Chapter VII

Effects of Alternative Energy Conditions on Transit

This chapter examines the relationship between the energy shortage and transit ridership in several metropolitan areas and in the Nation as a whole. The relationships established have then been used to forecast transit ridership under the three energy futures.

Chapters VII and VIII present the relationship between energy and transit in a similar manner to Chapters V and VI which presented the relationships between the economy and transit. Chapter VII presents the impacts on transit of energy conditions, just as Chapter V presented the effect of the economy on transit. Chapter VIII goes on to examine actions which could be taken in order to increase transit ridership and influence energy consumption, corresponding to Chapter VI which summarized transit's potential for influencing economic conditions, Chapter IX summarizes all of these impacts on Energy, the Economy, and Mass Transit. The next chapter briefly examines recent experience in several metropolitan areas. Chapter XI concludes the report with a discussion of national policy issues and possible actions to deal with the problems of energy, the economy, and mass transit.

INTRODUCTION

The discussion of the effect on transit of energy shortage conditions contained in this chapter is divided into three parts: First, the experience in several metropolitan areas; second, the relationship between national energy indicators and transit ridership as revealed by regression analysis; and third, the effect on transit of the three energy futures described in Chapter IV. In order to predict the effects of energy futures on transit, an exact relationship between energy and transit ridership was established.

Although most transit systems experienced substantial increases in ridership during and after the energy crisis, an exact relationship is difficult to establish because very little evidence is available which would allow the quantification of energy availability, thus permitting the calculation of an exact quantitative relationship between transit and energy for local areas. Much of the limited information which is available is contained in the first section of this chapter and some additional data is available in Chapter X. "The Metropolitan Experience."

In section 2 the results of a regression analysis using national data on energy supply, economic conditions, and ridership are presented. This analysis revealed that the reduction in energy supply during the energy crisis was responsible for about a 5 percent increase in ridership, all other factors being equal.

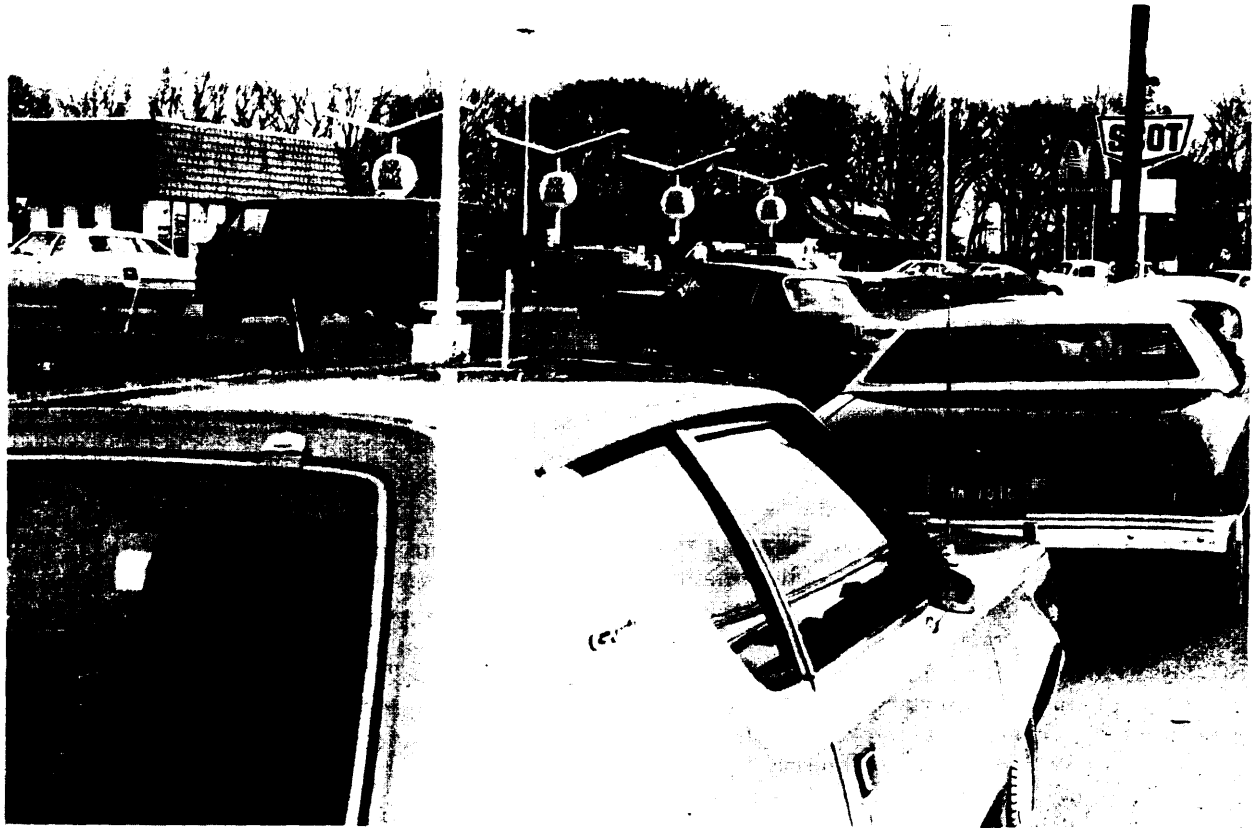
This relationship was then used to forecast the effects on transit of the three energy futures,

