THE EFFECT OF INCREASING RETAIL GASOLINE PRICES ON PUBLIC TRANSIT RIDERSHIP

By

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ABSTRACT

In the spring of 1983, when this project was in its most preliminary stages, a simple hypothesis was put forward. This hypothesis suggested that auto users would react to rising retail gasoline prices by switching to an alternative mode of transportation, such as public transit. It was thought that, since any increase in fuel costs could be spread out among all transit users, public transit would become an attractive alternative to the private automobile in an individual's transportation mode decision as retail gasoline prices increased. Therefore, a positive relationship was anticipated to exist between public transit ridership and retail gasoline prices.

Having established the hypothesis to be investigated, an extensive review of current literature associated with the hypothesis was completed. This review presented conflicting opinions concerning the hypothesis, and also suggested that other variables were more important than the price of retail gasoline in affecting an individual's transportation mode decision.

Unfortunately, the literature review did not suggest any relevant method of analysis for this project. It was decided that, for reasons to be discussed later, linear regression would be the method of analysis. The results of the application of a number of linear regression models to data obtained for the Hamilton study area indicated that no definitive statement could be made with respect to the hypothesis of this project. This lack of significant results was attributed to extraneous variance created by certain variables that could not be controlled.

However, as a contribution to knowledge, this project provides a basis on which future studies can be built. If the extraneous variance that is discussed in this project can be eliminated in future studies, then it may be possible to obtain more significant results with respect to the hypothesis that public transit ridership is positively related to retail gasoline prices.

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INTRODUCTION

Since the success of the O.P.E.C. cartel in 1973, North American energy price increases have been significant. The oil shortages of 1973-74 and 1979 have resulted in accelerating retail gasoline prices throughout the western world. Whether or not these price increases have changed people's driving habits is open to question. During the 1970's and 1980's, the automobile has become a major mode of transportation in the United States and Canada as cities expanded and became more suburbanized. This growth has also led to the increased availability of alternative modes of transportation, such as public transit. Since rising retail gasoline prices have increased the cost of operating an automobile, it seems feasible to expect that increasing retail gasoline prices may have led to a change in an individual's mode of transportation from the automobile to public transit.

It is the intent of this paper to investigate the hypothesis that rising retail gasoline prices have led to an increased use of public transit. (In chapter one, a total of twenty-five articles have been reviewed in an attempt to determine the best approach for this project. Unfortunately, as chapter one explains, no articles could be found that dealt specifically with the hypothesis of this project. However, the articles were helpful in that they suggested a number of other variables that may be important in an individual's transportation mode decision, and which are used in the analysis.

Chapter two discusses the research design, data, and the method of analysis used in this project. The chapter defines the study area and the public transit system to be used in this study, which is the Hamilton Street Railway (H.S.R.) of Hamilton, Ontario. This is followed by the defining and operationalizing of the variables to be used, and also a discussion of the measurement problems encountered in the data collection process. The chapter ends by justifying linear regression as the method of analysis, and presents the four regression models that are used in this project.

The third chapter of this paper discusses the results of the application of each of the linear regression models. Also included in this chapter will be a visual representation of the actual relationship found in the data between public transit ridership and retail gasoline prices.

The conclusions of this project are then presented, along with a discussion of why specific results were evident in the analysis of chapter three. This is followed by suggestions of possible changes in the analysis of this project in order to obtain more significant and conclusive results.

CHAPTER 1: LITERATURE REVIEW

A review of the current literature associated with this topic is necessary in order to provide a strong background before the project is undertaken.

A total of twelve articles were found that were directly related to the relationship between public transit ridership and retail gasoline prices. Of these articles, four supported the hypothesis that rising retail gasoline prices have led to an increased use of public transit, while the remaining eight rejected this hypothesis.

With respect to the four articles in support of the hypothesis, two general themes are evident. The most important of the two appears to be that consumer attitudes are changing in favour of public transit as gasoline prices continue to rise. According to the literature, the shift from the automobile to public transit is described as a push-pull process; public transit pulls people from their cars while increasing gasoline prices help push them from behind the wheel (Gallo, 1980). Therefore, consumers are discovering that public transit can satisfy their transportation needs and is less costly than car travel (Smerk, 1980, 1981). Smerk asserts that new transit users are riders by choice rather than by necessity. A shift of motorists to transit signifies their new perception that driving costs have risen much higher than transit costs, and that the benefits of driving may not be worth the expense (Smerk, 1980).

The second theme found in the articles supporting the hypothesis is concerned with the duration of the effect of rising gasoline prices on public transit ridership. The literature suggested that the ridership gains would be shortlived because of the fact that new riders would return to their cars as gasoline prices stabilized at a new, higher price (Dean, 1980). Therefore, these new riders could only be retained if public transit services were improved and maintained.

The four articles which supported the hypothesis used primarily transportation statistics and survey results to make their conclusions. The surveys elicited responses concerning travel habits and perceptions of transport modes under simulated situations of varying retail gasoline prices. An aggregate approach was used in studies which were based on reference to transit statistics, while an individual level approach was applied in those studies which utilized survey techniques.

Two general conclusions were found in the eight articles that rejected the hypothesis that rising gasoline prices have led to an increased use of public transit. The notion of habit formation was supported by a number of articles as a barrier preventing a switch to public transit from car travel (Khan, 1983; Blase, 1980; McDermott, 1978;

Banister, 1978). In an extensive study of responses to gasoline price increases in London, England, Blase argued that the collective habits of individual travellers would prevent them from switching to public transit as gasoline prices increased. He defined a "habit threshold" as being the amount by which gasoline prices had to increase before the habit effect was broken, and the switch to public transit was made. Therefore, gasoline prices could effectively increase without any change in transportation mode choice.

A change to more fuel efficient automobiles as a response to rising gasoline prices was another argument that was presented in the literature that rejected the hypothesis (Elmberg, 1978; Keck, 1974). In these articles, it was suggested that people would not switch to public transit, but would respond to rising gasoline prices by purchasing smaller, more fuel efficient cars, or by changing their driving habits in order to conserve fuel. Johnson concluded from his study that, for most auto users, public transit was not viewed as a feasible alternative as gasoline prices increased (Johnson, 1975). Therefore, switching to public transit was viewed as highly unlikely.

The majority of the data used in the eight studies that rejected the hypothesis was obtained at the individual level through questionnaires and home interviews. Exceptions to this approach were studies by Blase and by Khan, who both made use of aggregate data as an input into their respective models of modal choice. These models are probabilistic in nature, and incorporate the price of retail gasoline as a variable that influences the mode choice decision.

