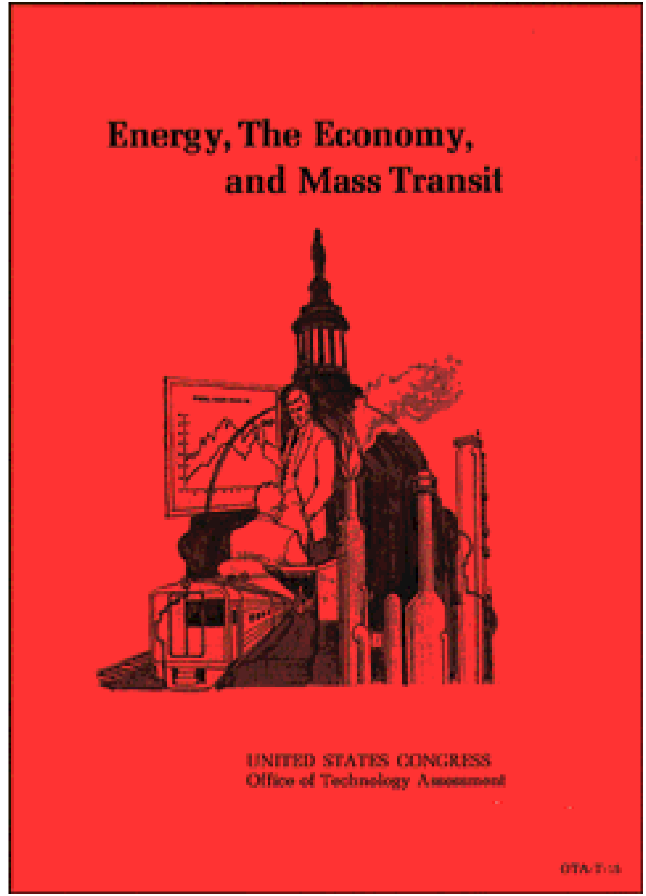
Energy, the Economy, and Mass Transit

October 1975

NTIS order #PB-250624



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Congress of the United States
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WASHINGTON, D.C. 20510

OCT 211975

The Honorable John L. McClellan
Chairman, Committee on
Appropriations
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

On behalf of the Board of the Office of Technology Assessment, we are pleased to forward to you the attached report on Energy, the Economy and Mass Transit. This is in accordance with your request to the Office of Technology Assessment dated September 27, 1974. An earlier summary of this report was transmitted to you on June 18, 1975.

This report is being made available to your Committee in accordance with Public Law 92-484.

Sincerely,
Olin E. Teague
Chairman of the Board

Sincerely,
Clifford P. Case
Vice Chairman of the Board

Enclosure

Congress of the United States
OFFICE OF TECHNOLOGY ASSESSMENT
WASHINGIVN, D.C. 20510

OCT 21 1975

The Honorable Olin E. Teague
Chairman of the Board
Office of Technology
Assessment
Congress of the United States
Washington, D. C. 20510

Dear Mr. Chairman:

In response to the letter of September 27, 1974, from Senator John L. McClellan, Chairman, Senate Committee on Appropriations, the Office of Technology Assessment undertook an analysis of Energy, the Economy and Mass Transit.

I am pleased to submit the attached report on this analysis and to express my appreciation to all of those who contributed to it.

Sincerely,

EMILIO Q. DADDARIO
Director

Enclosure

PREFACE

This assessment of Energy, the Economy, and Mass Transit was requested by the United States Senate Committee on Appropriations on behalf of its Transportation Subcommittee. The Committee requested the Office to review the relationship of mass transit to energy consumption and to alternative economic conditions.

OTA examined: (1) the probable effects of changes in energy supplies and prices on transit patronage and the transit industry; (z) the potential role of public mass transit programs in stimulating a depressed economy; and (3) the effect on the economy and urban transit if transit funds were sharply reduced. In addition, the study evaluates alternative transportation policies for responding to various economic and energy conditions and examines within this framework the effect of transit incentives and automobile disincentives on transit patronage and automobile use.

The assessment was carried out by OTA'S Transportation Assessments Group with the assistance of its Urban Mass Transit Advisory Panel. Skidmore, Owings and Merrill and Systems Design Concepts Inc. conducted systems studies for the assessment. Data were received from nine metropolitan regions throughout the United States. We are indebted to numerous local officials for their kind assistance.

This report is a joint effort, identifying a range of viewpoints but not necessarily reflecting the judgment of any individual.

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PURPOSE OF THE STUDY

This final report presents the results of a study entitled Energy, the Economy, and Mass Transit which was sponsored by the Office of Technology Assessment (OTA). The United States Senate Committee on Appropriations requested that the study be undertaken on behalf of its Transportation Subcommittee.

Responding to increasingly serious energy and economic conditions the Committee asked the Office of Technology Assessment to examine the following basic issues:

- How would future changes in the supply of energy (and energy prices) affect transit patronage, the Federal transit program, and the transit industry?
- What roles could transit play in a program to offset a severe recession or depression?
- How would the economy and urban transit be affected if transit funds were sharply reduced as part of a general anti-inflationary program?

The study was designed to provide answers to these questions and to evaluate the ways in which Federal policy and programs relate to and are affected by national energy and economic policy, Although the study's major concern was with short to medium, rather than long-term conditions, some of the policies discussed have long-term implications. The study had the following objectives:

- To evaluate the impact of alternative future economic conditions on the public transit sector.
- To evaluate the impact of alternative future energy conservation measures or shortages on the public transit sector.
- To define alternative transportation policies for responding to various economic and energy conditions,
- To assess how effectively these transportation policies respond to the economic and energy conditions, and to appraise the capacity of Federal and local governments to carry out the effective policies.

This study is related to An Assessment of Community Planning for Mass Transit, a project which the Office of Technology Assessment initiated in July of 1974. The primary objective of that project was to evaluate the process by which U.S. metropolitan areas make decisions about the development or modernization of rail transit systems. In early December 1974, after much of the field work had been done in the nine metropolitan areas[1] examined by the study, OTA'S consultants, Skidmore, Owings & Merrill and System Design Concepts, Inc. were asked to undertake this additional work on the relationships between energy, the economy, and mass transit. Each study has benefitted from work done on the other.

This final report, which contains the detailed results of this study, was preceded in June 1975 by a Summary Report which is also available from the Office of Technology Assessment.

SUMMARY OF MAJOR FINDINGS

The report summarizes a number of findings regarding recent trends in the transit industry, the effects of current economic and energy conditions on the use of transit, and the relative merits of adopting alternative transportation strategies to increase transit use and achieve energy conservation objectives. The major findings are highlighted below.

Recent Trends in the Transit Industry

- Transit ridership declined each year from the end of World War II to 1972. A large number of factors contributed to this decline. These include: increasing affluence and automobile

1Atlanta, Boston, Chicago, Denver, Los Angeles, Minneapolis, San Francisco, Seattle, and Washington, D,C.

ownership; improved highway access to plentiful cheap land; increased suburban development (with more scatteration and lower densities than preauto era city development); segregation of land uses in suburban areas; lack of improvements to transit; deterioration of the quality of transit service; increases in the real dollar costs of transit; and decreases in the real dollar costs of automobile ownership and operation.

- The decline in transit ridership halted in 1973. The last three months of that year all showed increases over the previous year. Ridership in 1974 was up almost 6 percent over 1973. This reversal appears to have been due primarily, but not exclusively, to the gasoline shortage.
- Another factor in the recent reversal is that transit fares have generally decreased in real dollar terms over the last 4 years, reversing the post World War II national trend in fares. Fares have been held relatively constant with some actual decreases, due largely to public takeovers of systems and decisions to assume public responsibility for operating losses. The recent real dollar fare decreases, together with some overall service improvements, contributed to the 1973-74 reversal in the decline of transit.
- Recent evidence indicates, that an end to the gasoline shortage, together with the recession and nearly constant fares, have resulted in stable transit ridership in 1975 compared with 1974.

Effects of Economic Conditions on Mass Transit Ridership

- Relatively large changes in the unemployment rate produce relatively small changes in transit ridership. For example, an increase in the unemployment rate from 5 percent to 9 percent causes a decline in transit ridership of "about 2-1/2 percent. In absolute terms, this means that an increase in unemployment from about 4.6 to 8.4 million persons, results in a decline of less than 400,000 average daily transit trips.
- Reduction in personal income during a recession or depression causes no significant shift of travel from automobile to transit in the short term.
- The primary effect of economic downturns on personal travel is to decrease work trips by both auto and transit. Households in which the head-of-household is unemployed will make about as many trips for non-work purposes as households in which the head-of-household is employed.
- The effects of a recession or depression on transit operators is relatively mild. Because a high proportion of the loss in ridership that occurs during a prolonged economic downturn develops during the peak period, it may be possible to reduce operating costs by cutting back on peak period operations. However, other factors, such as labor agreements or public pressure, may limit the size of the reductions that actually could be achieved.

Employment Effects on Investment in Mass Transit

- Investment in transit results in about 80 man-years of employment per million dollars invested. This includes the full multiplier effect of the investment. This approximate level of employment is achieved whether the investment is in bus or rail rolling stock, construction of new fixed guideways, or through increases in transit operations. Another study has indicated that mass transit construction generates 3 percent more employment than highway construction per million dollars invested.
- Increased investment in transit operations can generate additional employment within a few months, and the purchase of new buses or rail cars can generate new jobs within a year, However, it is not likely that increased expenditures on rapid transit construction will have significant employment effects within 2 years due to the long lead time required for planning, design, financing, etc.
- Investment in improved transit operations will result in local employment gains. Investment in buses or new rail cars will tend to distribute employment effects nationally rather than locally.
- Investment in fixed guideway construction "has very localized employment effects. Evidence from Washington and Atlanta indicates that about 2 percent of the total metropolitan

employment could be traced to fixed guideway construction.

Capacity of Transit Industry To Respond to Increased Investment in Transit

- Transit rolling stock manufacturers can rapidly increase production output if demand requires. The transit fleet could be doubled nationally within 5 years if a firm commitment were made to do so.
- Manufacturers of bus rolling stock are handicapped by the tendency for rush orders to be concentrated at the end of the fiscal year due largely to the way in which grant approvals are administered by Urban Mass Transportation Administration (UMTA). This may restrict competitive bidding and affect prices adversely.
- Prices of rolling stock are adversely affected by the lack of standardized specifications. There are nearly 1,600 options available for transit buses (not including interior and finish options), which could account for up to 25 percent of the purchase price of a $60,000 bus.

Relationship of Energy to Mass Transit

- Transit's share of total energy consumption is very low, Mass transit and intercity buses consume only 1 percent of the total energy consumed by transportation in the United States. Automobiles in urban areas consume 34.2 percent of total transportation energy. The percentage of urban passenger transportation fuel that autos consume is 98 percent.
- The energy efficiency of transit also is higher than automobiles. A transit bus with 30 passengers is six times as efficient as the auto which carries an average of 1,4 people.
- The energy efficiency of heavy rail transit systems is high. However, the construction of fixed guideway systems consumes a great deal of energy. Construction of the Bay Area Rapid Transit (BART) system consumed 44 percent of the energy the system will use over the next 50 years.
- During the recent oil embargo, it appears that most people continued to use the automobile for work trips and basic shopping trips but cut back on discretionary travel rather than maintaining their previous levels of mobility by shifting to transit.
- Between 1950 and 1970 auto transportation increased its share of total energy consumption. This was due primarily to increases in the vehicle fleet, and secondarily, to increases in the average miles driven per vehicle and decreases in average fuel consumption efficiency.
- Despite the increase in the number of "small cars" bought by the public after 1965, and a decrease in the number of "standard" (large) cars, the average amount of fuel consumed per mile has continued to increase. This trend can be attributed to an emphasis on auto performance and later to the mechanisms used by manufacturers to comply with Federal regulations for auto exhaust emissions. Prior to the 1975 models, these mechanisms resulted in increased fuel consumption per mile in each engine category. This more than offset the declining average engine and auto size in the auto fleet as a whole.

