for all other accident categories, both PPV's and stakes/dumps have a statistically higher accident rate than non-trucks. The rejection of the hypothesis is seven out of eight cases leads to such an inference. Table 27, on the other hand, indicates that truck tractors have a higher accident rate only in the case of fatal accidents; in all three other accident categories the rates of truck tractor accidents are statistically lower than those of non-trucks.

Further review of the exposure data for stakes and dumps indicated that the original VMT figures for this category of trucks may have been somewhat underestimated. The 1972 census data, for example, indicated an average rate of 13,900 miles/year as opposed to the figure 10,525 miles/year used in the original analysis (Table 14). In view of this difference in rate, the analysis of accident data for dumps and stakes was reworked with revised VMT data. In this analysis, the VMT data reported in Table 14 was updated for each analysis year by the factor of $\frac{13,900}{10,525}$.

The revised VMT's resulted in a somewhat reduced accident rate. The results of the revised analysis are reported in Table 26A. A comparison of results from Table 26 and 26A indicates that although the revised VMT did change in accident rate, these were not significant enough to cause any change in the statistical results. The statistical inferences to be drawn from these two tables are exactly the same - indicating that the revised VMT's had very little impact upon the final analysis. This again shows that the process of estimation of VMT's did not introduce any significant error to the overall analysis.

Comparison Among Truck Categories: Tables 28, 29, and 30 provide the results of statistical comparison of accident rates for the three truck categories as they are compared among themselves. Table 28 indicates that compared to PPV's, dump and stake trucks have a consistently higher rate in all categories[1]. Table 29 shows on the other hand, that compared to PPV's, truck tractors had a higher rate in case of fatal accidents and lower rates in the other three accident categories. Table 30, which shows the comparison between dumps/stakes[1] and truck tractors, indicates that in all accident categories, dumps/stakes had a higher accident rate.

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[1]The analysis was reworked with revised VMT's for stakes/dumps as in the earlier case. Since this analysis did not cause any changes in the final results, these are not reported in the study.

TABLE 28. COMPARISON OF ACCIDENT EXPERIENCE BETWEEN PICKUPS, PANELS & VANS AND DUMPS & STAKES (BASED ON NO. OF ACCIDENT/VMT)

Accident Type	Mean Rate	Test	$t_{Calculated}$	$t_{Critical}$	DF	Conclusion
Fatal Accident	3.7317 16.767	PPV's vs Dumps & Stakes	-19.435	1.812	10	Reject Ho (Dumps & Stakes Higher)
PI Accident	1.8050 8.0267	PPV's vs Dumps & Stakes	-12.951	1.812	10	Reject Ho (Dumps & Stakes Higher)
PD Accident	4.8800 23.450	PPV's vs Dumps & Stakes	-11.041	1.812	10	Reject Ho (Dumps & Stakes Higher)
Total Accident	6.7283 31.650	PPV's vs Dumps & Stakes	-11.479	1.812	10	Reject Ho (Dumps & Stakes Higher)

Ho - There is no difference between accident rates of compared classes
Accept Ho - No difference
Reject Ho - Difference exists

TABLE 29. COMPARISON OF ACCIDENT EXPERIENCE
BETWEEN PICKUP, PANEL & VAN AND TRUCK TRACTORS
(BASED ON NO. OF ACCIDENT/VMT)

Accident Type	Mean Rate	Test	$t_{Calculated}$	$t_{Critical}$	DF	Conclusion
Fatal Accident	3.7317 5.6533	PPV's vs Truck Tractors	-3.6051	1.812	10	Reject Ho (Truck Tractor Higher)
PI Accident	1.8050 1.2033	PPV's vs Truck Tractors	5.8634	1.812	10	Reject Ho (PPV's Higher)
PD Accident	4.8800 3.5700	PPV's vs Truck Tractors	4.2010	1.812	10	Reject Ho (PPV's Higher)
Total Accident	6.7283 4.8333	PPV's vs Truck Tractors	4.5704	1.812	10	Reject Ho (PPV's Higher)

Ho - There is no difference between accident rates of compared classes
Accept Ho - No difference
Reject Ho - Difference exists

TABLE 30. COMPARISON OF ACCIDENTS EXPERIENCE BETWEEN DUMPS & STAKES AND TRUCK TRACTOR BASED ON NO. OF ACCIDENT/VMT

Accident Type	Mean Rate	Test	$t_{Calculated}$	$t_{Critical}$	DF	Conclusion
Fatal Accident	16.767 5.6533	Dumps & Stakes vs Truck Tractors	13.316	1.812	10	Reject Ho (Dumps & Stakes Higher)
PI Accident	8.2067 1.2033	Dumps & Stakes vs Truck Tractors	14.172	1.812	10	Reject Ho (Dumps & Stakes Higher)
PD Accident	23.450 3.5700	Dumps & Stakes vs Truck Tractors	11.867	1.812	10	Reject Ho (Dumps & Stakes Higher)
Total Accident	31.650 4.8333	Dumps & Stakes vs Truck Tractors	12.381	1.812	10	Reject Ho (Dumps & Stakes Higher)

Ho - There is no difference between accident rate of compared classes
Accept Ho - No Difference
Reject Ho - Difference exists

4. SUMMARY AND CONCLUSIONS

The objective of this study was to conduct an investigation on the relative incidence of truck accidents, compared to all other motorized vehicles, based upon an analysis of factual data from the State of Michigan. The primary emphasis of this study was on the maximization of the use of available accident and exposure data, with no effort on new data collection.