An additional thirteen articles were found that were indirectly related to the hypothesis that rising gasoline prices have led to an increased use of public transit. Two general considerations appear in these articles. One is that variables other than the price of gasoline are much more important in a consumer's transportation mode decision. Variables such as speed, comfort, and convenience were suggested in a number of articles as being the critical factors in making this decision (Curtis, 1980; Solomon, 1980; Hensher, 1979; Golob, 1977). According to a paper published by Transport Canada, other important factors such as the availability of the car since WWII, and the increased suburbanization of cities have led to an increased consumer preference for the automobile (Fundamentals of Urban Transit, 1978). This has increased the importance of the convenience variable associated with the automobile, and has decreased the overall service level of public transit because of the longer routes that are associated with suburbanization. Several articles also suggested that the image of public transit and the social status associated with it were important in a consumer's transport mode decision (Curtis, 1981; Recker, Stevens, 1976; Stopher, 1982). According to Stopher, the car has become a symbol of the desired lifestyle and an indicator of wealth and status. Therefore, the image of public transportation is predominantly negative. In another article, the transportation mode choice decision of the elderly was examined, with the conclusion being that the quality variable associated with the mode of transportation was most important in their decision (Paaswell, Edelstein, 1976). Since using public transit involved the inconvenience of overcrowded buses and also the problem of walking to bus stops in bad weather, the quality variable associated with public transit was not rated very highly.

The consumer's perception of costs for different travel modes is the second consideration that was discussed in the literature. (The general conclusion was that most auto users tended to underestimate driving costs relative to bus costs) (Henley, Levin, Louviere, Meyer, 1981; Heads, 1980; Gilbert, Foerster, 1977). Therefore, consumers would choose the automobile for their mode of transportation because they perceive bus costs as being higher than automobile costs.

Most of the articles indirectly related to the hypothesis based their conclusions on the analysis of individual level data. This data was obtained through the use of questionnaires and home interviews, and was primarily concerned with perceptions of travel costs and reasons for preferring different modes of transportation under simulated changes in the price of retail gasoline. A few articles, such as those by Curtis, by Gobol, and by Recker and Stevens, used multinomial logit models of modal choice. These models are probabilistic, and use data from questionnaires and interviews as an input. They are primarily concerned with determining the probability of an individual choosing a transport mode alternative from a given set of alternatives when a specific variable, such as the price of retail gasoline, changes.

In assessing the literature that has been reviewed, it can be suggested that the degree to which increases in gasoline prices affect public transit ridership depends primarily on the habits of consumers. If gasoline prices have risen sufficiently, consumer habits may well have been broken, and a switch to public transit could possibly be the result. Also, as gasoline prices continued to rise, consumer attitudes and their perceptions of travel costs may have changed in favour of public transit, which would result in increased ridership over the years. However, as suggested in the literature, the importance of other variables in the transportation mode choice decision must not be ignored. Therefore, these variables should be taken into consideration when examining changes that have occurred in public transit ridership as gasoline prices increased.

If it is found that rising gasoline prices have led to increased public transit ridership, this increase may only exist in the short run. As consumers adapt to higher prices for retail gasoline, they may return to their cars after a certain period of time has elapsed. Therefore, as consumers familiarized themselves with higher gasoline prices, the switch to public transit would be reduced, and a return to the automobile may well have occurred.

Most of the articles that have been discussed in this review have based their conclusions on questionnaire or home interview data. Since many of the questionnaires presented simulated "what if" situations to the respondent, the data obtained from this approach may have represented the respondents' intentions and not necessarily their actual behaviour when retail gasoline prices increased. Therefore, individual level data obtained in this way may not be reliable. Since factual aggregate data is readily available, it will be used in this project.

The remainder of the articles used mode choice models that were probabilistic in nature. However, these models were used to determine modal choice rather than the factors that were significant in choosing public transit. In fact, no study dealt specifically with finding the determinants of choosing public transit. Therefore, the literature did not suggest any suitable methods of analysis. This project will use linear regression as the method of analysis. The rationale for this choice of method is discussed in the following chapter.

CHAPTER 2: RESEARCH DESIGN, DATA, AND ANALYSIS

This chapter begins by discussing the research design of the project, which includes the defining and operationalizing of the variables to be used, as well as the defining of the study area and time period. This will be followed by a discussion of various measurement problems that were encountered when collecting data for the project. The choice of linear regression as the method of analysis will then be defended as a logical and feasible approach. Finally, the linear regression models used in this project will be presented.

The hypothesis of this paper is a general one suggesting a positive relationship between a dependent variable, public transit ridership, and an independent variable, retail gasoline prices. The literature review has suggested that other variables are important in the decision to use public transit. Therefore, three additional variables have been included as independent variables. These are public transit fare, number of buses in service, and city population.

The study focuses on the public transit system of Hamilton, Ontario -- the Hamilton Street Railway (H.S.R.). The study period extends from 1960 to 1982 so that a comparison can be made between the years prior to and since the success of O.P.E.C.. Aggregate annual data regarding public transit ridership have been obtained from the H.S.R..

Ridership is measured in terms of revenue passengers, which refers to the total number of trips paid for in cash or by ticket.

The public transit fare statistics are yearly figures and are also obtained from the H.S.R.. Since any increase in public transit ridership that results from higher retail gasoline prices may be offset by an increase in transit costs for the consumer, the public transit fare variable is included in order to account for this possible source of variance.

The H.S.R. has also provided statistics for the variable, number of buses in service. This variable is included in an attempt to represent the quality of public transit service and reliability. It is assumed that if the number of buses in service increases, average waiting time at bus stops will be reduced if no new routes have been added. Therefore, public transit may become more attractive to an individual, and may result in increased public transit ridership.

City population figures have been acquired from the Corporation of the City of Hamilton Handbook (1960-1977), and from the Municipal Directory (1978-1982). This variable is included to identify any effect that changes in Hamilton's population may have on public transit ridership. It is anticipated that a positive relationship exists between these two variables. If this is true, then one would expect that Hamilton's stagnant and at times decreasing population since the mid 1970's may have a distorting effect on any relationship that exists between public transit ridership and retail gasoline prices.

The retail gasoline price statistics are end-of-year prices for regular leaded gasoline from full-service stations, and have been obtained from Shell Canada Ltd.. Unfortunately, these figures are not available for Hamilton, since they are recorded only for major regional centers. Therefore, end-of-year prices for regular leaded gasoline from full-service stations in Toronto have been substituted. This substitution is justified by the fact that both cities are major centers of Southern Ontario and are located in close proximity to each other. Therefore, it is fair to assume that any difference in retail gasoline prices between the two cities will be minimal, and should not adversely affect the results of this project.