Current Trends in Metropolitan Areas' Use of UMTA Funding

- The vast majority of the Section 5, Formula Grant funds provided under the National Mass Transportation Act (NMTA) of 1974, is being programed for operating assistance rather than capital grants. This is true despite the fact that a minimum of a 50 percent local match is required as compared to 20 percent for capital grants and despite the requirement for provision of reduced fares for the elderly and handicapped. The trend is due to rapidly increasing operating costs, local commitments to maintain fares and to improve service, as well as the desire of local officials to maximize total Federal grants by obtaining capital grants from the regular discretionary capital grant program,
- In the event of a critical gasoline shortage in the future, metropolitan transit operators may have difficulty providing immediate increases in capacity even if large amounts of emergency funds were to be provided. Generally, metropolitan areas do not have "emergency" plans for such eventualities, and without such

plans, local operators may be confronted with excessive costs for such factors as overtime wage payments,

- UMTA can respond to substantial short-term increases in Federal transit expenditures if given adequate support for expanded administrative operations.

Policy Initiatives for Increasing Transit Ridership and Achieving Energy Conservation Objectives

- The UMTA Formula Grant program provides an opportunity for the achievement of new short-term national objectives. If UMTA had the authority to vary the Federal share, which now stands at 50 percent, it could use increases in the Federal share as an incentive for localities to initiate programs to achieve national objectives. These programs could include immediate, non-capital intensive actions for improving the efficiency and effectiveness of urban transportation,

- Pure transit improvement strategies and economic incentives for transit use (including no fare transit) can be very effective in attracting increased ridership, but they are ineffective by themselves in substantially reducing national energy consumption.

- Total elimination of the transit fare would cause a 60 percent to 80 percent increase in transit ridership. This increase in ridership could be accommodated by about a 40 percent increase in the size of the transit fleet. The cost of no fare transit would be about $5 billion per year in 1974 dollars.

- Maintaining peak-hour fares at their current levels and totally eliminating off-peak fares would increase total transit ridership by about 40 percent. This increase in ridership could be accommodated with no significant increase in the size of the transit fleet. Off-peak no fare transit would require about 1 billion (1974) dollars over current levels of operation assistance.

. It is likely that without complementary auto restraints, less than 50 percent of the riders attracted to transit by fare reductions would otherwise have been automobile drivers.

- Automobile energy conservation strategies of various kinds are much more effective than any transit incentive strategies in reducing oil consumption. In particular, gasoline taxes or other actions which would raise the price of gasoline by 50 percent would result in a reduction of about one million barrels per day of gasoline consumption—more than ten times the reduction resulting from a maximum pure-transit strategy for oil conservation. (The maximum pure-transit strategy considered included no-fare transit and a doubling of the transit fleet by 1980.).

- However, in comparison with its impact on energy consumption, the impact of a 50 percent increase in the price of gasoline on transit ridership is relatively slight, causing a less than 10 percent increase. This is because the primary response of motorists to gasoline price increases is to purchase more fuel-efficient automobiles rather than alter their travel behavior, at least through 1980. In the long term there are limits in the extent to which energy consumption can be decreased through improvements in auto fuel economy.

- An auto restraint actlon-such as a $1.50/day increase in the price of commuter parking in those areas where auto commuters could most easily shift to transit—has a far greater effect on transit ridership than does a 50 percent increase in the price of gasoline. A large part of this shift could come from elimination of employer subsidies for parking so that employees would pay free-market rates.

- In terms of energy saved per new rider attracted, generating additional ridership through auto restraints is more than twice as efficient as generating additional ridership through transit incentives,

- Transit ridership increases generated through auto restraint actions alone would have a negative impact on transit agency finances, since riders hip increases would occur primarily in the peak period, As a result, required increases in rolling stock would be proportionally greater than ridership increases generated through transit incentive strategies.

- New rolling stock required to handle the increase in peak period ridership associated with auto restraint actions would stand idle or make runs nearly empty in the off-peak period. Auto restraint actions should be combined with incentives to off-peak transit use (such as off-peak fare reductions) to enable more efficient use of the transit fleet.

- A combined strategy incorporating both transit incentives and auto restraints is the most effective strategy to promote energy conservation without lowering the efficiency (measured in passengers per vehicle) of the transit fleet.

- Opportunities exist for financing major transit improvements through revenue generated by auto restraints. For example, no-fare transit service coupled with a doubling of the transit fleet nationally could be financed by the taxes generated from about a 150! gas tax increase applied only in metropolitan areas. This tax could be applied nationwide and be refunded in rural areas, The national application of this tax would tend to decrease gasoline consumption nationally without imposing a financial hardship on rural residents.

- Any major indiscriminate auto use restraint policy will cause substantial hardships, particularly for those low and moderate income households who must use autos for work trips and other necessary travel. This burden can be substantially eliminated by taking all of the following actions: (a) applying the major auto restraints only in metropolitan areas, ('b) placing the strongest auto restraints in areas where high quality transit service is available as a substitute, and (c) substantially improving the quality of transit service and the incentives for its use.

- Achieving major increases in the use of transit and reducing energy consumption has long-run implications for national land use and urban growth policy. Existing patterns of metropolitan growth are not conducive to the achievement of these goals, and recent studies by the Council on Environmental Quality indicate that substantial savings in energy consumption could be achieved by fostering less scattered patterns of metropolitan settlement.

TABLE 1

ALTERNATIVE ENERGY AND ECONOMIC FUTURES SELECTED FOR ANALYSIS OF IMPACT ON TRANSIT INDUSTRY

Type of Alternative Futures	Assumed Conditions
L Economic Conditions:	
A. Recession	Unemployment averaging 8% for 1975, 7% in 1 of the 5-year period. Duration--36 months peak to ness cycle (24 months decline, 12 months recovery).
B. Depression	Unemployment averaging 9% for 1975, 11% for 1976, 9% for 1977, 6% for 1978 through 1980. Duration—48 months peak-to-peak of the business cycle (30 months decline, 18 months recovery).
IL Energy conditions:	
A. Decreaee=hllld	Decline in total oil consumption of of 1 million bbls/dayt by January 1976. Some cuts in imports (cuts of 10-20% of 1975 level of imports by January 1976) 1977-80 growth in oil consumption: 3%/year.
B. Demaee-wderate	Decline in total oil consumption of 3 million bbls/day by January 1977. Cut in imports equal to 50-70% of the 1975 level of imports by January 1977, 1978-80 growth in oil consumption: 1.5%/year.
c. Decrea-vefe	Decline in total oil consumption of 6 million bbls/day by January 1980. Imports cut equal to 100% of the 1975 level.

SOURCE: 88~d on S.O.M./SyDec Work Program prepared for OTA on December 9, 1974, but revised for February Progress Report to reflect deepening recession and more peasfmistlc forecasts generally being made by othera, and further revised to reflect changing conditions and final needs of the study in April and May.

FLOW DIAGRAM-CONCEPTUAL APPROACH TO THE ANALYSIS OF ALTERNATIVE FUTURE ECONOMIC AND ENERGY CONDITIONS AND THEIR RELATION TO MASS TRANSIT

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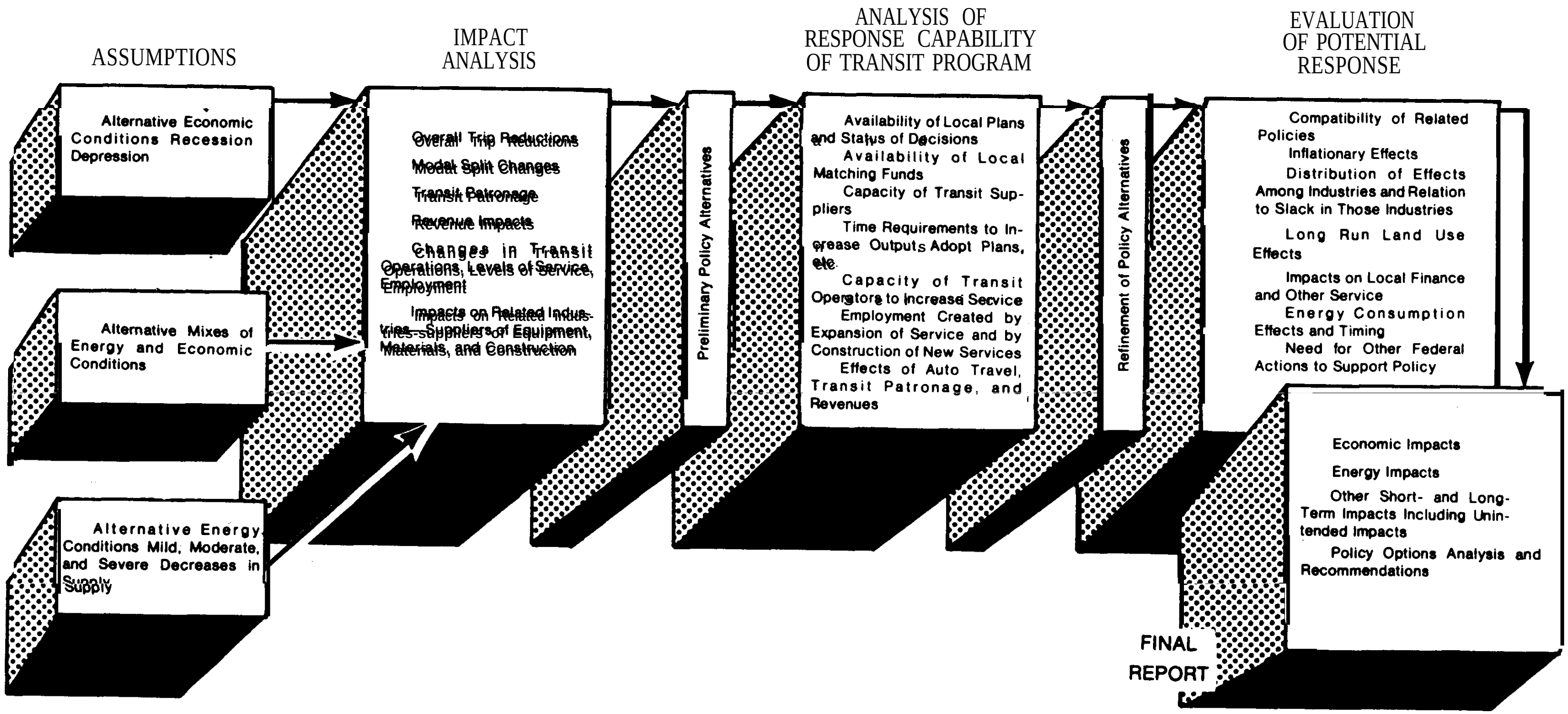


FIGURE 1

APPROACH TO THE STUDY

The study approach involved five major steps plus preparation of the final report. These steps are summarized below as a framework for the following sections of the report. (See Figure I).

The first task was to postulate a range of alternative future conditions for the national economy and the level of national energy supplies. The economic and energy assumptions are shown in Table 1. The economic assumptions were revised during the study to reflect current forecasts, and the assumptions about the reductions in energy consumption range from very short-term reductions, similar to the oil embargo of **1973-74,** to a reduction in consumption approximately six times as great as the embargo and nearly equivalent to the 1973 level of all United States oil imports.

The second task was a thorough analysis of the impacts that these assumed conditions would have on the transit sector. This involved analyses of effects on urban travel patterns, transit operations, and the transit industry.

In carrying out the impact analysis a wide variety of sources were used. A general analysis was made of the economic and energy studies recently issued by the Ford Foundation, the Federal Energy Administration, and the U.S. Department of Transportation,

With regard to urban travel patterns and transit operations, the consultants anaIyzed data on the effects that previous recessions and the recent oil embargo had had on total urban travel, type of travel, choice of mode, and transit usage, revenue, and operations. This analysis was strengthened by a statistical analysis of monthly and quarterly time-series data on national transit ridership in relation to other economic and transportation trends.

In the assessment of the role of the transit industry two types of analyses were undertaken. The first was an input-output analysis to determine the effects that changes in the level of transit investment and operations would have on the level of employment in that sector and related industries. The second was an analysis of the production capacity of major suppliers of transit equipment. These interviews with top management provided insight into the problems confronting the industry and its ability to accelerate production in response to changes in national policy.