Travel Pattern Changes in Metropolitan Areas During the 1973-74 Fuel Crisis and Their Implications for Transit

While the national aggregate number of public transit rides increased during the fuel crisis (see Table 31), the increase was not dramatic, not exceeding 10,55 percent in any embargo month when compared with the same month of the previous year. Since transit had been in a state of continuous decline for many years the bottoming out in 1973 was in itself a major event. Ridership growth continued after the embargo, however no clear pattern of the longrun trend is yet evident. The raw national aggregates are not very helpful except to indicate that a relatively small but significant portion of total trips shifted. Public transportation accommodates approximately 8 percent of alJ trips in urbanized areas (12.7 percent of all home-work trips by vehicular transport were on transit in SMSA'S over 250,000 in 1970). 1

The amount of trips represented by the maximum monthly increase during the actual embargo (10.55 percent in April), therefore, was only about 0,8 percent of all trips in urbanized areas. Clearly a key factor here was the public anticipation (correct,

[1] Bureau of Census, Journey to Work, 1970 *Census of Population*, table 2.



The gasoline shortage in the winter of 1973-74 caused long waits at gas stations and increases in transit ridership

it turned out) that the crisis would be short and there was no need to change commuting and other travel habits.

Hard evidence on the trip-making impacts of the fuel crisis is scarce since almost no jurisdiction could organize quickly enough to do the necessary surveys to secure precise data, Few localities perceived the importance until it was too late to act. Only three bodies of evidence on fuel interactions are known to the consultant. This data is from widely different urban areas—New York, Baltimore, and Greenville, S.C.

The New York City data are available from (1) the large number of toll facilities ringing Manhattan, the major CBD and employment center of the region, and from (2) a regular sampling program, These data, summarized in table 32 are unfortunately designed to measure only the average weekday traffic volumes. They show that weekday auto commuting was hardly affected, in fact it actually increased over the toll facilities. Informal communications with the operator of Trans-Hudson crossings indicated that during the first 3 months of 1974 evening travel and weekend travel were very sharply cut. That is, for this brief period, home to work travel was preserved at the expense of shopping and recreation trips. The total decline in vehicle crossings from 1973 to *1974* was **2.0** percent. Previous increases were in the range of 2 to 4 percent per year. It is noted that traffic using toll facilities was less elastic than that using free facilities. The "marginal" users of the toll facilities have already been squeezed out at high costs.

Data from Baltimore's Regional Planning Council and the Maryland DOT[2] confirms the New York experience, Figure 9 shows that during the energy crisis period (early 1974) transit ridership increased significantly (by well over 10 percent in 2 months), while gas sales decreased by about 10 percent in each of the first 3 months of the year. The off-peak auto travel decreased much more than peak travel during the first 3 months of 1974. This

[2]Regional Planning Council and Maryland DOT, *Impact of the Energy* Crisis on *Travel* in *the* Baltimore Region During *1974,* Technical Memorandum No. 23, March 1975.

indicates that trips for social, recreation, shopping purposes were cut back much more than work trips. Unfortunately no breakdown of peak and off-peak trips was given for transit usage, so the type of trip which was diverted from autos to transit cannot be determined.

Greenville, S. C. was an SMSA population of 3 million and in 1972-73 completed a comprehensive transportation study with all of the usual origin-destination surveys. The study conducted during the oil embargo concerns a single suburban area west of Greenville and served by a new interstate highway and a new bus transit line. This study area, Dutch Fork, had a 1970 population of 12,256 and has subsequently had an estimated growth of 10 percent per year. Fifty-one percent of the households had 1974 incomes in excess of $15,000 and the households owned 2.1 vehicles on the average. [3]

Auto travel by residents of the Dutch Fork area was estimated to be reduced by 10 to 15 percent.

[3] Hajjand Sacco, *The* Impact *of* Energy *Shortage on Travel* Patterns *and* Attitudes, paper given January 1975 at Annual Meeting of Transportation Research Board, Washington, D.C.

TABLE 31

INCREASES IN NATIONAL TRANSIT RIDERSHIP DURING THE 1973-74 FUEL CRISIS AND ADJACENT MONTHS

Month	Percent Change Over Same Month in Prior Year	Months Directly Affected By Embargo
September 1973	- 3.81	
October .		+ 1.77
November*		+ 0.86
December		+ 0.47
January 1974*		+ 5.41
February*		+ 8.41
March		+ 3.68
April		+10.55
May*	+ 6.02	
June	+ 5.54	
July	+12.30	
August	+ 6.76	
September	+ 7.87	
October*	+ 9.11	
November	+ 1.04	
December	+ 5.44	
January 1975*	+ 0.62	
February*	- 1.25	
March*	– 0.98	
April*	0.00	
May	- 1.24	
June	+ 1.07	
July*	+ 0.54	