Some other measurement problems also arose in this project. Since public transit strikes had occurred in Hamilton in 1971 and 1982, the lower ridership figures associated with these years had to be adjusted or deleted so that a more accurate account of any relationship between public transit ridership and retail gasoline prices could be identified. Therefore, a public transit strike variable is included in order to account for the extraneous variance created by transit strikes.

Another measurement problem involves the manner in which public transit ridership is measured. During most of the 1960's and the early 1970's, Hamilton's population was increasing, while it has remained stagnant through the mid and late 1970's and early 1980's. These changes in population may have contributed to any increases or decreases in public transit ridership, or may have had the effect of distorting any relationship that may exist between public transit ridership and retail gasoline prices. In order to remove this possible distortion, public transit ridership per capita will also be used as a dependent variable.

A final element encountered in this project which created a measurement problem was the introduction of monthly transferrable bus passes by the H.S.R. in 1977. Since public transit ridership is measured in terms of revenue passengers, all riders who use these passes are excluded. Unfortunately, the H.S.R. could not provide statistics pertaining to how many rides were made each year through the use of these passes since 1977. Therefore, there was no way of controlling the extraneous variance created by this source.

The method of analysis that has been chosen for this project is linear regression. This method was selected for the following reasons. First of all, the data available for this project is made up of observations of a number of variables over an extended period of time. That is, the project deals with time series data. Linear regression is a strong method of analysis when using this type of data.

Secondly, linear regression is an appropriate method of analysis because through this method one can control other factors in order to evaluate the contributions of a specific variable or set of variables. The measurement problems along with the discussion of variables found above have led to possible sources of extraneous variance. Therefore, through the use of linear regression, most of these sources can be controlled when investigating the relationship between public transit ridership and retail gasoline prices.

A final reason for choosing linear regression as the method of analysis is that by employing a stepwise multiple linear regression procedure, one can determine which independent variable explains the greatest amount of variance in the dependent variable. Therefore, the most important variable in explaining changes in public transit ridership can be identified.

A total of four models will be employed in the linear regression analysis. These models are as follows:

(1) $RIDSHIP = K + b_1 GAS\$ + b_2 STRIKE$

(2) $RIDSHIP = K + b_1 GAS\$ + b_2 FARE + b_3 BUSES + b_4 POP + b_5 STRIKE$

(3) $RPERCAP = K + b_1 GAS\$ + b_2 STRIKE$

(4) $RPERCAP = K + b_1 GAS\$ + b_2 FARE + b_3 BUSES + b_4 STRIKE$

where: RIDSHIP = annual public transit ridership

RPERCAP = annual public transit ridership per capita

GAS$ = end-of-year price for regular leaded gasoline at full-service stations

FARE = annual public transit fare per ride

BUSES = number of buses in service per year

POP = annual city population

STRIKE = dummy variable equal to "1" for strike years and "0" otherwise

K = constant

$b_1 b_2 b_3 b_4 b_5$ = regression coefficients

Each model will be run over the entire time period from 1960 to 1982, and also over two sub-time periods. These sub-time periods are from 1960 to 1973, inclusive, and from 1974 to 1982, inclusive. This division is made to enable a comparison between a period of relatively stable retail gasoline prices (1960-1973), and a period of unstable and increasing retail gasoline prices (1974-1982). The level of significance upon which all results will be tested is the 0.05 significance level. All calculations and graphs have been formulated on the Cyber computer system at McMaster University. The computer program used in this project is the Statistical Package for the Social Sciences (S.P.S.S.).

CHAPTER 3: ANALYSIS OF RESULTS

This chapter begins by graphing the actual relationship as found in the data between public transit ridership and retail gasoline prices. The results of the application of the two linear regression models having public transit ridership as the dependent variable to the entire time period (1960-1982) will then be discussed, followed by a discussion of the results for these models as applied to the two sub-time periods (1960-1973; 1974-1982). This approach will then be repeated after substituting public transit ridership per capita for public transit ridership as the dependent variable.

Figures 1 and 2 plot annual public transit ridership against end-of-year retail gasoline prices from 1960 to 1982, including the two strike years (1971, 1982) in figure 1, and excluding these years in figure 2. Also, these graphs have been divided into the two sub-time periods that will be studied. For the entire time period, the slope coefficient associated with each of the two figures is positive. This suggests that a positive relationship does exist between annual public transit ridership and retail gasoline prices. The same result is obtained for the sub-time period from 1960 to 1973. However, for the sub-time period from 1974 to 1982, the slope coefficient in both figures is negative. This contradicts the expectation of this project that a strong positive relationship would exist for this sub-time

FIGURE 1: Public transit ridership vs retail gasoline prices (including strike years)