The third major step in the study was to analyze the abilities of the Urban Mass Transportation Administration and local metropolitan transit operators to respond to changes in the transit program. A review was made of the current management of the Urban Mass Transportation Administration program from the standpoint of its capacity to administer new responsibilities under the National Mass Transportation Act of 1974 and to increase the scale of the various components of the program,

Metropolitan transportation planning, financing, and implementation capabilities were evaluated in depth as part of the Assessment of Community Planning for Mass Transit. This provided a basic picture of the response capability at the metropolitan level. In addition, a survey was done of the use to which metropolitan areas planned to put the new NMTA formula-grant funds-capital versus operating expenses. Metropolitan experience was also surveyed in terms of the local effects of the recent energy crisis, the recession, and potential capacity of local areas to expand transit operations and/or rates of investment in new equipment and facilities as part of an expanded national program,

The fourth major step involved developing and refining public policy alternatives, This process involved a number of iterations that began in the preliminary stages of the study (as shown in Figure 1).

The range of policy options covered initiatives to increase the use of mass transit as well as to achieve energy conservation objectives, More specifically, these alternatives included service improvements, capital investments in new systems and expansion of existing systems, economic incentives such as fare reductions, fare elimination, or indirect tax incentives, and various automobile pricing and regulatory restrictions designed to encourage shifts from auto to transit. Consideration was also given to long-term policies for land use and urban growth.

The fifth major phase of the study was to evaluate these policy initiatives. This evaluation considered the experiences of communities throughout the country which had implemented similar policies and programs. It involved a preliminary comparative assessment of the effectiveness of alternative actions or combinations of actions, and an evaluation of the means for implementing these actions. The results of this evaluation provided the basis for comparing the potential advantages and disadvantages of alternative policies.

This report is the product of completing this five-step approach.

Chapter II

The Historical Relationship Between Transit and the Economy

Chapter II very briefly summarizes the historical relationship between transit ridership and economic conditions, incIuding the decline in transit use corresponding to increasing affluence since the 1920's and the recent increases in ridership which can be at least partially attributed to economic factors such as the stabilization of fares.

This chapter, plus the following chapter, which discusses the relationship between energy and transit, present the general context in which the study was conducted. Later chapters present assumptions of future economic and energy conditions especially as they differ from past trends, and the results of the detailed investigations on the relationships between energy, the economy, and mass transit.

THE DECLINE OF TRANSIT AND ITS CAUSES

By the middle of the 1920's the automobile had begun to assert itself as a major form of urban transportation. With prosperity and mass production, automobile ownership and use expanded quickly. A pattern of serious competition between the private automobile and public forms of transportation in urban areas emerged, and transit ridenhip began to decline.

Table 2 shows the general decline in transit patronage from 1926 to 1972 except for the World War 11 interlude. From 1960 to 1972, revenue passengers declined at a compound annual rate of 2.9 percent.

In the three decades since World War II, there has been a continuous financial decline in the urban public transit industry in the United States paralleling the decline in ridership. Even though fares have risen at a faster pace than the consumer price index since 1965, passenger revenues have not grown rapidly enough to offset increased costs. More and more systems have experienced operating deficits and many privately owned systems have either ceased to operate or have sold their depleted operations to the municipalities they served.

The financial difficulties of transit systems and the emergence of urban public transportation as a major issue can be attributed to a number of interdependent causes:

- The urban population has grown primarily outside of the central cities where public transportation systems were located. From 1960 to 1970, suburban population increased by 34 percent while central city population increased only 1.5 percent. Most of the older central cities with higher densities and major transit systems suffered population decreases during the decade.

- Suburban living in the United States is largely automobile oriented. Population densities are low and parking space is usually free. Because of the wide dispersion of origins and destinations, transit cannot operate profitably and is often not even available.

- Automobile ownership has increased dramatically as shown in Table 3. Between 1960 and 1970 it increased from 1.09 to 1.27 autos per household. By 1970 only 20 percent of all households were without automobiles, and therefore, transit dependent. Such households contain a disproportionate number of the poor, the old, the young, and the handicapped.

TABLE 2

TRANSIT TRENDS
1926-1974

Year	Revenue Passengers			Vehicle Miles			Number of Passengers Per Vehicle Mile	
	Rapid Transit	Streeet Transit	Total	Rapid Transit	street Transit	Total	Rapid Transit	Street Transit
	(millions)			(millions)				
1926			17,234			2,670	6.5 (avg.)	
1930	—		15,567			2,707	5.8 (avg.)	
1935	2,262	7,497	9,782	439	1,790	2,327	4.4	4 2
1940	2,282	8,222	10,504	471	2,125	2,596	4.8	3.7
1945	2,555	16,393	18,982	458	2,721	3,254	5.6	6.0
1950	2,113	11,699	13,845	443	2,489	3,008	4.8	4.7
1960	1,670	5,516	7,521	391	1,677	2,143	4.3	3.3
1970	1,574	4,186	5,932	407	1,442	1,863	3.9	2.9
1$72	1,445	3,806	5,253	386	1,370	1,756	3.7	2.8
1973	1,424	3,870	5,294	407	1,428	1,635	3.5	2.7
1 974P	1,435	4,171	5,606	436	1,452	1,888	3.3	2.9

P - Preliminary

SOURCE: American Transit Association, *'74-'75 Transit Fact Book*, Washington, D.C.

TABLE 3

AUTOMOBILE OWNERSHIP IN THE U.S.
1960 AND 1970

	1960	1970
Automobiles in Use		
Per Capita	0.32	0.39
Per Household	1.09	1.27
Percent of Households Owning Automobiles	75.5	79.6
One Automobile Only	62.1	50.3
Two or More Automobiles	13.4	29.3
Percent of Households with no Automobiles	24.5	20.4

SOURCE: Automobile Manufacturers Association, Inc., Automobile *Facts and Figures*, 1968 and 1971. Data estimated by the Association from Census Information.

- Extensive freeway and other highway construction has improved the level of traffic service and increased the diversion from public transportation systems to the use of private automobiles.

- In the face of the financial squeeze, transit management did not have the resources to increase or improve service nor to market what services they did have. In addition, management of a declining publicly owned or publicly regulated enterprise is particularly difficult when much of the public still perceives it as a break-even enterprise.

- Federal programs to assist different urban transport modes have been enacted and administered separately and inconsistently. Highway funding has encouraged the use and ownership of automobiles, while public transportation has had low priority.

- Federal funds for comprehensive urban planning and development available from the Department of Housing and Urban Development have been only partly coordinated with transportation programs and their implementation within metropolitan areas.

- During most of the period in which transit's problems increased, State and Federal Governments were largely concerned with the problems of transportation between urban areas. Interest in transportation within urban areas was low.

RECENT UPTURN IN TRANSIT USE

The long downward trend in transit ridership reversed in late 1973 and 1974. The last 3 months of 1973 each showed increases over the same months of the previous year. This resulted in an increase for the year—the first time this had occurred in more than 20 years. In 1974 transit ridership increased by 5.9 percent above 1973. Ridership figures for the first half of 1975 indicate that transit has been able to hold on to the riders gained in 1974, but has not gained any additional riders.

Although energy conditions appear to have been the major cause for the increases in transit ridership in 1973-74, economic factors also contributed to the reversal of the historic trend. One condition that set the stage for the reversal is that by 1973 transit ridership had declined about as far as it could. Few "noncaptive" riders used transit, and most of the riders who could choose between using transit or automobiles for their trips had already shifted away from transit. Another economic reason has to do with the stabilization and reduction of fares. During 1968-1974 public takeovers of transit systems tended to stabilize fares, and during the past 3 years of that period, a number of large cities reduced fares. Both of these actions resulted in increased ridership. Finally, the public takeovers often led to improved service which also has helped to attract additional riders to transit.

While no direct evidence is available, the increase in UMTA funds for capital improvements and for transportation planning probably sparked the interest of many local governments to "do something" about transit.

Chapter III

Relationship Between Transit and Energy

Chapter 111 begins with a brief description of how de facto public policies in the past have encouraged inefficiencies in the use of fuel in urban transportation. Next, transit's present role is defined in relation to the overall national energy picture; first by examining the proportion of energy consumed by transit and then by comparing the opportunities for energy conservation in the transit field in relation to other modes of transportation. These discussions will show that transit's basic potential in energy conservation lies in providing a substitute for auto travel in urban areas.

This chapter completes a brief discussion of the general context in which this study of energy, the economy, and mass transit was conducted. The remainder of the report is devoted to an examination of the relationship between transit and future economic and energy conditions. Chapter IV describes a range of assumed possible future economic and energy conditions which were used to determine their effects on the transit industry. The remainder of the report describes in detail the ability of transit to save energy and create jobs under these and other future conditions.

THE ROLE OF CHEAP GASOLINE IN URBAN TRANSPORTATION

There is general agreement that the United States followed a "cheap energy" policy in the Post World War II period along with a "cheap auto transportation" policy. The real cost for both autos and fuel declined in the 1950-70 period. (That is, the rate of increase in these prices was less than the rate of increase in personal income after removal of inflation factors.) The taxes imposed on gas and automobiles were also very low by world standards. There was no public policy favoring conservation of any of the related resources. The combination of declining real cost and increasing real incomes produced a long run trend of increase of about 5.5 percent per annum for motor fuel consumed in urbanized areas.[1]

During this period, auto transportation increased its share of total energy consumption (Figure z). This increased share was due primarily to increases in the vehicle fleet (see Figure 3), and secondarily to increases in the average miles driven per vehicle (Figure 4) and decreases in average fuel consumption efficiency (Figure 5).

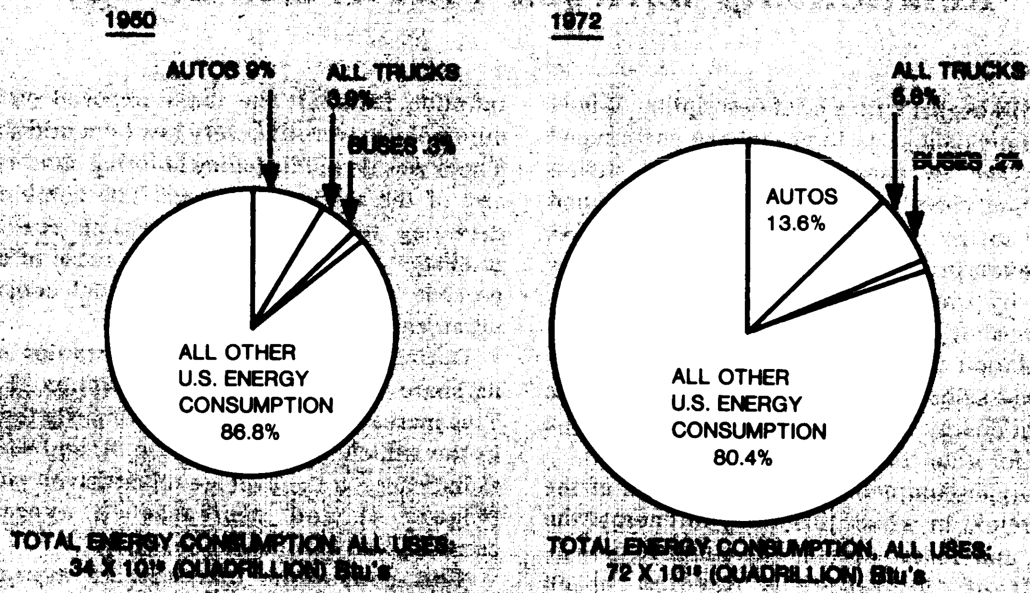
The continued increase in average fuel consumed per mile of auto travel is particularly interesting because there was a continuing decline in the number of large (standard) cars and an increase in the number of small cars bought by the public after 1965 (Figure 6). This would have decreased average fuel consumption except for the effect of Federal regulation of auto exhaust emissions which began in 1966. Prior to the 1975 model year the means chosen by the manufacturers to meet the required Federal standards resulted in sharply increased fuel consumption per mile in each engine size category. This more than offset the declining average engine size in the fleet as a whole.

The most important effect on transit of the de facto public policies has been to reduce transit ridership by encouraging the widespread use of cars, and to make transit fares appear relatively high. One of the effects of the continuing decline in transit ridership has been a parallel decline in the average number of passengers per vehicle mile (refer back to Table z). This in turn has caused a steady increase in transit's rate of energy consumption, measured in either gallons of fuel per passenger mile or kilowatt hours per passenger mile.

1Calculated from Highway Statistics, Federal Highway Administration, Washington, D.C.