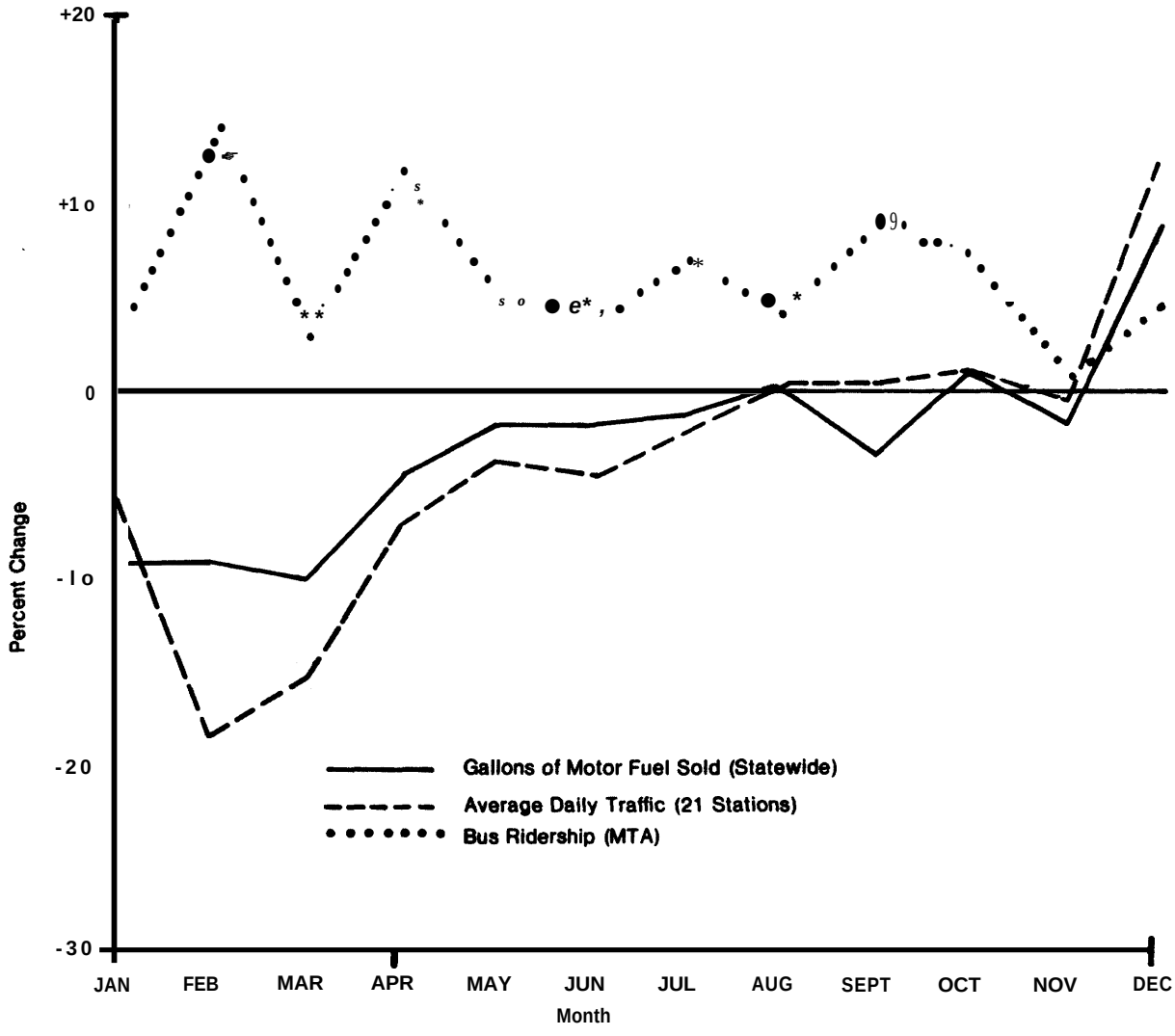
.Same number of working days in months compared.

Note: These ratios are not based on data normalized for changes in the number of Saturdays, Sundays, holidays and work-days in the same month from year to year. Normalized data were used in the regression analyses reported in Chapter V and Appendix A.