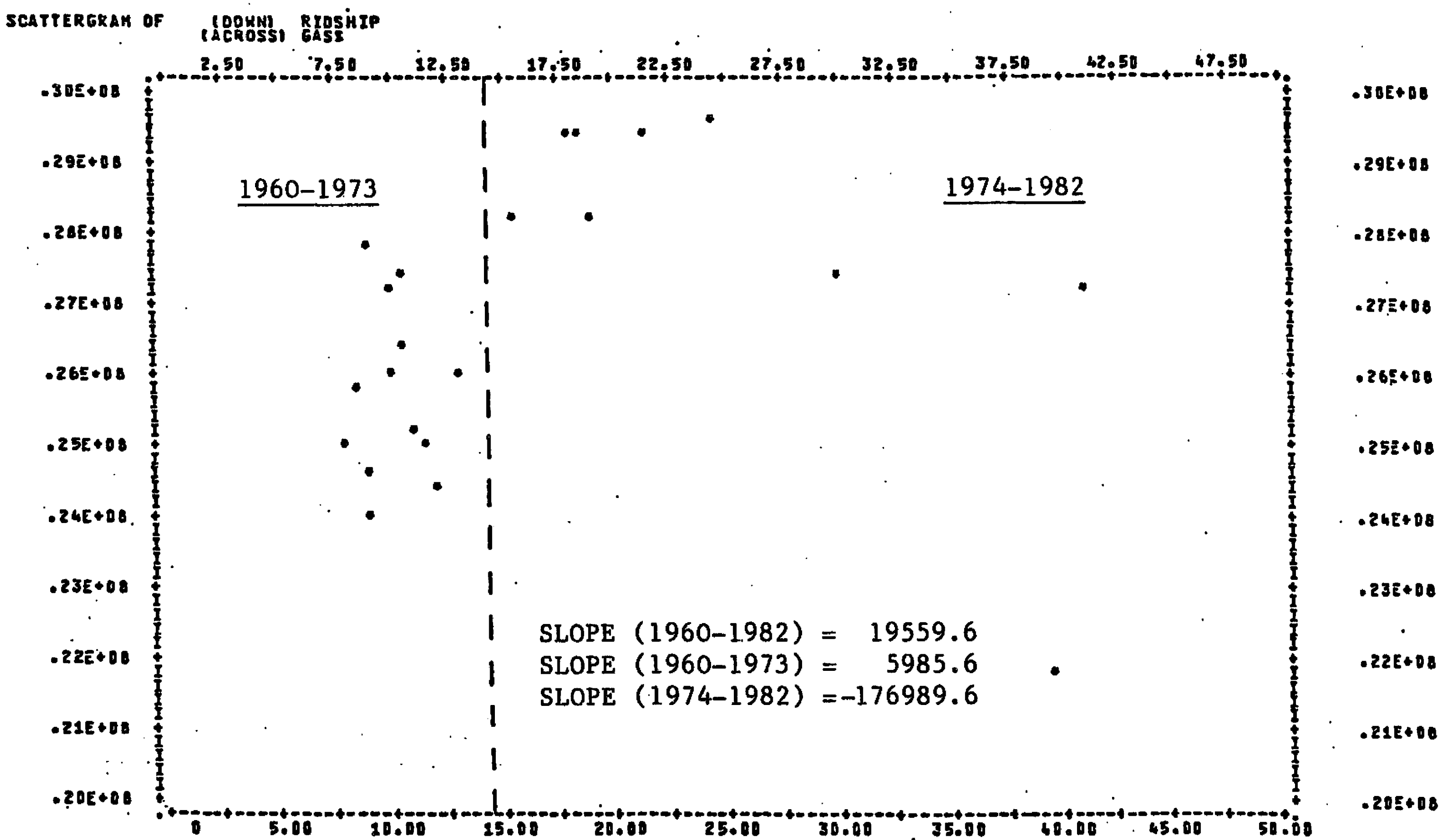
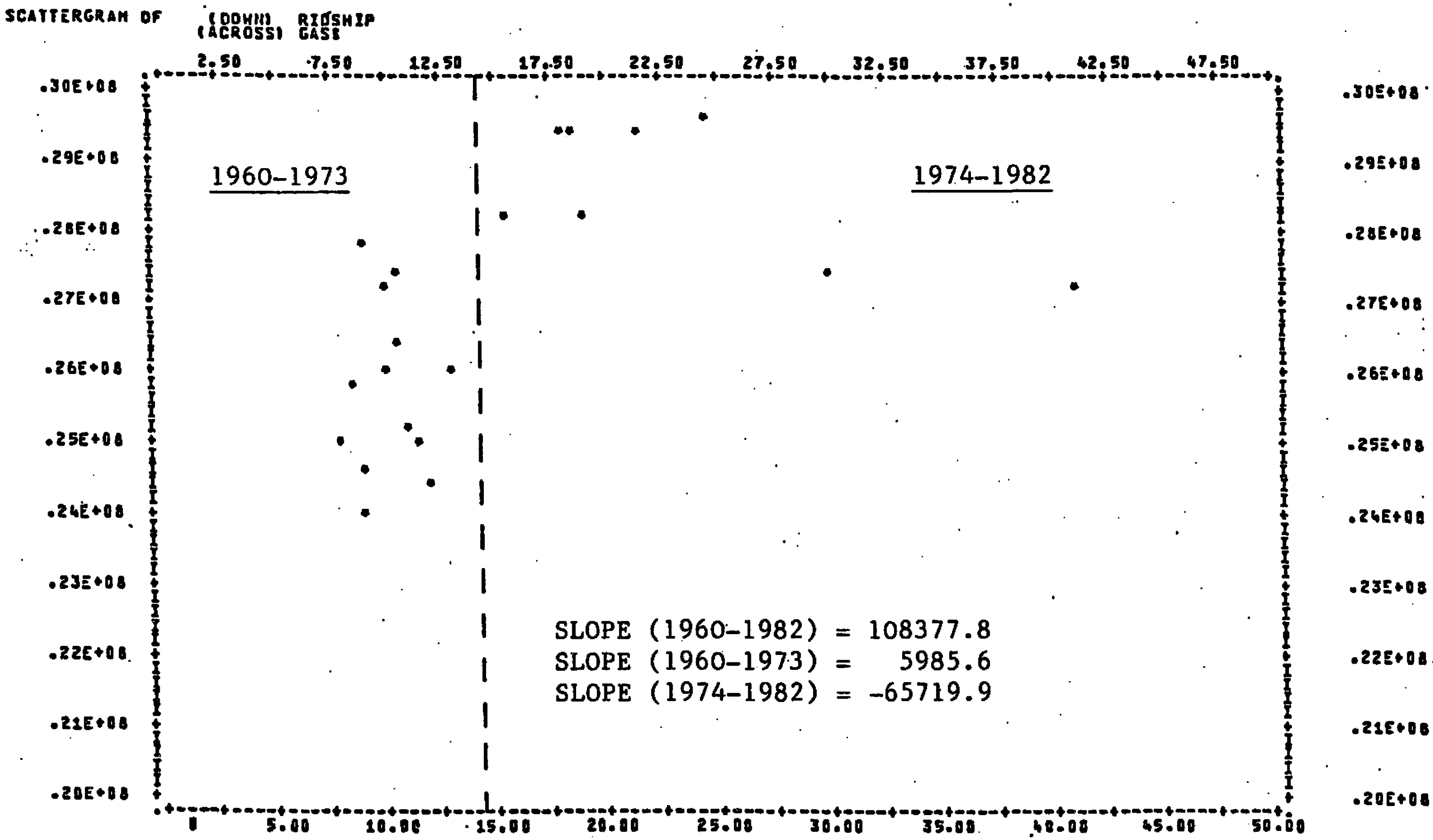


FIGURE 2: Public transit ridership vs retail gasoline prices (excluding strike years)



period since it is characterized by unstable and increasing retail gasoline prices.

The results from the first linear regression model having annual public transit ridership as the dependent variable and retail gasoline prices as the independent variable are found in tables 1, 2, and 3 for the entire time period and the two sub-time periods respectively. Table 1 shows that for the entire time period, the retail gasoline price variable is significant at the 0.05 level when the strike years are excluded, and is not significant when these years are included. Therefore, the null hypothesis can be rejected and it can be said that from 1960 to 1982, a significant relationship exists between annual public transit ridership and retail gasoline prices. Furthermore, this relationship is in the expected positive direction since the retail gasoline price coefficient is positive.