FIGURE 2

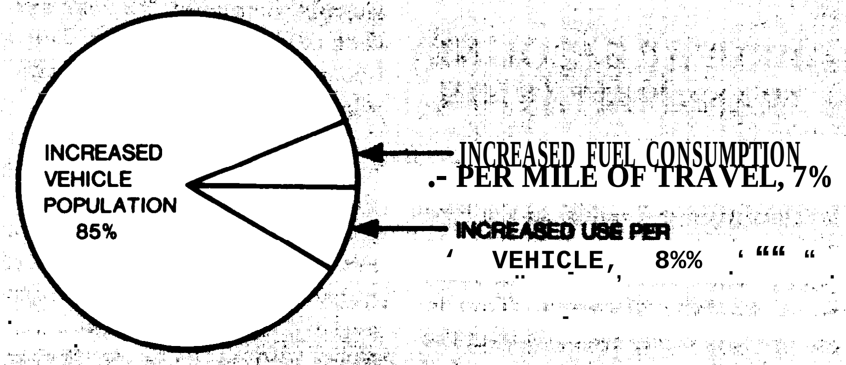
SHARE OF U.S. ENERGY CONSUMED BY MOTOR VEHICLES IN 1950 AND 1972



Source: (1) U.S. Bureau of Mines, *Minerals Yearbook*
(2) FHWA *Highway Statistics, 1972*

FIGURE 3

FACTORS CONTRIBUTING TO INCREASED PASSENGER CAR FUEL CONSUMPTION BETWEEN 1950 AND 1972

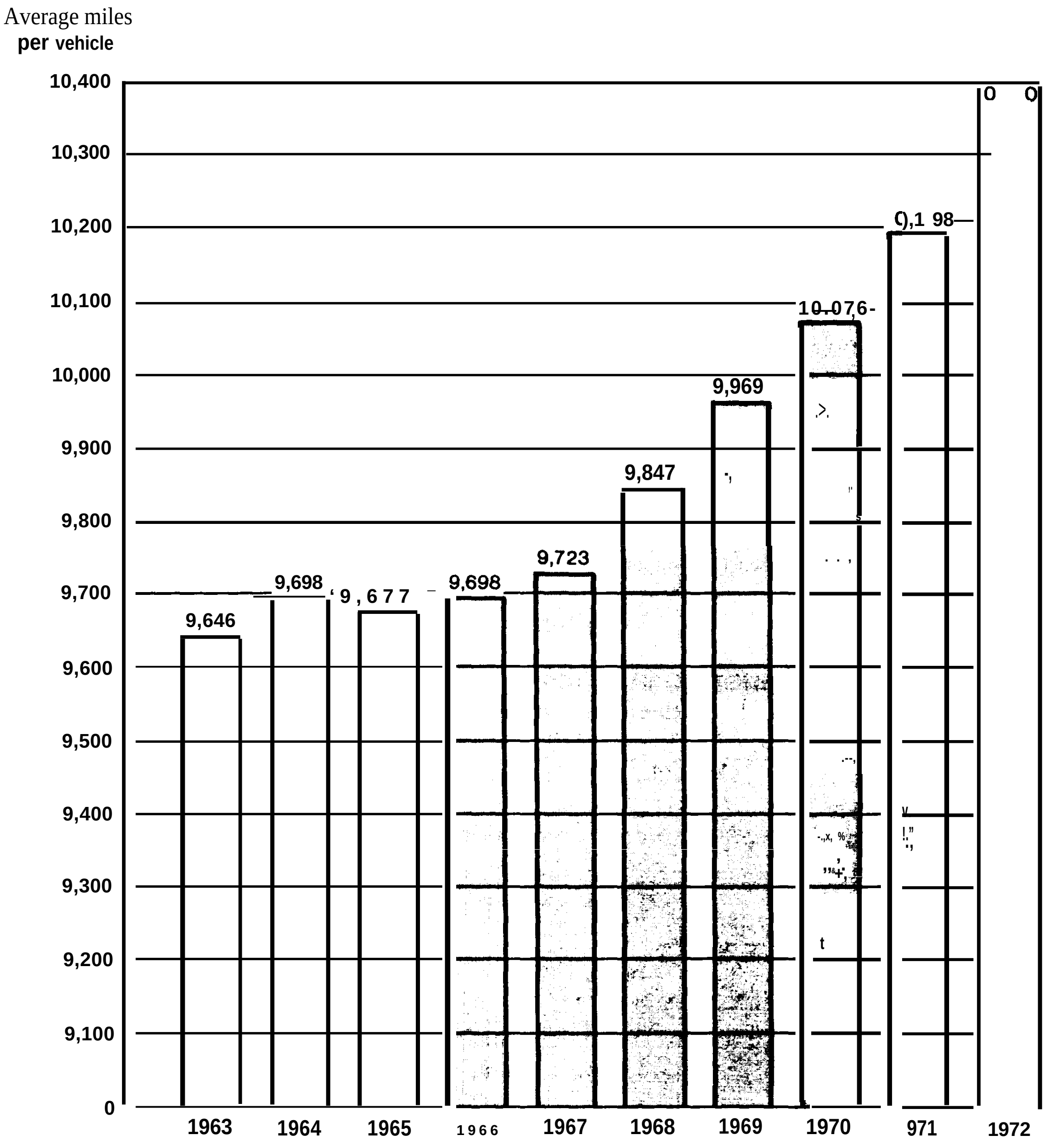


(ANNUAL GASOLINE CONSUMPTION IN PASSENGER CARS HAS MORE THAN TRIPLED FROM 1950 TO 1972.)

source: FHWA Annual Highway Statistics

FIGURE 4

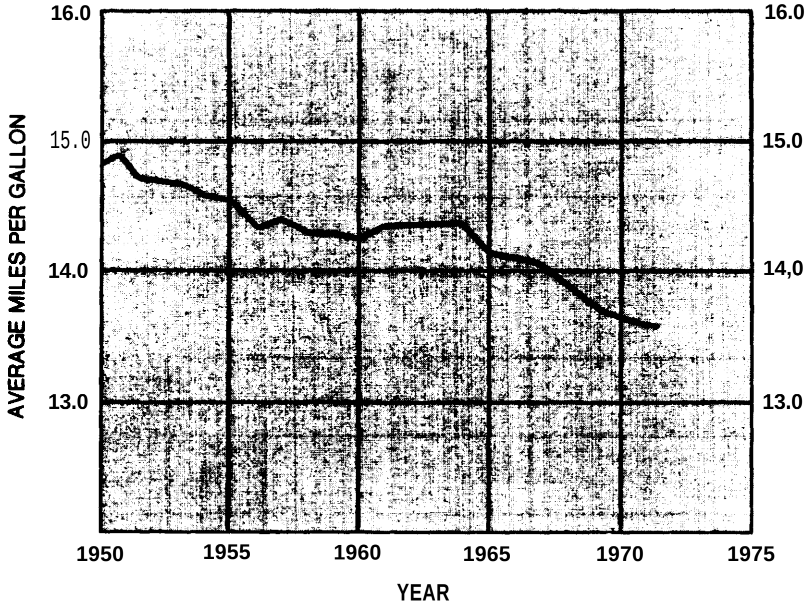
AVERAGE ANNUAL USE OF VEHICLES



SOURCE U.S. Department of Transportation, Federal Highway Administration, Table W-l.

FIGURE 5

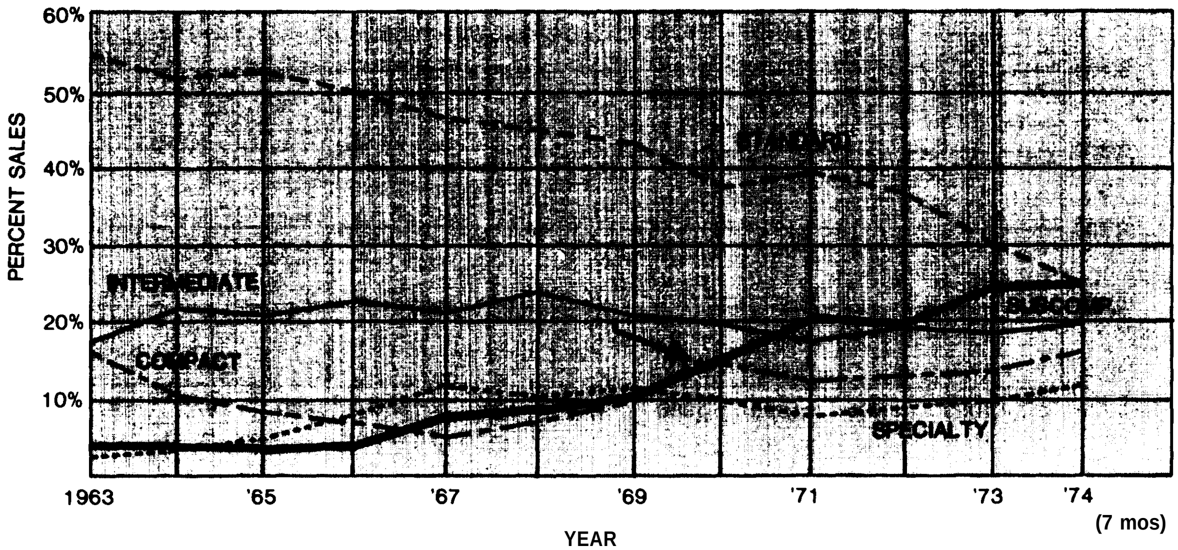
AVERAGE FUEL ECONOMY (MPG) OF U.S. PASSENGER CAR FLEET 1953-1972



SOURCE: FHWA Annual Highway Statistics

FIGURE 6

PASSENGER CAR SALES BY MARKET CLASS (Including imports)



SOURCE, Automotive News

The only significant period of time when gasoline was not readily available since World War 11 occurred between November 1973 to March 1974 for 1 to 4 months, depending on the region of the United States. The supply of motor fuel compared to the same months of the previous year was decreased by 3 percent to 15 percent. This fuel shortage, and increased gasoline prices during and after the shortage coincided with a significant increase in transit ridership. Figure 7 shows the number of transit riders and vehicle miles traveled by month for this period. Whether, and to what extent, transit ridership would have increased had there been no gasoline shortage and price increases is a difficult question. However, an analysis of the relationship between transit ridership and energy conditions reported in Chapter VII and Appendix A suggests that the shortages and price increases of gasoline more than account for the increase in transit ridership and, had they not occurred, transit ridership would have declined. However, more data over a longer time period is required to associate a high degree of confidence with this observation.

While these gains were important to transit operators, they do not represent a major change in the overall national urban travel picture, Transit accounts for only about 5 percent to 8 percent of total trips by vehicuIar transportation in the urbanized areas of the United States as a whole and it accounts for only 12 percent of the home-to-work trips in the urbanized areas of more than 250,000 population, transit's strongest market.[2] Thus an increase of 6 percent over prior periods in an 8 percent share of the national market affects only 0.5 percent of the total trips made in that market.

It is of interest that the increase in transit ridership seemed to accelerate in 1974 after the gasoline shortage was over (see Figure 7), but in 1975 ridership has remained steady with the previous year. This suggests that in the second half of 1974 people believed the price of gasoline would maintain its current level or increase further and have gradually restructured their trip-making habits to accommodate the higher cost of auto travel with less sacrificing of mobility. The lack of increased ridership in 1975 indicates that people are no longer responding to past shortages and price increases of gasoline by shifting to transit in significant numbers.

TRANSIT'S SHARE OF TOTAL ENERGY CONSUMPTION

Three points will be made in this section:

- Transit consumes less than one percent of U.S. transportation energy.
- Transit is a much more efficient user of energy than the automobile.
- Energy consumed in the construction of rapid rail systems may approach half of the total energy consumed by a system over a 50-year period of operation.

Preliminary figures[3] for 1973 show that the United States consumed 75,561 trillion Btu's in that year and that the transportation sector consumed 24.8 percent of that energy.

Figure 8 shows that mass transit and intercity buses together consume only 1 percent of the U.S. transportation energy, while automobiles in urban areas consume 34.2 percent. A more detailed study by Pollard, Hiatt, and Koplow[4] estimated that bus and rail urban transportation consumed only 0.66 percent of the total transportation energy, or 1.8 percent of all urban passenger transportation fuel.

Transit's importance in providing urban transportation is much greater than its low energy consumption implies because transit makes more efficient use of energy. Transit carries 5-8 percent of urban vehicular person trips while consuming less than 2 percent of all urban passenger transportation fuel.