Source: APTA: *Monthly Transit Traffic Bulletins*

FIGURE 9

CHANGE IN MOTOR FUEL SALE~ TRAFFIC VOLUMES, AND BUS RIDERSHIP BETWEEN 1973 AND 1974

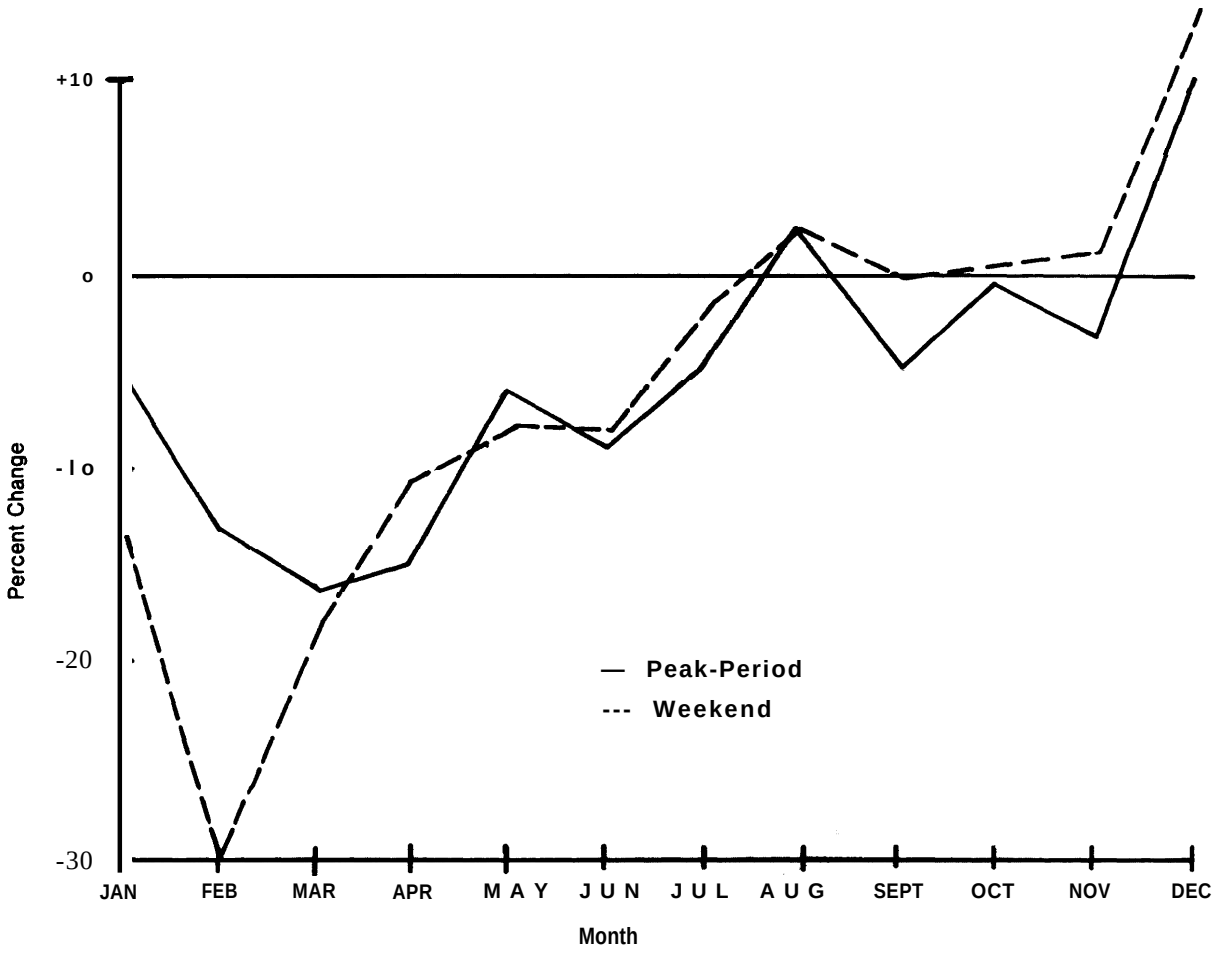


SOURCE: State Comptroller, State Highway Admin., Mass Transit Administration,

Reproduced from *Impact* of the *Energy* Crisis *on Travel in the Baltimore Region During 1974,* Technical Memorandum No. 23, Baltimore Regional Planning Council, March 1975.

FIGURE 10

CHANGE IN PEAK-PERIOD AND WEEKEND TRAFFIC VOLUMES BETWEEN 1973 AND 1974



SOURCE: State Highway Administration-5 Selected Stations. "

Reproduced from *Impact of the Energy Crisis on Travel in the Baltimore Region During 1974,* Technical Memorandum No. 23, Baltimore Regional Planning Council, March 1975.

[illegible]

DATA FROM NEW YORK CITY MANHATTAN BRIDGE CROSSINGS 1973-74

(ANNUAL AVERAGE DAILY TRIPS)

Bridge-Tunnel Groups	1973	1974	Volume	Percent
Hudson River Crossings (Toll)				
Inbound	196,532	197,875	+1,343	+0.7
Outbound	200,571	200,501	- 70	N.C.
East River Crossings (Toll)				
Inbound	180,458	175,057	-5,401	-3.0
Outbound	170,088	173,616	+3,528	+2.1
East River Crossings (Free)				
Inbound	121,171	129,977	+8,086	+6.7
Outbound	124,511	117,638	-6,873	-5.5
Harlem River Crossings (Free)				
Inbound	235,175	222,728	-12,397	-5.3
Outbound	246,229	227,965	-18,264	-7.4
Manhattan Island Totals				
Inbound	733,336	725,667	-7,649	-1.0
Outbound	741,499	719,820	-21,679	-2.9
Grand Totals	1,474,835	1,445,507	-29,328	-2.00

SOURCE: Unpublished data collected by West Side Highway Project, New York City.

Traffic volumes decreased primarily on weekends, with less decline on weekdays. Travel was reduced by driving more slowly and limiting social, recreation, and shopping trips. Shifts in travel behavior were moderate, although people expressed an interest in mass transit. Gasoline supply appears to have exerted a greater effect on habits than did price, although the effect of price appears to be emerging in the form of greater small car buying. People, in other words, did not cease to rely on the car, but rather adjusted their driving behavior to conserve gasoline.