The results in table 2 are as expected in that no significant relationship exists between annual public transit ridership and retail gasoline prices during the sub-time period from 1960 to 1973. This is due to the fact that retail gasoline prices were fairly stable during this period.

For the sub-time period from 1974 to 1982, it was expected that a strong positive relationship would exist between annual public transit ridership and retail gasoline prices. However, table 3 shows that the only significant relationship that exists for this time period occurs when

TABLE 1: Public transit ridership vs retail gasoline prices, 1960-1982

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	34,451.487	.538	1.835

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	108,377.77	.016	26.807

TABLE 2: Public transit ridership vs retail gasoline prices, 1960-1973

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	-295,374.4	.448	4.87

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	5,985.5754	.981	.005

TABLE 3: Public transit ridership vs retail gasoline prices, 1974-1982

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	-176,989.59	.037	48.695

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	-65,719.871	.115	36.086

the strike year (1982) is included in the analysis. Also, the retail gasoline price coefficient is negative, which suggests that the relationship is a negative one.

It should be noted that in each of tables 1, 2 and 3, the coefficient of determination is never above 50%. This implies that less than half of the variation in annual public transit ridership is explained by variations in retail gasoline prices. Therefore, as suggested in the literature review, other variables must be significant in explaining the variation in annual public transit ridership. Table 4 gives the results of the second linear regression model over the entire time period having annual public ridership as the dependent variable and the price of retail gasoline, city population, number of buses in service, and public transit fare as the independent variables. From the table, it can be seen that the retail gasoline price variable entered into the equation in the third step when the strike years were included, and did not enter until the final step when the strike years were excluded. In both cases, only the number of buses in service and the public transit fare variables are significant at the 0.05 level. Therefore, over the entire time period, the retail gasoline price variable is not significantly related to annual public transit ridership when other variables are included in the equation.

Tables 5 and 6 give the results of the same multiple

TABLE 4: Public transit ridership vs retail gasoline prices, city population, number of buses in service, public transit fare, 1960-1982

STEP 1

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
number of buses in service	11,623.985	.091	13.031

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
number of buses in service	30,318.933	.000	52.802

STEP 2

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
number of buses in service	70,290.048	.000	49.119
public transit fare	-18,495,895.	.001	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
number of buses in service	59,582.978	.000	67.959
public transit fare	-13,223,570.	.009	

TABLE 4: (cont'd)

STEP 3

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
number of buses in service	54,687.231	.003	61.102
public transit fare	-36,026,372.	.000	
retail gasoline price	326,499.38	.026	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
number of buses in service	78,392.978	.000	73.150
public transit fare	-14,133,648.	.004	
city population	-45.985099	.088	

STEP 4

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
number of buses in service	70,151.548	.026	61.982
public transit fare	-33,886,006.	.002	
retail gasoline price	273,459.1	.104	
city population	-31.253492	.527	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
number of buses in service	70,804.523	.001	74.345
public transit fare	-20,634,063.	.030	
city population	-31.540234	.317	
retail gasoline price	97,539.506	.401	

linear regression model for the sub-time periods from 1960 to 1973 and from 1974 to 1982 respectively. For the earlier sub-time period, table 5 shows that the retail gasoline price variable was the last to enter into the equation in both the case when the strike year (1971) was included and when it was excluded. Furthermore, no significant relationship exists between annual public transit ridership and any of the independent variables. The results for the later sub-time period are found in table 6. For this period, the retail gasoline price variable was the third variable to enter into the equation when the strike year (1982) was included, and was the last variable to enter when the strike year was excluded. It can be seen from this table that only the public transit fare variable is significant at the 0.05 level, and that this is only true for the case which includes the strike year. The retail gasoline price variable is far from being significant in both cases, and it should be noted that the retail gasoline price coefficient is negative in the case that excludes the strike year. This implies that the relationship between annual public transit ridership and retail gasoline prices is in a direction opposite to what was expected in this project.

In figures 3 and 4, annual public transit ridership per capita is plotted against retail gasoline prices, including the strike years in figure 3, and excluding these years in figure 4. Once again, these graphs cover the

TABLE 5: Public transit ridership vs retail gasoline prices, city population, number of buses in service, public transit fare, 1960-1973

STEP 1

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-15,904,919.	.173	14.873

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-5,024,245.1	.530	3.687

STEP 2

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-4,035,976.3	.123	23.783
number of buses in service	61,625.607	.281	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-33,244,344.	.035	37.888
number of buses in service	72,028.442	.041	

TABLE 5: (cont'd)

STEP 3

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-46,085,970.	.127	25.529
number of buses in service	39,128.118	.604	
retail gasoline price	527,951.35	.639	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-29,394,725.	.142	38.683
number of buses in service	74,346.073	.050	
city population	-16.115373	.742	

STEP 4

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-33,507,666.	.348	29.230
number of buses in service	3,832.8418	.967	
retail gasoline price	1,709,540.2	.427	
city population	-107.43725	.510	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-26,260,323.	.213	41.981
number of buses in service	46,914.725	.401	
city population	-67.094629	.477	
retail gasoline price	805,110.35	.518	

TABLE 6: Public transit ridership vs retail gasoline prices, city population, number of buses in service, public transit fare, 1974-1982

STEP 1

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-13,698,958.	.003	74.291

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-5,595,820.	.096	39.313

STEP 2

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-19,221,591.	.001	86.232
number of buses in service	79,099.6	.063	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-10,476,163.	.028	65.428
number of buses in service	46,332.374	.110	

TABLE 6: (cont'd)

STEP 3

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-24,984,758.	.016	88.360
number of buses in service	58,404.103	.214	
retail gasoline price	122,989.89	.383	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-9,762,942.7	.046	73.797
number of buses in service	52,484.849	.092	
city population	113.74344	.322	

STEP 4

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-26,561,447.	.027	89.426
number of buses in service	61,275.446	.236	
retail gasoline price	158,868.54	.344	
city population	119.87327	.560	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-6,784,637.6	.508	74.901
number of buses in service	55,480.158	.144	
city population	99.025149	.472	
retail gasoline price	-44,486.659	.741	

entire time period from 1960 to 1982, and have been divided into two sub-time periods. As can be seen in the figures, the slope coefficients associated with the entire time period as well as the two sub-time periods are all negative. This implies that rising retail gasoline prices have been associated with falling annual public transit ridership per capita. However, this result may have been strongly influenced by changes in the composition of Hamilton's population over the years.