Table 4 (reproduced from the APTA 1974-75 Transit Fact Book) shows an array of urban

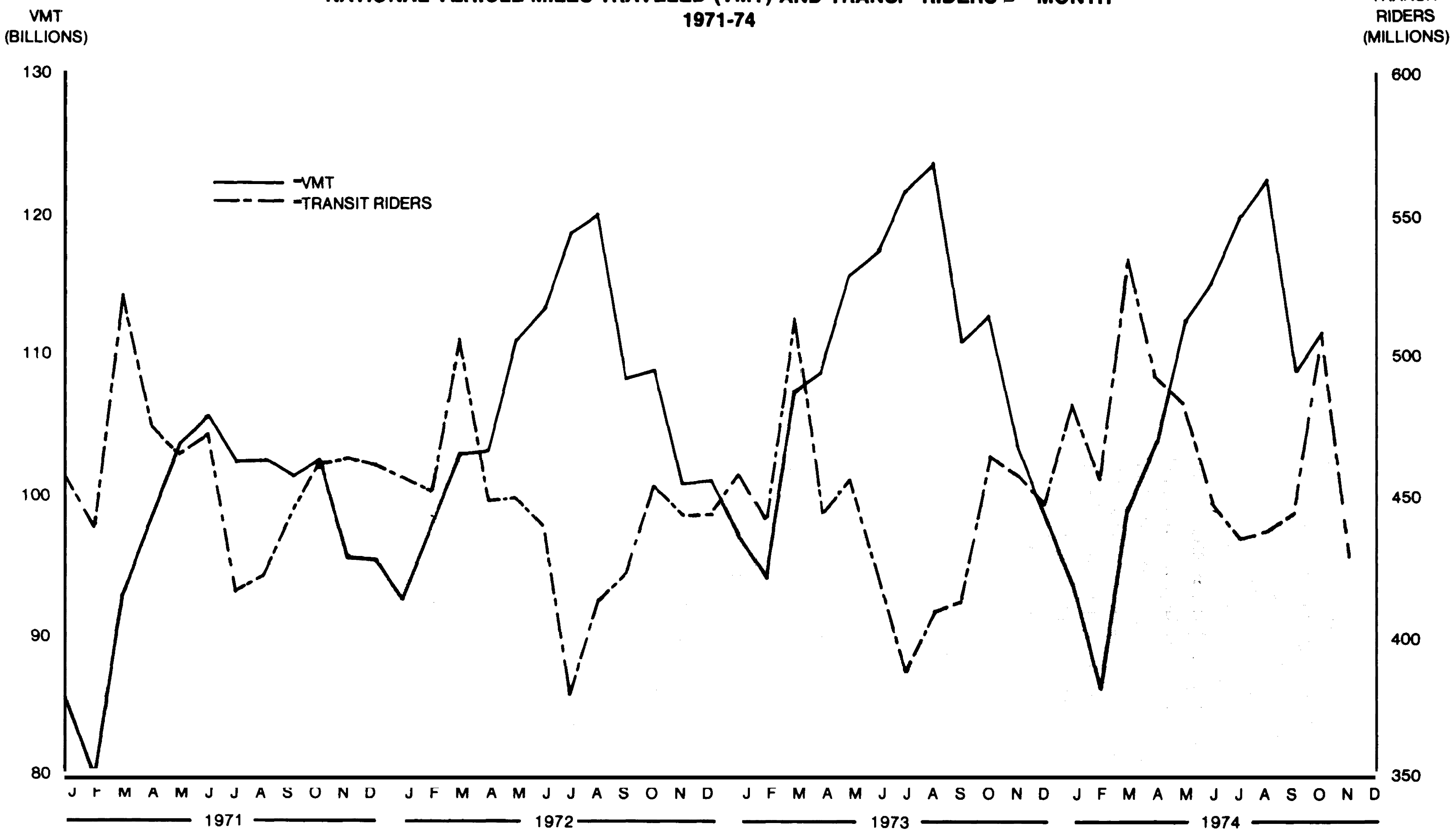
'Bureau of the Census, journey to Work, Report PC(2)6D, Census of Population 1970, Tables I and 2.

[3]U.S. Department of the Interior, News Release, March 10, 1974.

'Opportunities to Conserve Transportation Energy, Transportation Systems Center, U.S. Department of Transportation, 1974.

FIGURE

NATIONAL VEHICLE MILES TRAVELED (VMT) AND TRANSIᵕ RIDERS ɜ *MONTH
1971-74



Source: Transit Riders—APTA monthly transit traffic bulletins
VMT—Traffic Volume Trends, Table 9A, Program Management Division, FHWA

transportation modes for which passenger-miles per gallon figures are available. The private car at usual peak-hour loading is by far the least efficient of alI modes. This reflects the price Americans have been willing to pay for individual personal transport with its high level of personal comfort, convenience, and reliability, eroded only by congestion.

All of the main urban transportation vehicles are represented at both peak and off peak passenger loadings in Table 4. The energy efficiency effect of varying average load factors is apparent for all modes. Although an off peak transit bus with 30 people is six times as efficient as the auto with an average of 1.4 people, the peak load transit bus with 75 riders is almost three times as efficient as the 30-rider bus.

Heavy Rail Transit (subways) is shown to be even more efficient than buses, With a load of 35 passengers per car, subways are more than 7 times as energy efficient as commuter autos. Under peak loads, subways are nearly 30 times as efficient. However, the energy consumed in operation shown here is only a portion of the energy required for rail rapid transit and construction energy should also be considered.

The construction of fixed guideway systems such as BART consumes a great deal of energy. Table 5 indicates that on a 50-year basis, 44 percent of BART's total energy requirement was expended during construction. Since this system represents the most expensive type of construction, including a long underwater tunnel, this may be considered an upper bound on the range of such requirements.

A study by Eric Hirst of the Oak Ridge National Laboratory includes an analysis of automobile energy requirements (see Table 6). The Hirst study showed the energy consumption in automobile vehicle manufacturing, repair, sales, and financing, as well as the energy consumed in refining the gasoline, but did not include highway construction energy. These functions reduce the average miles per gallon from about 14 to 7. If highway construction energy had been included the average miles per gallon would have been reduced even further.

It seems unquestionable that in determining national transportation policies the complete array of energy consumption requirements should be taken into account.

SOME ALTERNATIVE COURSES FOR ENERGY CONSERVATION IN TRANSPORTATION

The principal message from the above review is that conservation efforts must focus on the consumer of 98 percent of urban passenger transportation fuel—the automobile. Shifting travel to transit will have beneficial energy saving effects, but, as will be shown in Chapter IX the most effective ways of accomplishing this shift, from an energy conservation standpoint, involve emphasis on disincentives to auto use coupled with transit use incentives.

The need to concentrate on auto efficiency has been noted by both the Department of Transportations and the Federal Energy Administration (FEA).[5,6]

The FEA paper reported estimates of energy savings in 1980 for three transportation policies as shown in Table 7. For the increase in car occupancy, the savings represent less than 5 percent of the motor fuel consumed in I973 and for the increase in fuel economy the savings are over 8 percent, But doubling transit ridership by itself produces a less than 1 percent savings according to the FEA.

The Department of Transportation study is summarized in Table 8 in terms of the potential fuel savings of a wide variety of options considered, including vehicle design changes, car pooling (load factors), traffic operations improvements, as well as a wide range of shifts among modes. Note that the shift from urban auto to bus is given the greatest potential for fuel savings of all mode shifts by either 1980 or 1990, but much less potential than car pooling and an order of magnitude less effective than many vehicle design measures,

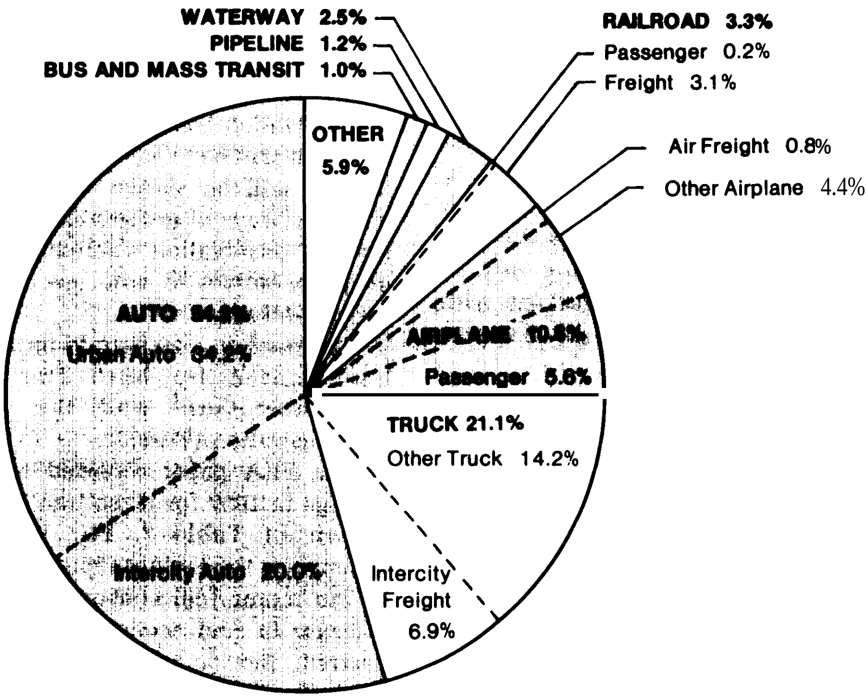
What is not often recognized or emphasized in many discussions is the complementarily of programs aimed at discouraging auto use in urban areas and programs to encourage transit use. From

[5] *Summary of* Opportunities *to* Conserve Transportation Energy, Pollard, Hiatt and Koplow, Transportation Systems Center, a Report for the Office of the Secretary of Transportation, Final Draft, January 1975.

[6] Stuntz Mayo S. Jr., Mass Transit and Energy Conservation, Federal Energy Administration, March 5, 1975.

FIGURE 8

ENERGY CONSUMPTION BY TRANSPORT MODE, 1970



SOURCE Lutin, J. M., Comparison of Energy Savings *for* Work *Trips,* Princeton University Transportation Program, 1974.

TABLE 4

ENERGY REQUIREMENTS OF PASSENGER TRANSPORTATION MODES

Type of Transportation	Paseenger	Vehicle Miles Per Gallon Of Fuel or Equivalent	Passenger Miles Per Gallon of Fuel or Equivalent
Heavy Rail Transit (Subway) Car, Peak Load (a)	135	4.00	540
Intercity Passenger Train (b)	540-720	0.50	270-360
Transit Bus, Peak Load (c)	75	4.10	307
Intercity Bus (d)	47	6.00	282
Commuter Rail Car, Diesel Powered (a)	125	2.00	250
Heavy Rail Transit (Subway) Car, Off-Peak Load (a)	35	4.00	140
Transit Bus, Off-Peak Load (c)	30	4.10	123
Rail Turbine Train (b)	320	0.33	110
Standard Size Automobile, Intercity, Maximum Load (e)	6	18.00	108
Standard Size Automobile, Urban, Maximum Load (e)	6	14.40	86
Wide-Body Commercial Jet Aircraft, 1,000-Mile Flight (9	256-385	0.1 4-0.2:	54-60
Twin Jet Commercial Aircraft, 500-Mile Flight (9	68-106	0.44-0.54	37-47
Average Commuter Automobile (a)	1.4	13.5	19

source:

(a) Commonwealth of Pennsylvania, Depirttibnt of Transportation
(b) National Railroad Passenger Corporation (Amtrak)
(c) Cleveland Transit System
(d) U.S. Department of Transportation, Transportation Systems Center
(e) U.S. Department of Transportation, Federal Highway Administration
(f) National Aeronautics and Space Administration

(Reproduced from American Public Transit Association '74-'75 TRANSIT *FACT BOOK)*

TABLE 5

TOTAL "BART" ENERGY REQUIREMENTS FOR ALL PURPOSES DURING 50-YEAR LIFE SPAN

Major purpose	Energy Used	Percent
Construction Energy:	1.1 x 10^{14}Btu	44
Traction Energy (Vehicle Operation):	1.0 X 10^{14}Btu	40
Station Operation and Maintenance Energy	0.4 X 10^{14}Btu	16
Total Energy Required:	2.5 X 10^{14}Btu	100

SOURCE: Heaiy and Dick; *Total Energy Requirements of the BART System,* Santa Clara University, July 1, 1974

TABLE 6

TOTAL ENERGY REQUIREMENTS FOR AUTOMOBILES IN THE U.S.