The proportionate effects on weekday and weekend traffic are shown in Figure 11. At the height of the crisis weekend traffic was off 25 percent, Since this is a location of very mild climate there appears to be little seasonal variation except during the summer months,

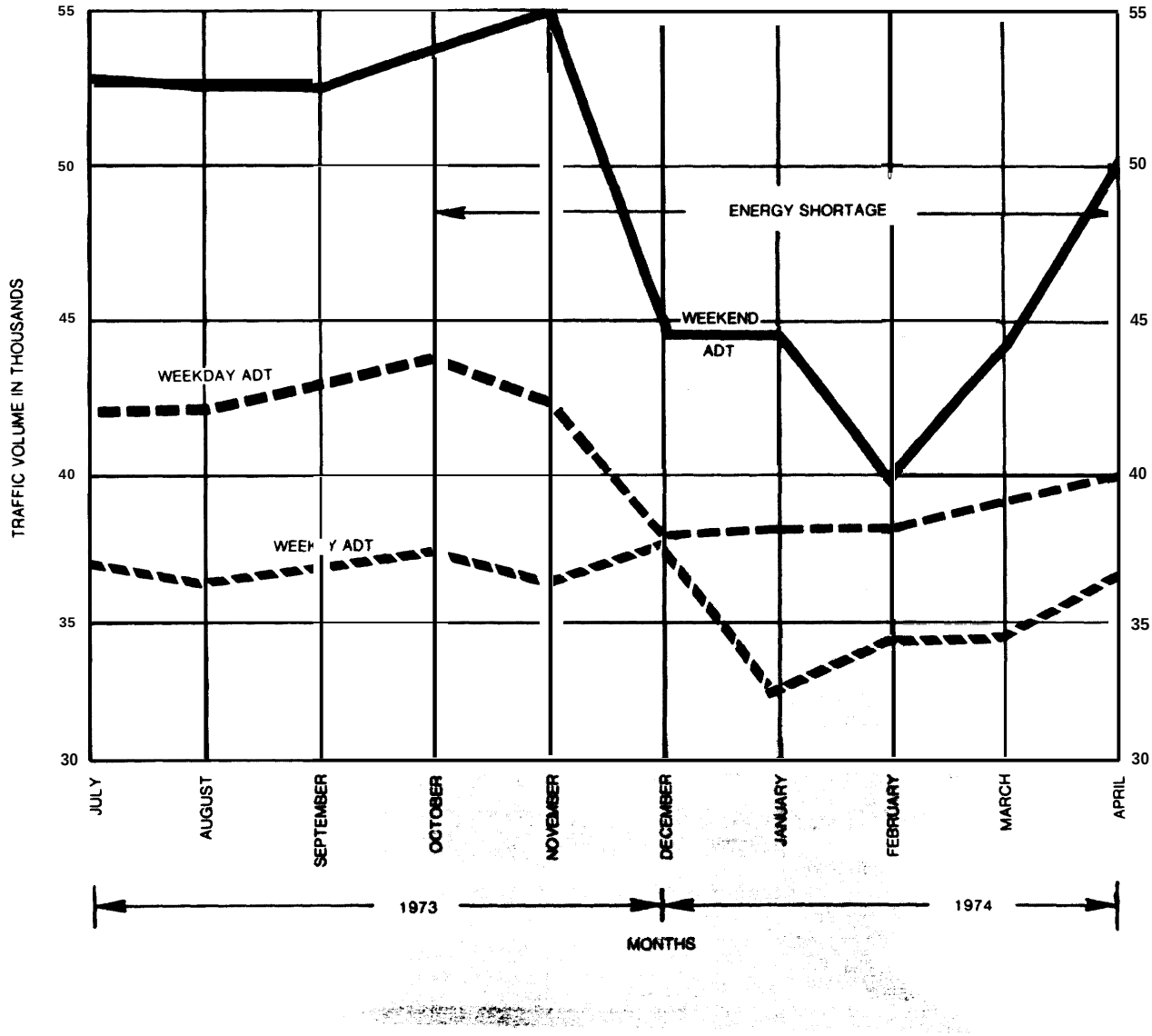
The proportion of work trips increased and shopping and "other" decreased (see Table 33). Only one percent of the trips in this table were made by transit in the 1974 study period. The transit service had not commenced in the 1972-73 study period. The proportionate effect on transit was, however, dramatic as shown in Figure 12,

The Greenville Study conducted a substantial home interview survey on public attitudes related to the fuel crisis; the following Tables, 34, 35, and 36, summarize some of the more interesting findings. They reveal a moderately strong interest in carpooling and transit use; stronger interest in economy cars and other gasoline-saving methods and little interest in rationing or using price controls. The attitudes expressed in Greenville accord with those the consultants have observed outside of the very largest cities,

It appears reasonable to assume that a prolonged fuel shortage not alleviated by improvements in auto efficiency would lead to much greater transit usage and carpooling than was observed anywhere during the 3-month shortage in 1974. The exact degree of this pressure on transit and other fuel saving actions will be a direct result of timing. If the virtually complete reduction of crude and refined imports being analyzed as the severe reduction alternative in this study were achieved in less than

FIGURE 11

MONTHLY **CHANGE IN TRAFFIC VOLUME FOR TOTAL** WEEK,
WEEKDAY, AND WEEKEND ADT, ON I-126
Dutch Fork **Area Transit Study**



5 years, the shift to transit would be great, but some of the shift would be temporary, assuming the forecast evolution to more efficient cars and assuming a return to the energy consumption growth trend after the end of the 5-year period. If the petroleum reduction were made over a period of 6 to 8 years, the anticipated evolution in vehicle fleet efficiency could maintain at least the present level of vehicle miles of travel almost continuously and would provide for some increase beyond this period. This would limit the long run growth potential for transit in the absence of some active program of restraints on auto use, at least in city centers.