The results from the third linear regression model having annual public transit ridership per capita as the dependent variable and the price of retail gasoline as the independent variable are found in tables 7, 8, and 9 for the entire time period, and the two sub-time periods respectively. From these tables, it can be seen that the retail gasoline price variable is only significant during the earlier sub-time period. Furthermore, with reference to the retail gasoline price coefficient, this relationship, is negative. This may be explained by the following reasoning. During this sub-time period, Hamilton's population and local economy was growing, which resulted in an increase in suburbanization around Hamilton. Since these suburban areas were not as well serviced as the inner city, public transit ridership per capita would decrease. These decreases may have occurred at the same time as marginal increases in the price of retail gasoline. Therefore, this would result in

FIGURE 3: Public transit ridership per capita vs retail gasoline prices (including strike years)

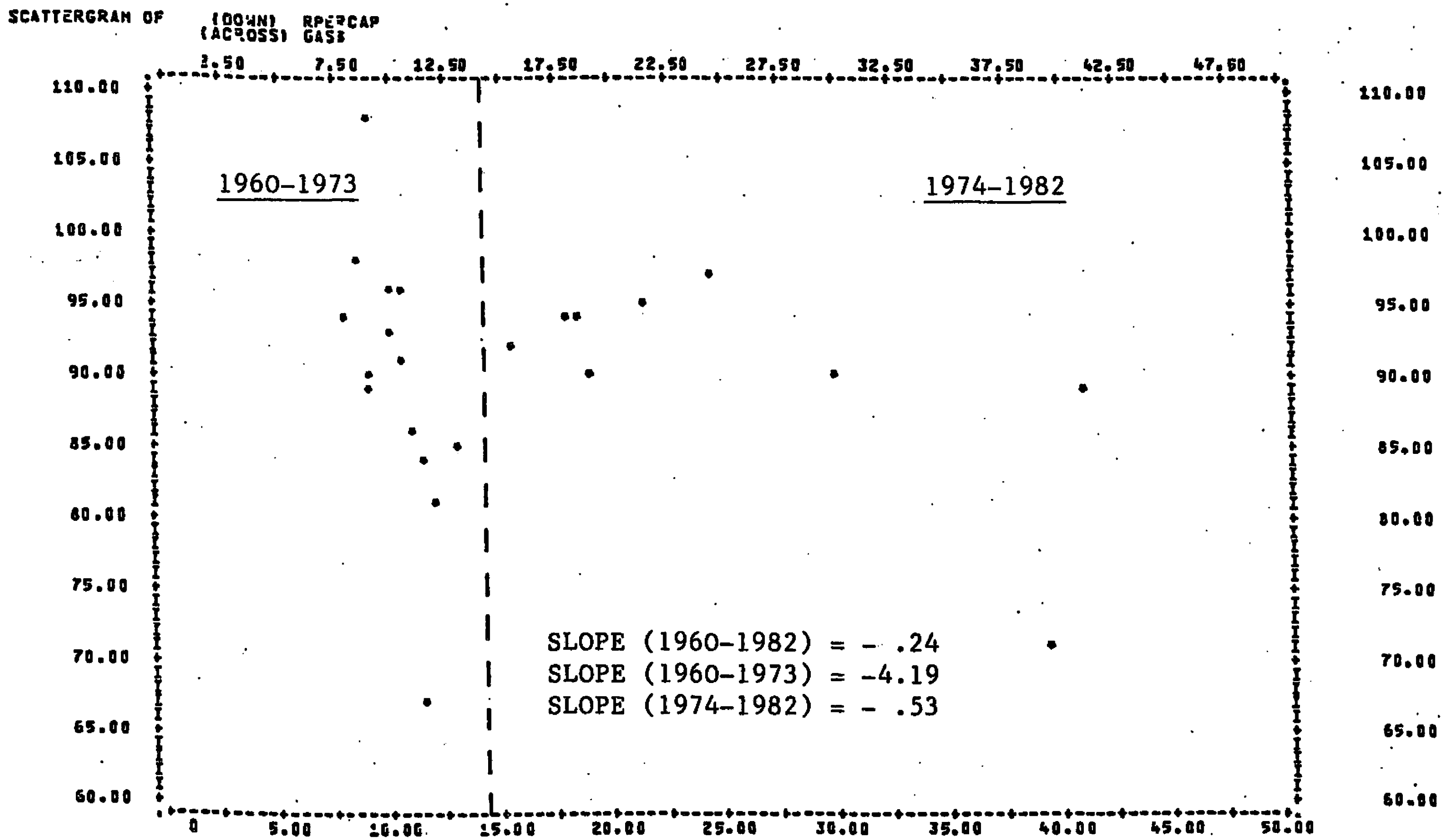


FIGURE 4: Public transit ridership per capita vs retail gasoline prices (excluding strike years)