	1960 (10^{16}BtU)	1968 (10^{16} Btu)	1970[a] (10^{15}Btu)
1. Gasoline Consumption	5.60	7.96	8.95
2. Petroleum Refining	1.16	1.64	1.84
3. Automobile Manufacturing	0.78	1.05	0.71
4. Automobile Retail Sales	0.77	0.99	0.82
6. Repairs, Maintenance, Insurance, Replacement Parts, Accesssories, Parking, Tolls, Taxes, etc.	3.03	3.95	4.44
TOTAL (10^{16}Btu)	11 .33	15.59	16.76
Total Automobile Mileage (10^{9} miles)	588	814	901
Total Energy Required (Btu/mile)	19,270	19,150	18,620
. (miles/gal)	7.06	7.10	7.31
Total U.S. Energy Consumption (10^{15}Btu)	44.96	62.45	68.81
Percent of Total Energy Consumption Devoted to Automobiles	25.2	25.0	24.4

[a]The 1970 figures are low for manufacture and sale of automobiles. This is probably due to the economic condition of the country that year, and may not represent a long-term secular decline in automotive energy consumption.

SOURCE: Hirst, E.; *Energy Consumption for Transportation in the U.S.* Oak Ridge National Laboratories, March 1972

TABLE 7

ENERGY CONSERVATION POTENTIAL OF VARIOUS TRANSPORTATION POLICY ACTIONS

Policy	Estimated Energy savings (1980)
1. Double mass transit system size and ridership	40-50,000 barrels/day[1]
2. increase car occupancy to 2.0 PM/VM	350,000 barrels/day
3. 40% increase in new car fuel economy	640,000 barrels/day

[1]The American Public Transit Association (APTA) vehemently disputes this figure. In an undated paper entitled Energy Conservation and Public Transit: An Interim Rebuttal by *American Public Transit Association,* APTA implies that the savings should be at least 178,000 bbl/day and that much greater savings could be achieved if transit's efficiencies could be fully utilized.

The primary source of the disparity between the FEA and APTA estimates is that they make considerably different assumptions about the reduction in automobile vehicle miles of travel which would be associated with a doubling of transit ridership.

In actuality, the amount of energy saved will depend upon how transit ridership increases are achieved. As discussed later in this document, the mere doubling of the national transit system's size, in and of itself, would not cause a doubling of ridership-it would result in an estimated 20°6 to 40% increase in ridership. In order to achieve a doubling of ridership it would be necessary to take substantial actions to restrain auto use and/or to create substantial transit incentives in addition to the doubling of the transit system's size. Doubling transit ridership by auto restraint actions generates energy savings of not much more than 100,000 barrels/day through the diversion of auto drivers to transit. With most auto restraint actions, however, there would be substantial additional energy savings over and above the shift to transit because of more efficient use of autos and reduction in travel. On the other hand, doubling transit ridership by transit incentive actions alone, such as the elimination of fares, would be likely to produce energy savings of only about 60,000 barrels/day or less,

SOURCE Mayo S. Stuntz, Jr. *Mass Transit and Energy Conservation,* FEA, March 5, 1975.

both the public policy and political standpoints, it would be desirable for major transit incentives to be implemented first, while being clearly linked to a later auto restraint program. Insofar as possible, all nonfrivolous demands for transportation movement should be met. That is, there should be an approximate balance between the number of trips which are reduced by urban auto travel through any auto restraint measures and the number of trips which are attracted to transit by incentives such as service improvements and fare reductions.

TABLE 8

SUMMARY OF EFFECTS OF VARIOUS OPTIONS ON FUEL SAVINGS FROM DEPARTMENT OF TRANSPORTATION PROGRAM

OPTION	Fuel Savings As % of Total Direct Transport Fuel 1980	1990
DOMESTIC PASSENGER HIGHWAY		
Auto: Vehicular Efficiency Improvements		
1) Market Response:		
(a) 65¢ current	2.7	7.0
(b) 65¢ real	9.8	11.8
2) Small Cars (19 mpg)	9.4	13.9
3) Lean Bum Engines	3.8	0.3
4) Stratified Charge Engines	4.0	13.3
5) Diesel Engines	3.0	12.4
6) Cont. Vars. Transmissions	3.3	13.0
7) Intermediate w/Tech. Options	3.0	14.7
8) Small w/ Tech. Options	9.4	21.4
9) Battery Electric	"?	?
10) Retrofits (radials only)	0.7	0
Load Factor (49% participation in carpools)	2.5	2.1
Operational Improvements		
1) Speed limits (55 m.p.h.)	1.4	1.2
2) Maintenance	0.7	0.4
3) Driving Habits	2.4	2.1
4) Traffic Flow	0.5	0.9
Demand Reduction	2	3
URBAN AUTO SHIFTS		
urban Auto to Bus	0.8	1.3
Urban Auto to Rail	No Potential	
urban Auto to Bicycle	0.6	0.9
IC AUTO SHIFTS		
Intercity Auto to Bus	0.3	0.7
Intercity Auto to Rail	0	0
AIR PAX SHIFTS		
Air Passenger to Auto	0.2	0.3
Air Passenger to Rail	0.1	0.2
Air Passenger to Bus	0.1	0.4
AIR FREIGHT SHIFTS		
Air Freight to Truck	o	.0
IC TRUCK SHIFTS		
intercity Truck Freight to Rail	.0.1	0.5

SOURCE: Pollard, Hiatt, and Koplow, *Summary of Opportunities To Conserve Transportation Energy*, Transportation Systems Center, A Report for the Office of the Secretary, Final Draft, January 1975.

Chapter IV

Alternative Economic and Energy Futures

The alternative economic and energy futures developed for this study are presented in this chapter along with a brief discussion of and a comparison with the Ford and Federal Energy Administration (Project Independence) studies completed in 1974. The alternatives in this chapter cover a wide range of possible futures including mild, moderate, and severe energy decreases and recession and depression economic conditions.

Having set the general context in Chapters II and III, this chapter introduces the assumptions of the future used in the study and presents these assumptions within the context of the two major energy studies. The development of these alternative economic and energy futures completes the first major task of the study, as described on page 7 in Chapter I, and provides a wide range of economic and energy forecasts, for which the effects on the transit industry are calculated. Chapter V examines the historical relationships between transit ridership and economic conditions (depressions and recessions) and then forecasts the effect on ridership of the economic futures presented in this chapter. Chapter VI explains the capacity of the transit industry and its capital goods suppliers to create employment opportunities and to respond to major changes in the transit program. Succeeding chapters estimate the effects of energy conditions on transit and forecast the effect of the energy and combined economic and energy futures on transit.

GENERAL FORECASTS

Although a number of forecasts have been made of projected energy demand, those of the Ford Foundation's Energy Policy Projects and the Federal Energy Administration's Project Independence represent the most frequently used and accepted. For purposes of comparison and to provide some perspective of the recent and forecast energy consumption levels, Table 9 summarizes gross energy resource consumption in 1972/73 and for the year 1985 (expressed in Quads-quadrillion Btu's per year),

As may be seen, both the Project Independence and Ford estimates are quite comparable, particularly when the difference in the base year is taken into account. These two projections are based on "historical growth" and "business-as-usual" concepts without any conservation effort. The Project Independence estimate shown in Table 9

TABLE 9

COMPARISON OF ENERGY DEMAND PROJECTIONS GROSS ENERGY RESOURCE CONSUMPTION 1972/73 - 1985

(In Quads)[1]

Estimating Group	Projected Demand 1972/73	1985	Compared Annual Growth Rate (1972/73-85)
Ford Study (1973)[2]	75.0	116.1	3.7%
Project Independence (FEA)[3] (1972)	72.1	109.1	3.2%

[1] Quadrillion Btu's per year
[2] "Historical Growth Scenario"
[3] "Business as Usual Without Conservation," $7 oil price

SOURCE: Ford Foundation, *Final Report*, by the Energy Policy Project, "A Time to Choose," Ballenger Publishing Company, Cambridge, Mess., 1974, page 21, table 1. Federal Energy Administration, *Project* Independence, Government Printing Office, November 1974, appendix 1 of 3, table P-5.

assumes a $7 per barrel oil price, but there are estimates in the study which include assumptions of $4 and $5 prices per barrel of oil. The consumption estimates shown in Table 9 were selected because they are based on assumptions roughly comparable to the Ford estimates and to the assumptions used in this study for the trend forecast. In terms of the future, the forecasts to 1985 are relatively similar, with compound annual growth rates over the period of 3,2 percent per annum for Project Independence and 3.7 percent for the Ford study.

In terms of the relative share for the various consumers of energy, both the Ford and Project Independence data indicate that the transportation sector consumes about **25** percent of total gross energy (in **1972** about **18.0** quads out of a total of ***72.1*** Quads). About 92 percent of the transportation sector's energy is from petroleum sources, re~ecting its dependence on petroleum fuel products.

The Energy Alternatives of the Ford and Project Independence Studies

The controlling factor in the Project Independ*ence* analysis is the price per barrel of crude oil, All of the "effects" are derived from the assumed results of particular price levels with the analysis generally using $7 and $11 per barrel prices, and in some cases $4 (in effect, the price level for 1973) and $15.

Two basic strategies are considered independently and in combination. C)ne is acceleration of domestic supply by a number of means, all relatively well known. The other is energy conservation and demand management which assumes Federal regulation of major consumers (autos, power plants) and intervention in fuel mix consumed such as accelerating adoption of nuclear fuels. There are some proposals for handling supply emergencies, but they seem more pertinent for embargo situations and not longrun transit impact assessment. All of the fully developed comparisons include a "base case" referred to as BAU or "business as usual. "

The following comments from Project Independence summarize their perspective and viewpoint:

"- Rather than evaluate hundreds of alternative actions, the study contrasts the broad strategic options available to the United States:

— Increasing domestic supply,

—Conserving and managing energy demand,

—Establishing standby emergency programs.

"— The strategies are evaluated in terms of their impact on:

—Development of alternative energy sources,

— Vulnerability to import disruptions,

—Economic growth, inflation, and unemployment,

— Regional and social impacts.

"— The strategies are only illustrative, and in reality, a national energy policy will probably contain elements from each."[2]

The Ford Foundation study is more policy-oriented in its approach, and three energy scenarios are analyzed.[3] The first, "Historical Growth" (HG), is simply a continuation of the 1950-70 trend to 2000 supported by a vigorous program to maintain supply up to the level of demand, The second, "Technical Fix" (TF), assumes the use of already proven engineering techniques to control consumption, with a result that the rate of increase to the year 2000 is reduced by half (and the actual amount consumed per year by two-thirds). The third alternative, Zero Energy Growth (ZEG) analyzes the consequences of halting all increases in annual energy consumption by 1990 and involves some revisions in the economy. As stated in the report:

> "Under the Historical Growth scenario there would be little scope to pick and choose among sources of supply, no matter what economic, foreign policy, or environmental problems they might raise. For example, no matter how we juggle the mix of sources, coal and nuclear power would have to be the mainstays of energy supply by the year **2000,** Together they would furnish more energy than all sources combined provided in 1973.
>
> "Supply options are more flexible in the Technical Fix scenario. The slower growth in

[1]Federal Energy Administration, Project Independence Report, Project Independence, Government Printing Office, November 1974, Appendix page 37, Table P-5.

'Federal Energy Administration, Project Independence Report, op. *cit.*, page 1.

[3]*Ford* Foundation Energy ***Policy project, Final*** **Report,**^ Time to Choose, Ballenger Press, Cambrige, 1974, pages 14-15.