TABLE 33

FIRST TRIP TO COLUMBIA BY PURPOSE

Dutch I%dcAmTrandtStudy—1972 and 1974

	Percent of Total	
Trip Purpose	1972	1974
Work/	80.2	88.4
Shopping and Bill Paying	3.6	1.8
Sohool	10.8	9.6
Serve Passengers	1.1	1.3
Other	4 . 3	0.9
Total	100.0	100.0

Multiple Regression Analysis of National Data

The regression analyses conducted for this study covered both long term (1952-74) and short term (1971-74) time periods. As was mentioned in chapter V the short term analysis, was most appropriate for predicting the relationship between ridership and energy availability because it covered the period of the energy crisis in more detail. This analysis examined the relationship between transit ridership and a number of national energy indicators including motor fuel sold, VMT, Urban VMT, etc., plus several national economic indicators. A detailed description of this process is contained in Appendix A.

The regression analysis produced the following relationship, which is explained below:

$$TRP = 1.032\ (TVMT)\text{-}.8BB \qquad (R^2 = .718)$$

where TRP = the annual growth factor for transit revenue passengers and

TMVT = the annual growth factor for highway vehicle miles of travel.

The variable most strongly related to transit ridership in the 1971-74 time period was total highway vehicle miles of travel. Figure 7 shows the relationship between these two variables on a month-by-month basis. This figure rather dramatically demonstrates the complementary relationship between highway and transit travel during this period,

TABLE 34

FREQUENCY WITH WHICH RESPONDENTS SAID THEY USED A Particular GAS SAVING METHOD

Dutch Fork Area Transit Study - 1974

	Percentages				
Method	Frequently	Sometimes	Rarely	Never	Total
Driving Slower	33.8	8.8	1.9	0.7	100.0
Reducing Shopping and Recreational Trips	31.4	45.0	12.6	11.0	100.0
Carpooling	13.6	12.2	10.4	63.8	100.0
Using Mass Transit	0.6	4.4	6.1	89.9	100.0