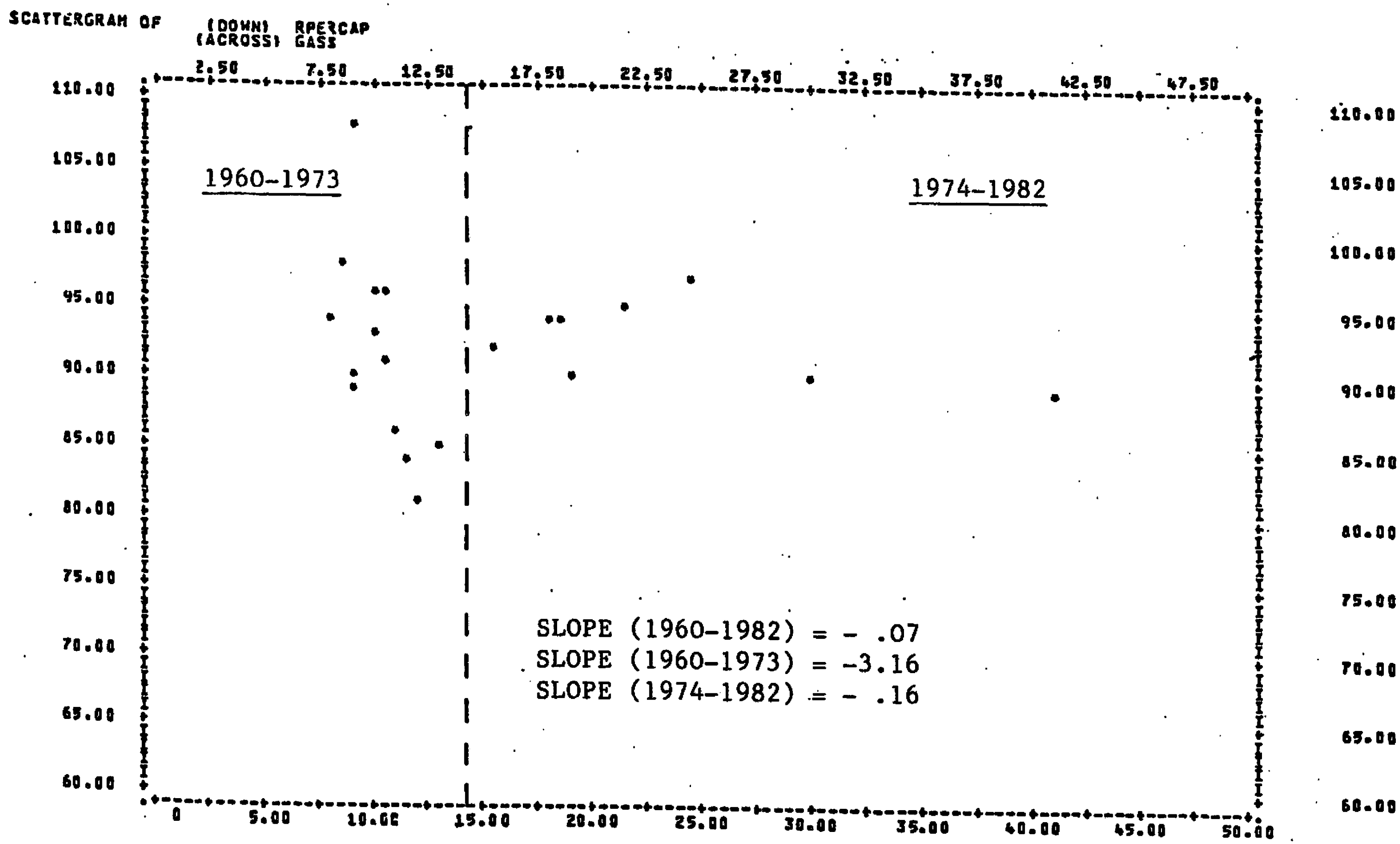


TABLE 7: Public transit ridership per capita vs retail gasoline prices, 1960-1982

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	-.23741698	.230	6.797

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	-.06937515	.662	1.028

TABLE 8: Public transit ridership per capita vs retail gasoline prices, 1960-1973

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	-4.1922125	.014	40.992

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	-3.1602214	.017	41.918

TABLE 9: Public transit ridership per capita vs retail gasoline prices, 1973-1982

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	-.53487364	.052	43.852

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
retail gasoline price	-.16205847	.210	24.764

the significant relationship that is found in table 8.

The results from the final linear regression model having annual public transit ridership per capita as the dependent variable and the price of retail gasoline, the number of buses in service, and the public transit fare as the independent variables are found in tables 10, 11 and 12.

Table 10 contains the results for the entire time period from 1960 to 1982. It can be seen that the retail gasoline price variable is the second variable to enter into the equation. In both the case that includes the strike years and the case that excludes these years, the retail gasoline price variable is significant at the 0.05 level after all the variables have entered into the equation. The retail gasoline price coefficient is positive, which implies that a significant positive relationship exists between annual public transit ridership per capita and the price of retail gasoline over the entire time period. The public transit fare variable is also significant at the 0.05 level, and indicates, as expected, a negative relationship.

The results for the two sub-time periods are found in tables 11 and 12. In each sub-time period, the retail gasoline price variable is not significant at the 0.05 level. For the earlier sub-time period, none of the independent variables are significant when the strike year (1971) is included. However, when the strike year is excluded, both the public transit fare variable and the number of

TABLE 10: Public transit riderhsip per capita vs retail gasoline prices, number of buses in service, public transit fare, 1960-1982

STEP 1

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-27.862533	.034	19.771

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-13.987102	.256	6.737

STEP 2

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-140.33554	.000	50.597
retail gasoline price	1.7109198	.002	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-108.87766	.008	33.826
retail gasoline price	1.2564668	.014	

STEP 3

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-140.91053	.001	51.049
retail gasoline price	1.6180233	.008	
number of buses in service	.026507598	.680	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-122.06049	.006	37.283
retail gasoline price	1.1893478	.021	
number of buses in service	.052837109	.347	

TABLE 11: Public transit ridership per capita vs retail gasoline prices, number of buses in service, public transit fare, 1960-1973

STEP 1

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-146.94307	.003	53.047

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-111.50552	.005	52.475

STEP 2

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-225.72796	.027	56.912
number of buses in service	.19853598	.342	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-202.56053	.009	62.764
number of buses in service	.23240708	.127	

STEP 3

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-201.38637	.075	58.230
number of buses in service	.29417078	.297	
retail gasoline price	-2.2442737	.587	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-159.04616	.038	70.237
number of buses in service	.39967578	.046	
retail gasoline price	-3.8739481	.167	

TABLE 12: Public transit ridership per capita vs retail gasoline prices, number of buses in service, public transit fare, 1974-1982

STEP 1

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-42.659149	.004	71.037

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-14.624777	.157	30.304

STEP 2

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-62.157883	.001	85.715
number of buses in service	.27927654	.048	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-32.230879	.021	68.661
number of buses in service	.16714654	.056	

STEP 3

STRIKE YEARS INCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-85.008337	.011	89.014
number of buses in service	.19722069	.182	
retail gasoline price	.48764425	.275	

STRIKE YEARS EXCLUDED

VARIABLE	B	SIGNIFICANCE	R^2(%)
public transit fare	-21.779806	.428	70.287
number of buses in service	.18005105	.084	
retail gasoline price	-.15141473	.664	

buses in service variable are significant at the 0.05 level. For the later sub-time period, only the public transit fare variable is significant at the 0.05 level when the strike year (1982) is included. No variables are significant when the strike year is excluded. In both cases, the retail gasoline price variable is the last variable to enter into the equation and is far from being significant. A peculiar result is that, when the strike year is included, the retail gasoline price coefficient is positive while, when the strike year is excluded, this coefficient is negative. This may be explained by the fact that the size of the negative public transit fare coefficient is sufficiently large enough to cover the strike effect, leading to this result.

From the results presented in this chapter, it seems that only a few definitive points can be made. One is that a significant positive relationship exists between annual public transit ridership and retail gasoline prices when the strike years are excluded over the entire time period. However, when the time period is divided into two sub-time periods, no significant relationship exists. A second point that can be made is that a significant positive relationship exists between annual public transit ridership per capita and the price of retail gasoline only when other independent variables are included in the regression analysis.