TABLE 10

ALTERNATIVE ENERGY AND ECONOMIC FUTURES SELECTED FOR ANALYSIS OF IMPACT ON TRANSIT INDUSTRY

Type of Alternative Future	*Assumed Conditions*
I. **Economic Conditions:** A. Recession	Unemployment averaging 8% for 1975, 7% in 1976 and 6°/0 for the rest of the 5-year period. Duration-36 months peak to peak of the bueiness cycle (24 months decline, 12-month recovery).
B. Depression	Unernployment averaging 9% for 1975, 11% for 1976, 9% for 1977, 8% for 1978 through 1980. Duration -48 months peak to peak of the business cycle (30 months decline, 18-month recovery).
II. **Energy Conditions:** A. Decrease-Miid	Decline in total oil Consumption of 1 million bbls/day by January 1976. Some *cuts in* imports (cuts of 10-20% of 1975 level of imports by January 1976). I977-80 growth in oil consumption: 3%/year.
B. Decrease-Moderate	*Decline* in total *oil consumption* of 3 mNiion bbls/day by January 1977. Cut in Imports equal to 60-70% of the 1975 level of imports by January 1977. 1978-80 growth in oil consumption: 1.5%/year. .
C. Decrease--Severe	Decline in total oil consumption of 6 million bbls/day by January 1980. Imports cut equal to 100% of the 1975 level.

SOURCE: Based on S.O.M./SyDec Work program prepared for OTA on December 9, 1974, but revised for February Progress Report to reflect deepening recession and more pessimistic forecasts generally being made by others, and further revised to reflect changing conditions and final needs of the Study in April and May.

energy consumption permits more flexibility and a more relaxed pace of development. The Nation could halt growth in at least one of the major domestic sources of energy-nuclear power, offshore oil and gas, or coal and shale from the Rocky Mountain region-and still demand less from the other supply sources than Historical Growth requires.

"Zero Energy Growth would allow still more choice in supply from conventional sources. After 1985, this scenario could also permit use of a cleaner, renewable, but smaller scale energy sources such as windpower, roof-top solar power, and recycled waste to meet a larger share of the total energy demand. Still, it should be remembered that even in this scenario the national energy appetite would be very large. Even if there were no further annual growth in energy use after the 1980's, the Nation would still need to find enough supplies every year to meet an energy demand one-third larger than that of 1973. "[4]

Economic and Energy Futures Used in This Study

Table 10 summarizes the economic and energy futures which were used in this study to evaluate the effects of such futures on the transit industry,

The futures were selected to reflect a wide range of possible future conditions. The economic conditions included a recession which reflected most forecasts for the current recession.

[4] Ford Foundation Energy Policy Project, "A Time to Choose," pages 16-17.

The depression future assumed economic conditions would be worse than has been generally forecast. Energy futures ranged from a mild decrease of 1 million barrels/day over I year to a severe decrease of 6 million barrels/day reduction within 5 years. The mild decrease in energy availability is equal to the amount of the reduction during the energy crisis, but spread over the entire year of 1975. The severe cutback assumes a reduction by 1980 that is about equal to the current petroleum imports.

Comparisons Between Ford, Project Independence, and OTA Study

The purpose of the section that follows is to evaluate and compare the three OTA alternative energy assumptions in Table 11 with the energy assumption of the Ford and Project Independence reports. That will be followed by a similar evaluation and comparison of the economic assumptions.

In terms of time horizons, the Ford study uses only 1985 and **2000 as** forecast years while Project Independence uses 1985 **as well as** 1977 and 1980, The time horizon for this study is ***1980.***

In order to compare energy consumption among the alternatives, it was possible to convert all of the principal data to "Quads" (quadrillion Btu's consumed per year). This study's "severe" assumption target of eliminating the current level of imports, or reducing future ***(1980)*** availability by a rate of 6 million barrels of crude per day, under what it otherwise would be, amounts to about a 12-Quad reduction, Since each barrel of crude yields 45 percent gasoline (based on U.S. averages), the 12-Quad reduction overall would result in a gasoline reduction of about 5.4 Quads. This reduction is roughly equal to the effect on total transportation fuel for this "severe" alternative.

The 3-million barrel per day rate (proposed as the moderate alternative in Table 10) would, of course, amount to half, or a total of 6 Quads reduction from the trend, of which the transportation impact would be **2.7** Quads. The mild energy assumption of I million barrels per day reduction is about equal to what was actually accomplished in 1974 and seems to provide no analytical problems with respect to transportation,

In order to use relationships developed by the two major studies (Ford and FEA), it is necessary to locate comparisons which involved approximately similar amounts of reduction in energy consumption. For this purpose Table 11 was prepared, converting all data to quads. The "Total Fuels" category includes all direct use of fuels and excludes generation and consumption of electricity in all cases, "Transportation Fuels" are the amounts as proposed in each of the reported cases.

The comparisons in Table 11 show that the severe energy alternative of this study, eliminating the equivalent of all current levels of imports by ***1980,*** is more severe than any of the FEA energy alternatives but not as severe as the Ford Foundation's "Zero Energy Growth,"

Inspection of the differences among the FEA alternatives for the $7 per barrel price group shows that the maximum total fuels difference between ***1985*** forecasts is ***–7.4*** Quads and for transportation **–4.2** Quads. For the $11 price group the largest ***1985*** difference is ***–6.5*** Quads and for transportation ***–3.3*** Quads—all much smaller than the proposed differences of 12 and 5,4 Quads for this study. While larger differences could be found going between the extremes of the two FEA price groups, each price group analysis is internally consistent, and they are not bridged in the FEA work.

While none of the Ford scenarios would provide a precisely equivalent reduction in actual fuel availability, the difference of ***10.5*** Quads between the first two Ford scenarios—Historical Growth and Technical Fix—for ***1985*** is reasonably comparable to the difference of 12 Quads for this study. The total is lower, which might be interpreted to assume some increase in coal or nuclear fuels as offset—reasonably by ***1985***—and the transportation difference is significantly higher (26.0 – 19.6 = ***6.4*** quads) than this study's "severe" reduction. This could be interpreted to imply a net transfer of petroleum to nontransportation uses, which would require strong conservation. Note that the Ford Foundation "Zero Energy Growth" scenario results in larger **1985** differences than our "severe" reductions for both total fuels and the transportation sector.

TAME 11

COMPARISON OF REPORTED ENERGY ALTERNATIVES FROM FEDERAL ENERGY ADMINISTRATION AND FORD FOUNDATtON

(Data in Quads: 1 Quad equals one quadrillion Btu's consumed per year)

Alternatives	1972 (FEA) 1973 (Ford)	1985	Diff 1972-3 to 1985
FEA-Project Independence			
$7.Barrel of Crude Price Scenario:			
a. Business as Usual Without Conservation:			
Total Fuels	53.5	68.1	14.6
Transportation Fuels	18.1	24.5	6.4
b. Business as Usual With Conservation:			
Total Fuels	53.5	61.2	7.7
Transportation Fuels	18.1	20.3	2.2
c. Accelerated Supply Without Conservation:			
Total Fuels	53.5	68.6	15.1
Transportation Fuels	18.1	24.5	6.4
d. Accelerated Supply With Conservation:			
Total Fuels	53.5	61.9	8.4
Transportation Fuels	18.1	20.4	2.3
$11/Barrel of Crude Price Scenario:			
a. Business as Usual Without Conservation:			
Total Fuels	53.5	63.7	10.2
Transportation Fuels	18.1	21.9	3.8
b. Business as Usual With Conservation:			
Total Fuels	83.5	68.6	5.1
Transportation Fuels	18.1	19.1	1.0
c. Accelerated Supply Without Conservation:			
Total Fuels	53.5	65.1	11.6
Transportation Fuels	18.1	22.4	4.3
d. Accelerated Supply With Conservation:			
Total Fuels	53.5	60.3	6.8
Transportation Fuels	18.1	20.0	1.9
Ford Foundation--Time to Choose			
Historical Growth Scenarlo:			
Total Fuels	58.8	78.6	22.8
Transportation Fuels	18.8	26.0	7.2
Technical Fix Scenario: - .			
Total Fuels	56.8	68.1	12.3
Transportation Fuels	18.8	19.8	0.8
Zero Energy Growth Scenario			
Total Fuels	55.6	65.2	9.4
Transportation Fuels	18.8	18.4	0.4
1985 Differences:			
Historical Growth to Technical Fix—	Total—10,5 Transportation- 6.4		
Historical Growth to Zero Energy Growth—	Total—13.4 Transportation- 7.6		

SOURCE Ford Foundation Energy Policy Project, *op. cit.:* FEA, Project *Independence, op cit.*

ECONOMIC CONSEQUENCES

Turning to the economic consequences of energy conservation assumptions on the economy as a whole, one notes that both the Ford report and Project Independence have attempted to estimate the impacts on GNP, employment, and other economic variables, Project Independence concludes that the impact on the economy must be considered from both a short- and longrun viewpoint (similar to the conceptual view in the Ford study). The impact will differ depending on the time frame under consideration. Employment and growth impacts in the short run are likely to be more severe than in the long run. The Ford report differentiates between conservation impacts and disruption impacts (e.g., the embargo). The terms of reference of this study do not include evaluation of shortrun or disruption consequences, so major focus is on the longrun impacts. In this context, the Project Independence report notes that:

> "Conservation strategies reduce the demand for energy. Unlike the reduction in demand brought about by embargoes, there is no necessary relation between the institution of an ***energy*** conservation policy and real economic growth. To the extent that conservation reduces waste and to the extent that substitutes are available for the conserved resources, conservation strategies will not diminish real economic growth or employment. They would, however, lead to less pressure on the domestic environment and would reduce the rate of depletion of domestic resources."?

Table 12 summarizes the Project Independence forecast of annualized compound growth rates for GNP (1971 dollars), personal consumption and employment for the Base case at $7 and $11/bbl, and for the Accelerated Supply case at $11/bbl. Comparison of the differences in the growth in GNP over the period **1973-77, 1973-80,** and **1973-85** between the Base case and the Accelerated Supply case, with both at $1l/bbl, indicates there are no differences-annualized growth rates are **2.4, 2.8,** and **3.2** percent per annum for GNP for both cases for the three forecast periods respectively. The same situation prevails for personal consumption (also in 1971 dollars) and employment. There is obviously some difference for the $7/bbl case but the differences are significant primarily in the short run for GNP and personal consumption rather than for employment, The effects of the oil price differences tend to diminish in the long run even for GNP and personal consumption.

Though not strictly comparable, the Ford report arrives at similar conclusions, although as noted earlier, the basis for comparison of energy requirements differs from that of Project Independence. The Ford study uses an energy model developed by Data Resources, Inc. (DRI). The model is essentially a macromodel of U.S. economic growth activity into a single framework that is then used to project the general economic environment within which energy simulations are undertaken. Specifically, the macromodel is used to define prices and availability of capital and labor inputs and the total levels of final expenditures,

The energy analysis is based on an interindustry model of the U.S. economy in which production and consumption are treated as follows: production is classified into nine sectors (each represented by a production submodel); the nine production sectors purchase inputs of primary factors—imports, capital services, and labor services; the nine producing sectors also purchase inputs from each other; and the nine sectors then sell their net output to final users—personal consumption, investment, government, and exports.

These elements are all integrated within the interindustry model and transaction flows made consistent with respect to both final and intermediate demands. Of critical importance in the DRI model is the fact that patterns of input into the producing sectors as well as the final demand levels, are functions of, inter aJia, prices, The consequences of this is that the model allows for production to substitute (within the limits of given technical parameters) relatively less costly for relatively more costly inputs, In terms of the energy model, it permits producers and consumers to react to higher energy prices by economizing on energy uses through substitution of different fuels, by substituting between fuel and nonfuel purchases as well as cutting back on "nonessential" energy without accompanying substitutions.

The approach uses information about past production relationships as the basis for predicting future production changes in response to price changes but with the assumption of "reversibility"- i.e., that producers' reactions to the substantial declines in real energy prices in the past will apply, but in reverse, The Ford study suggests

[5]FEA, *Project* ***Independence,*** *op. cit.*, page 319.