FIGURE 12

RIDERSHIP BY WEEK

Dutch Fork Area Transit Study

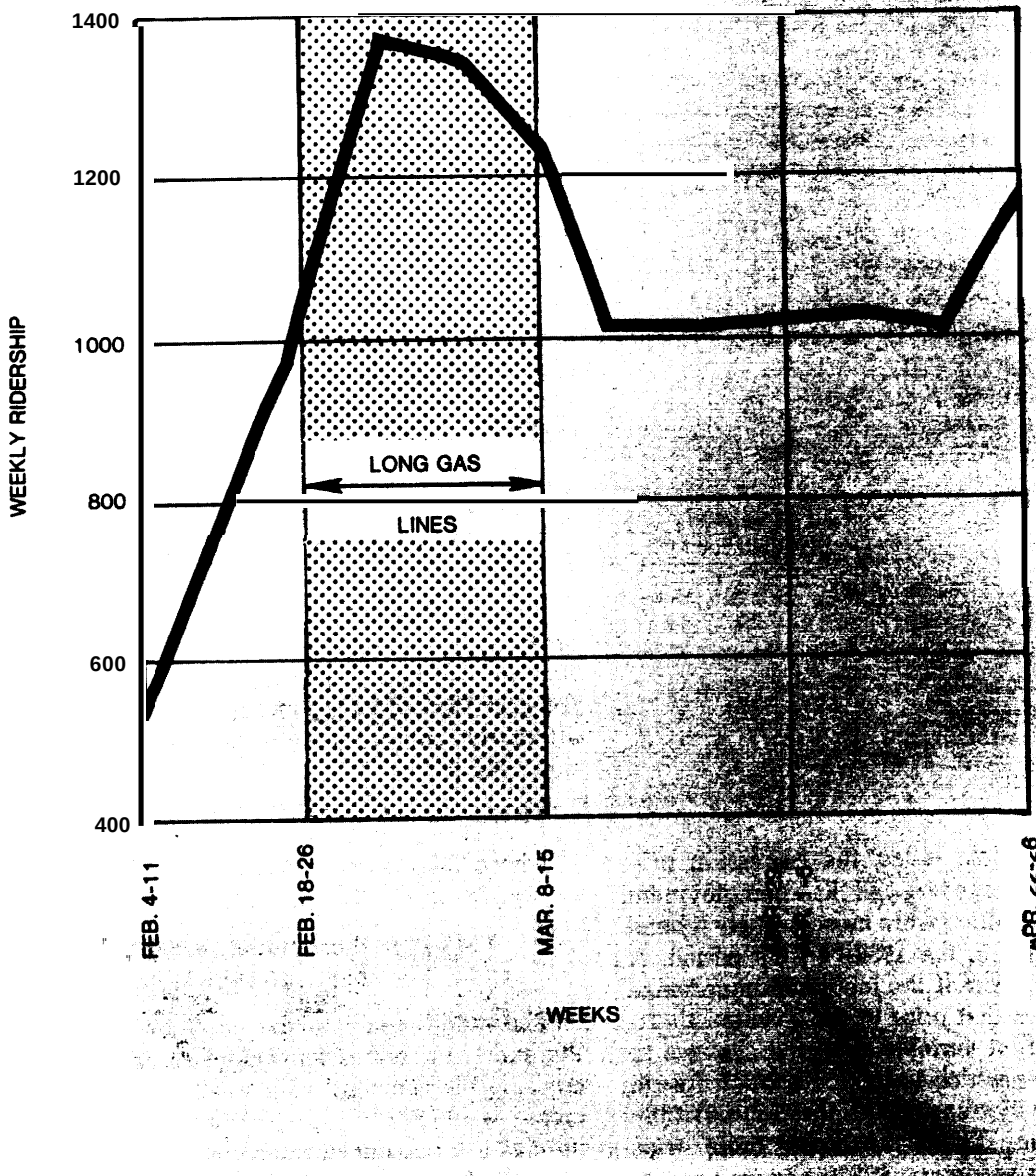


TABLE 35

Public Preferences for Cutting Fuel Consumption

Dutch Fork Area Transit Study--1974

Alernative	Percent Respondents Ranking An Alternative As 1st	2nd	3rd
Llmit of 50 mph	22	11	1
Ration Gasoline	8	6	8
Increase Gas Tax	2	2	1
Improve Public Transit	23	18	14
Relax Antipollution Standards	10	11	15
Limit of 60 mph	14	7	10

SOURCE: Continuous National Survey, National Opinion Research Center, Chicago, Ill., March 8,1074,0.27,

Table 36

Preferred Solution if GasolinePrices Go to 80 cents/Gallon

Dutch Fork Area Transit Study--1974

Alternatives[a]	Percent Respondents Ranking An Alternative As 1st	2nd	3rd	4th
Buy An Economy Car	40.5	28.7	16.4	16.4
Pay the Price	26.4	24.1	17.0	31.2
Carpool	18.0	29.6	29.9	21.9
Use Public Transit	14.5	20.3	35.4	28.6

[a]"Other" category not listed.

In selecting vehicle miles, the regression procedure rejected average fare and the unemployment rate, the variables which were most strongly related to transit ridership in the 1952-74 time period. A possible interpretation of the increased importance of vehicle miles is that prior to the gasoline shortage, changes in that variable reflected changes in discretionary trips which individuals might forego rather than make by transit, With the coming of the gasoline shortage, TVMT included more trips which individuals would not forego and, as a result, reductions in vehicle miles would become more closely related to increases in transit ridership. It is also likely that the relationship between highway travel and transit is not very significant in the longrun analysis simply because of the lack of variability in energy price and availability conditions over the long period taken as a whole.

In the second step of the shortrun analysis, a constant term entered the equation. This implies that, if highway vehicle miles of travel remain constant over time, transit ridership would increase at a rate of 3 percent/year.

The short run regression analysis did not explicitly incorporate measures of the quality or extensiveness of transit service (due to the lack of monthly data). Thus, any net effect on transit ridership due to changes in transit service would be reflected in the constant term of the estimated equation.

Preliminary estimates in the 1973-74 ATA Transit Fact Book indicate that transit vehicle miles, a measure of the extensiveness of transit service increased by 4 percent from 1972 to 1973. Previously, this measure had declined each year from 1950 to 1972. If the extensiveness of transit service also increased from 1973 to 1974 and if there were also improvements in the quality of transit service, this would account for a significant portion of the 3 percent/year increase.

Forecasts of Transit Ridership for Alternative Energy Futures

The results of the short run (1971-74) regression analyses were modified to account for the assumption of constant average fare and then used to forecast the effect upon transit ridership of the alternative energy conditions. The estimating equation used is

$$TRP = 1.063\ (TVMT)^{.866}$$

where TRP = the annual growth factor for transit revenue passengers and

TMVT = the annual growth factor for highway vehicle miles of travel.

The modification to the equation produced by the short run regression analysis consisted of increasing the constant from ***1.032*** to ***1.063.*** This increase assumes a 10 percent rate of inflation (which implies a 9 percent decrease in the transit fare in 1974 $) and a transit price elasticity of .3.

To use the above equation, it is necessary to translate the alternative energy futures presented in

chapter IV into annual changes in vehicIe miles of travel.

For this purpose, the following assumptions were made:

— In 1974, the United States consumed petroleum at a rate of 16.5 million barrels/day.[4]

— In the future, the amount of petroleum used as highway fuel will remain a constant share of total petroleum consumption.

—The average fuel economy over all highway vehicles will improve by 2.5 percent from January 1975 to January 1976 and then will improve by 5 percent/year to 1980. This represents an increase from 12 mpg in 1974 to 15 mpg in 1980.[5]

The forecasts of transit revenue passengers under the three assumed energy conditions are presented in Table 37.