The analysis was conducted in two stages. In Stage 1, a comparison of accident experience of all trucks with all other motorized vehicles was made. In Stage 2, truck accident data was further categorized into three truck categories and a comparison with non-truck data for each of the three categories was made. Additionally, a comparison of the accident data between the truck categories themselves was made. Data on the number of accidents by truck categories was not available directly, as such, these figures were estimated from data on the number of vehicles involved. The conclusions of the study are as follows:

Stage 1 Analysis

1. In case of fatal and property damage (PD) accidents, trucks had a higher accident rate compared to non-trucks.

2. For injury accidents, trucks had a lower accident rate compared to non-trucks.

3. When all accidents are considered together, it appears that there is not a significant difference in the accident rate of these two vehicular categories.

Note: The above conclusions have been schematically represented in Table 31.

Stage 2 Analysis

4. The Pickups/Panels/Vans (PPV's) appear to have a higher accident rate compared to non-trucks in case of fatal, PD and total category; in case of PI accidents the rate of PPV's are lower.

5. For straight trucks (stakes, dumps, etc.) the accident rates in all accident types is higher than those for non-trucks.

6. For truck tractors, only in case of fatal accident, these have a higher rate than non-trucks. In all three other categories, these have a lower rate.

7. A comparison of the accident rates of the three truck categories among themselves revealed that:

TABLE 31. SUMMARY OF ANALYSIS BASED ON NO. OF ACCIDENTS/VMT TRUCKS Vs. ALL OTHER MOTORIZED VEHICLES (NON-TRUCKS)

Truck Categories	Accident			
	Fatal	PI	PD	Total
All Trucks	X	·	X	-
PPV's	X	-	X	X
Dump & Stake	X	X	X	X
Truck Tractor	X	·	·	·

Note: X = Trucks have higher accident rate than non-trucks
· = Trucks have lower accident rate than non-trucks
- = No significant difference

a. Straight trucks (dumps, stakes, etc.) had a higher rate in all accident categories compared to PPV's and truck tractors.

b. PPV's had a higher accident rate in cases of PI, PD, and total accidents compared to truck tractors.

c. Truck tractors appear to have a higher accident rate compared to PPV's in the fatal category.

5. RECOMMENDATIONS FOR FURTHER STUDIES

The purpose of this study was to analyze the role of trucks in the incidence of traffic accidents in the light of historical accident data for the State of Michigan. A comparison of accident data for trucks and non-trucks revealed interesting trends. However, a number of new research topics can be identified as a result of this study which warrant further investigation.

(1) An analysis, similar to the one reported in this study, should be conducted in which accident rates for trucks by categories will be compared with similar rates developed for passenger cars. The scope of this study did not allow the consideration of passenger cars exclusively, rather all non-trucks were considered together. Considering the fact that passenger cars comprise the greatest majority of all motorized vehicles, such a study appears immensely justified.

(2) A more complete analysis of the accident data relative to severity of injuries should be made between trucks, non-trucks and passenger cars, in which each accident by severity would be specifically analyzed. The current State Police data makes it possible to study this phenomena following the KABCO[1] severity scheme. Again, this study is feasible with a minimum of data retrieval effort.

(3) An analysis should be conducted in which accident data may be further categorized by type of roadway facilities (e.g. urban vs rural, or interstate vs state,truck roads vs local facilities). Such an analysis is vastly justified in view of the fact that the type of roadway facilities and their associated geometric, operational features are said to be major factors in the incidence of traffic accidents. Such an analysis could indicate the type of roadway facilities that are perhaps more hazardous than others in view of the truck accident history. The findings from this study could lead to governmental programs to improve the safety features of hazardous facilities thus identified.

(4) The validity of the findings of this study could be further tested through a similar analysis with accident data from another comparable state. As an example, the data from the states of Ohio or Pennsylvania could be analyzed to determine if similar trends are true for the other two states. It may be mentioned that the states of Michigan, Ohio, and Pennsylvania are reasonalby similar to one another in terms of population, highway mileage and highway travel.

(5) As an alternative to recommendation (4) or in addition to it, an analysis with nationwide accident data should be conducted in an effort to identify if the trends observed at the statewide level (e.g. Michigan) are similar to the nationwide trends.

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[1] KABCO - Killed, A category of severity, B category of severity, C category of severity, and O others.

(6) The current study is to be considered macroscopic in nature, in that the accident and exposure data analyzed represents gross areawide information for the enitre State of Michigan. While this study provided valuable insights to the role of trucks in accidents, a better understanding of this phenomenon requires further studies that are more microscopic in nature. Specifically it is proposed that samples of accident report available from a smaller study area be analyzed in detail in which the specific role of the trucks in the occurrence of the accident, as a vehicular entity, should be studied. Attempts should be made to identify a set of causative factors in such truck accidents through the technique of accident reconstruction. The implication of specific variables such as weather, driver, roadway, and vehicle factors should be analyzed. An analysis of the frequency of citations issued to trucks in case of a multi-vehicle accident, should be studied in order to identify the relative proportion of sample accidents in which the trucks, as a vehicular entity, was responsible for the accident.

(7) As a further effort towards categorization by truck types, the feasibility of studying the incidence of double bottom truck accidents relative to all other truck accidents should be explored. The availability of necessary data would determine the viability of such a study.

(8) The growing upward trend of truck accidents, in almost all "truck category-accident type" combinations should be studied in greater detail so that necessary countermeasures to stall such trends can be effectively identified.

6. ACKNOWLEDGEMENT

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The opinions and viewpoints expressed in this report are entirely those of the authors. They do not in any way reflect the plans, policies, or programs of any particular agency mentioned above.

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