CONCLUSION

After completing the analysis, it appears that no definite conclusion can be made with respect to the supposed positive relationship between public transit ridership and retail gasoline prices. While this relationship is significant in the initial regression test having public transit ridership as the dependent variable and only the retail gasoline price as the independent variable, it has not been found to be significant in the remaining tests. Also, an unexpected result is the presence of a negative retail gasoline price coefficient in some of the test results. In the model having public transit ridership as the dependent variable, a possible explanation for this is that as retail gasoline prices rise, people may reduce their number of non-work trips (Horowitz, 1982). Therefore, annual public transit ridership would decrease as retail gasoline prices increased. Another possible explanation is that this negative relationship may be covering up a more significant relationship between annual public transit ridership and the local economy. Since the mid 1970's, Hamilton's economy has been depressed. Therefore, this may have resulted in lower annual public transit ridership levels if people on average reduced their overall expenses. Therefore, annual public transit ridership would be seen as decreasing as retail gasoline prices increased, but that no significant negative relationship existed between the two variables.

The lack of significant results which characterized many of the regression tests can be attributed to the inability to control extraneous variance. A major source of this variance is the availability of bus passes from the H.S.R. since 1977. The H.S.R. could not provide data concerning the number of rides made through the use of these passes each year. Therefore, public transit ridership figures since 1977 would not include the transit rides that were made through the use of these passes. This could very well result in a situation where decreasing public transit ridership statistics are associated with a period of increasing retail gasoline prices, when in actuality the total number of rides could have been increasing.

Another source of extraneous variance that was not controlled in this project is the effect of Hamilton's economy on public transit ridership. As mentioned above, Hamilton's depressed economy may have led to lower ridership figures as people reduced their overall expenses. In future studies, it would be desirable to include variables to account for both the sale of bus passes and the state of the local economy so that these sources of extraneous variance can be controlled. Additional changes to improve the effectiveness of the analysis are suggested as follows.

First of all, the four regression models used in this project could be altered. Through visual inspection of figures 1 to 4 and by considering the nature and meaning of the retail gasoline price coefficients throughout this study, it can be suggested that the relationship between public transit ridership and retail gasoline prices may be non-linear. Therefore, different forms of the regression equations should be used in order to determine which type of regression line bests fits the data.

A second change that seems feasible is to include an investigation into the number of new automobiles registered each year in the city of Hamilton. This may give some indication of how people are reacting to higher retail gasoline prices, and may account for additional extraneous variance.

A final addition to the approach taken in this project is to include an analysis of individual level data based on questionnaires or home interviews. The results from this individual level approach may aid in sorting out or explaining some of the unexpected results of this study.

BIBLIOGRAPHY

Banister, D. 1978. "The Influence of Habit Formation on Modal Choice - A Heuristic Model" Transportation 7, pp. 5-18.

Blase, J.H. 1980. "Hystersis in Travel Demand" Transportation Planning and Technology 6, pp. 109-116.

Canada, Transport Canada. 1978. The Fundamentals of Urban Transit Ottawa.

Curtis, E.F. 1980. "Institution-Building and European Mass Transit: Myths and Realities" Transportation Journal 20, pp. 23-36.

Curtis, F.A. 1981. "Work Trip Travel Demand Modelling in Kingston Township, Ontario, Canada" Transportation Planning and Technology 7, pp. 11-19.

Dean, M.L. 1980. "An On-Board, Self-Administered Survey Method for Researching the Mass Transit Rider" Transportation Journal 20, pp. 75-77.

Elmberg, M.J. 1978. "The Effect of the Oil Crisis on the Growth in the Ownership and Use of Cars" Transportation 7, pp. 45-68.

Gallo, A.J. 1980. "Lets All Leave Our Cars At Home Half the Time and Safe $520." Transit Journal 6, pp. 3-14.

Gilbert, G. and J.F. Foerster. 1977. "The Importance of Attitudes in the Decision to Use Mass Transit" Transportation 6, pp. 321-332.

Golob, T.F. 1977. "Mode Choice Prediction Using Attitudinal Data: A Procedure and Some Results" Transportation 6, pp. 265-286.

Hamilton-Wentworth. 1978. Corporation of the City of Hamilton Handbook.

Heads, J. 1980. "Transport Statistics: Sources and Limitations" Transportation Journal 20, pp. 33-47.

Hoel, L.A. 1977. "Recent Developments in Urban Bus Transit" Transportation Planning and Technology 3, pp. 257-266.

Henley, D.H., I.P. Levin, J.L. Louviere, R.J. Meyer. 1981. "Changes in Perceived Travel Cost and Time for the Work Trip During a Period of Increasing Gasoline Costs" Transportation 10, pp. 23-34.

Hensher, D.A. 1979. "Price Elasticity of Commuter Mode Choice: Effect of a 20% Rail Fare Reduction" Transportation Research 13A, pp. 193-202.

Horowitz, J. 1982. "Modelling Traveller Responses to Alternative Gasoline Allocation Plans" Transportation Research 16A, pp. 117-133.

Johnson, M. 1975. "Going to Work by Car, Bus or BART: Attitudes, Perceptions and Decisions" Working Paper No. 7518, Institute of Transportation and Traffic Engineering, University of California, Berkeley.

Keck, C.K. 1974. "Effects of the Energy Shortage on Reported Household Travel Behaviour Patterns in Small Urban Areas" Changes in Individual Travel Behaviour During the Energy Crisis, 1973-74 Preliminary Research Report No. 67, Planning and Research Bureau, New York State Department of Transportation.

Khan, D. 1983. "Transportation Mode Choice and City-Suburban Public Transportation Service" Transportation Research 17B, pp. 25-43.

McDermott, D.R. 1978. "Mass Transit Issues From a Marketing Perspective" Transportation Journal 18, pp. 28-35.

Ontario, Ministry of Municipal Affairs and Housing. 1979-1983. Municipal Directory Toronto.

Paaswell, R.E. and P. Edelstein. 1976. "A Study of Travel Behaviour of the Elderly" Transportation Planning and Technology 3, pp. 143-154.

Recker, W.W. and R.F. Stevens. 1976. "Attitudinal Models of Modal Choice: The Multinomial Case for Selected Non-work Trips" Transportation 5, pp. 355-375.

Smerk, G.M. 1981. "The Transit Act That Never Was: Public Transportation Legislation, 1979-1980" Transportation Journal 20, pp. 29-53.

Smerk, G.M. 1980. "Transit Management in an Energy-Scarce Environment" Transit Journal 6, pp. 27-34.

Solomon, B.D. 1980. "Gasohol Economics, and Passenger Transportation Policy" Transportation Journal 20, pp. 57-64.

Stopher, P.R. 1982. "Perception of Travel Modes: Some Pointers to Public Transit Patronage" Transport Policy and Decision Making 2, pp. 51-58.