The miId decrease in energy assumption leads to a 10 percent increase in transit ridership from 1974 to 1976. However, after 1976, transit ridership declines due to the, combined effect of the 1976-80 3 percent/year growth in gasoline availability (a return to a somewhat reduced rate of growth) and the assumed increases in fuel economy.

The moderate decrease in energy assumption leads to a 21 percent increase in transit ridership from 1974 to 1977. From 1978 to 1980, transit ridership remain roughly constant because gasoline availability is assumed to grow at a rate of only 1.5 percent/year after 1977, reflecting a growth rate reduced to somewhat under half of the trend growth rate.

The severe decrease in energy assumption leads to a 23 percent increase in transit ridership by 1977 and a 40 percent increase by 1980. In this case, the reductions in gasoline availability more than compensate for the assumed increases in fuel economy.

Some caution is indicated in placing too much reliance on the above relationship between transit ridership and gasoline availability. Crisis reductions in gasoline availability lasted for only 3 months and consumer reaction to these reductions appear to be based on the judgment that they would only be temporary. With the severe decrease assumption, consumers may seek to make more substantial modification to their travel patterns, particularly as they relate to home-work travel. Such modifications may have a limited effect prior to 1978. Their potential effect after 1978 will depend upon whether the shortage is perceived as a temporary or long-term phenomenon. In the latter case, the 1979 and 1980 estimates for the severe decrease assumption may underestimate transit ridership.

SUMMARY

The era of cheap plentiful gasoline ended with the fuel embargo beginning in late 1973.

During the first 4 months of 1974, wholesale gasoline sales were down from 4 to 9 percent compared with the same months of 1973. During this period, nationwide transit ridership increased by 7 percent over 1973. The maximum increase occurred in April 1974 when transit ridership was up by 10.5 percent over April 1973.

This increase in transit ridership was in itself a major event because transit had been in a state of continuous decline for many years. However, when the increase in transit ridership is compared with total urban area travel, it becomes apparent that only a small share of the reduction in automobile travel showed up as increased transit travel. Public transportation ‘accommodates approximately 8 percent of all vehicular trips in urbanized areas. Thus, the maximum increase in monthly ridership during the embargo period was less than 1 percent of all trips in urbanized areas.

It appears that during the embargo, most people continued to use the automobile for work trips and basic shopping trips and totally eliminated more discretionary trips rather than seeking to maintain previous mobility levels by carpooling or substituting transit trips for auto trips. Figure 12 shows monthly traffic volumes from one of the few areas where good data on the trip-making impacts of the fuel crisis exists—the Dutch Fork area in South Carolina.

In this area, weekday traffic declined by Iess than 15 percent while at the height of the crisis, weekend

[4]This estimate of the 1974 consumption rate was developed by factoring the 1973 consumption rate (estimated by Project *Independence* to be 17.2 million barrels/day) by the 1973-74 decline in motor gasoline sales estimated by the Federal Highway Administration (FHWA News, 01–75, January 2, 1975). The FHWA estimate compared January through October rates and indicated a 4.6 percent decline.

[5]*In "Summary of* Opportunities to Conserve Transportation Energy" (a document prepared for the Office of the Secretary, U.S. Department of Transportation), Pollard, Hiatt, and Koplow estimate that the market response to gasoline price increases of 7 percent/year will be to increase the fuel economy of new cars from 12.9 mpg in 1973 to 17.8 mpg in 1980.

TABLE #7

EFFECT OF ENERGY FUTURES ON TRANSIT REVENUE PASSENGERS

MILLIONS OF ANNUAL REVENUE PASSENGERS
(Percent Change from 1974)

	A. Mild Decrease	B. Moderate Decrease	C. Severe Decrease
1974	5623 (—)	5623 (—)	5623 (—)
1975	6005 (+6.8%)	6062 (+ 7.8%)	6062 (+ 7.8%)
1976	6197 (+10.2%)	6517 (+15.9%)	6517 (+15.9%)
1977	6118 (+8.8%)	6796 (+20.9%)	6961 (+23.8%)
1978	6039 (+7.4%)	6809 (+21.1%)	7316 (+30.1%)
1979	5960 (+6.0%)	6826 (+21.4%)	7642 (+35.9%)
1980	5882 (+4.6%)	6836 (+21.6%)	7878 (+40.1%)

SOURCE: System Design Concepts Forecasts Based on Time Series Analysis

traffic was off more than 25 percent. To further support the observation that drivers cut down on discretionary travel rather than seeking to find alternative modes for work trips and basic shopping trips, informal communication with the operators of bridge and tunnel facilities surrounding Manhattan indicates that evening and weekend traffic was cut very sharply during the embargo period while weekday auto commuting was hardly affected.

" A regression analysis using national data for the period covering the energy crisis revealed that if energy conditions resulted in no growth in the number of total vehicle miles traveled in the United States, transit ridership would increase by 3 percent annually.

Using the relationship between ridership and energy established by the regression analysis, the following increases in transit ridership are forecast for the energy futures:

Mild = 10% between 1974 and 1976

Moderate = 22'% between 1974 and 1980

Severe = 40% between 1974 and 1980

These increases in predicted ridership are due solely to energy conditions and constant fares. Any other factors such as service improvements would have an additional impact on ridership,