TABLE 12

PROJECT INDEPENDENCE Annualized COMPOUND Rates OF GROWTH FOR GROSS NATIONAL PRODUCT, PERSONAL CONSUMPTION; AND EMPLOYMENT

Groaa National Product[a]	$11/bbbl Base Case	%11/bbl Accelerated Supply	$7/bbl Base Case
1950-80	3.2	d.n.a.	d.n.a.
1960-70	4.0	d.n.a	d.n.a
1973-77	2.4	2.4	4,6[=]
1973-80	2.8	2.8	3.8d
1973-85	3.2	3.2	3.7[c]
Personal Consumption[e]			
1950-60	3.2	d.na.	d.n.a.
1960-70	4.2	d.n.a.	d.n.a.
1973-77	2.4	2.4	3.9[=]
1073-80	2.9	2.9	3.6[d]
1973-85	3.2	3.2	3.4[e]
Employment[b]			
1950-80	1.1	d.n.a.	d.n.a
1960-70	1.8	d.n.a.	d.n.a.
1973-77	1.8	1.0	1 .9d
1973-80	1.7	1.7	1.8°
1973-85	1.5	1.5	1 .5’

NOTE: d.n.a. means does not apply.

a,971 dollars
b Millions
c~Based upon 1974-78 Period
Based upon 1974-80 period
eBased upon 1974-85 period

8OURCE: FEA, Project *Independence,* report *op.* cit. page 320, Table VI.2.

that this is a conservative assumption because the behavioral adjustment is based on existing knowledge and in the future, new technology for conserving energy is likely to permit greater conservation than that predicted from historical relationships.

Within this framework, Table 13 summarizes the growth rates for GNP (1971 prices) and employment for the periods 1975, 1985, and 2000 for the three energy cases of Historical Growth (HG), Technical Fix (TF), and Zero Energy Growth (ZEG). Table 14 summarizes the differences in the respective growth paths, As *r-nay be* readily *seen* in Table 13, both the absolute and annual growth rate differences are small. The largest absolute difference between scenarios is in terms of GNP for the comparison between the HG and TF cases with TF’s GNP in the year 2000 about 3,8 percent less than would occur under the HG energy growth assumptions in that same year.

In terms of annual growth rates for GNP, the differences are very small indeed as maybe seen in the section of Table 13 showing annual average growth rates with differences of only fractional rates: for example, only 0.1 percent per annum for the period 1975-85 and similarly for other scenarios.

For employment, the TF and ZEG cases show increases in employment greater than for the Historical Growth trend in the bottom half of Table 13 largely the result of substitution of labor for energy due to high energy prices.

TABLE 13

COMPARISON OF KEY ECONOMIC VARiABLES FOR HISTORIC GROWTH TECHNICAL FIX, AND ZERO ENERGY GROWTH IN FORD FOUNDATION STUDY

Economic Variables and *Energy* case	-Year8- 1976	1985	2000	Annual *Growth* Rates (% per annum) 1975-85	1986“2000	1975-2000
GNP (billion 1971 $)						
Historical Growth	1 ,442.2	2,064.0	3,345.0	3.6	3.3	3.4
Technical Fix	1,442.2	2,030.0	3,218.5	3.5	3.1	3.3
Zero Energy Growth	1,442.2	2,030.8	3,226.7	3.5	3.1	3.3
Employment (billion man hours)						
Historical Growth	173.116	205.103	262.4557	1.71	1.66	1.70
Technical Fix	173.116	206.949	266.546	1.80	1.70	1.74
zero Energy Growth	1?3.11 5	207.667	271.274	1.04	1.80	1.80

SOURCE: Ford Foundation Energy Policy Project, “A Time to Choose,” *op. cit.,* Appendix F, Tables F-2, F-3, and F-6, pages 498, 502, and 506

TABLE 14

PERCENTAGE DIFFERENCE IN GROWTH BETWEEN THE THREE FORD STUDY SCENARIOS FOR BOTH GNP AND EMPLOYMENT

Variable	HG vs. TF 1985	2000	HG vs. ZEG 1985	2000	TF VS. ZEG 1985	2000
Real GNP	-1.64%	-3.78%	-1.61%	-3.54%	0.03%	0.25%
Employment	0.30%	1.62%	1.25%	3.32%	0.35%	1 .77%

SOURCE: Ford Foundation Energy Pollcy Project, A Time to Choose, OP. *cit.,* Appendix F, Tables F-2, F-3, and F-6, pages 438,502, and 508.

If the general characteristics of the Technical Fix case are used to represent this study’s severe energy conservation case, based on the findings of both the Ford and Project Independence studies, the level of secondary economic impacts on the economy are not likely to be substantial in the long run.

However, the mix of output (and employment) is likely to be somewhat different as a result of the changes in energy availability. Table 14 summarizes the shares of output for six sectors as reported in the Ford study for 1985 and 2000 for all three scenarios. The only significant changes between scenarios forecast by the model are in the slight increase in the share of output for the service sector and the substantial decline in the energy sector,

In conclusion the Ford study states that “substantial reductions in U.S. energy input, compared to the Historical Growth energy demand patterns, can be secured without major economic cost in terms of reduced real output or reduced real incomes or increased inflation or reduced unemployment. ”[6] This is based on the assumption that the factors of production will adjust to higher

[6]Ford Foundation Energy Policy Project Study, *A* Time To Choose, op. *cit.*, Appendix F, page 511.

energy prices in the long run-e. g., by 1985 and the year 2000. Over a period of 10 years, the scope for interindustry substitution is, of course, substantial. This does not, however, mean that there would be no repercussions or dislocations.

The Ford and Project ***Independence*** econometric models can only tell us what the result is in the terminal year of 1985 and 2000 (although Project Independence is somewhat more enlightening in this respect). However, the process of adjusting to changes in energy prices can cause disruptions, and the length and severity of these disruptions will depend on the extent to which, and how rapidly labor (capital, etc.) can be shifted to alternative resources. Neither model undertakes this analysis, although the ***Project Independence*** study did undertake analyses of the impact of the oil embargo. The results of that analysis are at least suggestive of the range of potential impacts, at least over the very short run.

The embargo impact studies were undertaken by the Department of Commerce (DOC) and Data Resources Incorporated (DRI), Because of other exogenous forces such as the already weak housing market, there was general agreement that there were important impacts from the embargo in terms of growth, unemployment, income distribution, and industrial output. Three overall conclusions were inferred from the DOC and DRI studies:

> "First, real output of the economy fell in the first quarter of this year about $10 to $20 billion, and the effect has been to put the economy on a growth path that is $10 to $20 billion lower than would have occurred without the embargo. The longrun implications of this estimated displacement of the growth path are uncertain, The estimates are based on quarterly economic models and the forecast errors for such models increase rapidly over time. Specifically, for periods greater than 2 years in the future, the forecast errors are larger than the estimated reduction in GNP. The embargo may have acted as an exogenous shock which caused a temporary downturn in the relevant economic variables. The longrun dynamic properties of the economy may not have been distributed, but given sufficient time, effects of the shock may dissipate. The point, however, is that we know little about the longrun implications of the embargo. "[7]

In terms of specific impacts, as might be expected, the repercussions were most serious on energy-dependent industries such as recreation, gasoline stations, airlines, and automobile and recreation vehicle manufacturing, etc. The Department of Labor estimated that for the period November ***1973*** to March 1974, 150,000 to 225,000 jobs were lost as a direct result of petroleum shortages, and an additional decline of about 310,000 jobs occurred indirectly. Thus, the total shortrun impact of the embargo on unemployment was a loss of about **500,000** jobs for about 0.5 percent of the civilian labor force.[8]

‘Federal Energy Administration, Project Independence Report, op. cit., Appendix page 291.

[8]Federal Energy Administration, Project Independence Report, op. cit., Appendix page 297 ff.

TABLE 15

PERCENT DISTRIBUTION OF FORECAST OUTPUT 8Y SECTOR FOR DIFFERENT SCENARIOS IN THE FORD STUDY

sector	1985 HG	1985 TF	1985 ZEG	2000 HG	2000 TF	2000 ZEG
Agriculture	9.1	9.2	8.7	8 7	8.9	8.8
Manufacturing	22.4	22.6	22.6	19.8		20.2
Transport	3.1	3.1	3.1	. 2.5	2.5	2.5
Services	49.4	50.1	50.2	50.0	51.5	52.2
Energy	4.9	3.8	3.7	5.7	3.0	2.5
Services of Durables	11.1	11.2	1 1 . 2	13.3	13.9	13.8
Total=_	100.0	100.0	100.0	100.00	100.0	100.0
Output— (billion 1971 $)	2,049.2	2,019.1	2,019.9	3,342.1	3,218.5	3,226.7

SOURCE: Ford Foundation Energy Policy Project, A *Time to Choose, op. cit.*, Appendix F, Tables F-2, F-3, and F-6, pages 498,502, and 508.

Chapter V

Effects of Alternative Economic Conditions on Transit

This chapter presents the findings of several approaches used by this study to determine the effects on transit of past economic downturns. All of the approaches indicate that a very large increase in the unemployment rate results in a small decrease in transit ridership. Thus for an increase in unemployment from 5 percent to 8 or 9 percent, as assumed in the two economic features discussed in Chapter IV, a decrease in ridership of about 2-1/2 percent should be assumed, all other factors being equal, In absolute numbers, an increase in unemployment from 4.6 to 7.5 or 8.4 million will be accompanied by a decrease in ridership of less than 400,000 average daily trips.

Chapter V completes the evaluation of the impact of economic conditions on transit. Chapter VI presents the relationship between the transit industry and the economy, by examining the capability of the industry to expand output and employment and thus reduce unemployment and help alleviate recession conditions. Subsequent chapters examine the relationship between energy and transit, including the effects on transit of the energy futures discussed in Chapter IV.

General Approaches Used To Determine the Effect of Recession Conditions on Transit Ridership

Studies on the effect of economic conditions on transit ridership are few and far between. In fact, the work conducted in this study is probably the first significant effort on the subject. The relationship between ridership and economic conditions is not obvious and a generally accepted methodology for determining this effect has not been developed. In order to properly study such an uncharted subject it has been necessary to pursue several approaches. Although the results of each of the approaches cannot be assumed to be conclusive on their own, the fact that each of the approaches produced amazingly similar results tends to confirm the conclusions reached.

The economic effects on ridership were investigated by three general approaches:

1. A study of changes in travel patterns and transit trip generation rates resulting from increases in the number of employed persons.
2. An examination of personal expenditures on transit service to determine income elasticities during recessions:
   a. by using consumer expenditure data, and
   b. by using national income and national transit service purchase data.
3. Multiple regression techniques correlating changes in national economic indicators with changes in national transit ridership since 1953.

The Effect on Transit Ridership of Increasing Unemployment

This section examines the limited data available on the differences in transit trip generation rates between employed and unemployed individuals in order to determine the impact of the increased unemployment levels associated with recessions on transit ridership.

This approach examined post-1950 trip generation data by occupation class at two levels: (1) locally, using CATS (Chicago Area Transportation Study) data and (2) nationally, using several data sources. A description of the procedures and results of these two analyses is presented below, along with a brief examination of the national experience during the Great Depression.

Analysis of CATS Data

One alternative approach for estimating the impact on transit ridership of changes in unemployment is to examine trip generating factors (e.g., trips per household) by occupation classification, and compare the trip rates for the unemployed versus the employed. Unfortunately, most studies estimating trip generation factors do not include the unemployed category so that very limited data is available for analysis. In this context, 1956 home interview data from the Chicago Area Transportation Study (CATS) developed as part of a study of household trip production and occupational status was available and is summarized in Table 16. In this study, in-depth interviews were conducted at about 60,000 dwelling units in the Chicago Metropolitan Area. Adult household members were asked to describe the origin, destination, purpose, and mode of trips made by all household members on the previous day. Households were classified according to the occupation of the person designated by the interviewees as the head of the household. Before moving on to an analysis of this data, it is essential to understand some (not all) of the most critical problems associated with the data—problems that make unambiguous conclusions difficult.

1. The category "Unemployed" really should be considered as "nonemployed" since it includes housewives, students, retirees, and others whose trip-making characteristics might be (and are likely to be) different than those of the unemployed. For example, as will be seen, the housewives, students, and retirees generate a high proportion of shopping, social, and recreation trips not likely to be generated by the "unemployed'' -at least to the same extent. In this context the "unemployed" category must be considered, at best, as only a crude indication because of the distortions these nonemployed groups introduce.
2. The "unemployed" category in Table 16 accounts for only a small part of total households (4.7 percent) and may therefore not be representative of the behavior patterns of a large sample of the same group. On the other hand, the fact that this percentage is not overwhelmingly greater than the unemployment rate tends to indicate that most of the people in the "unemployed" category are members of the labor force presently out of work, and therefore that the data may be reasonably representative of the unemployed.
3. The data are somewhat outdated since there have been significant changes in income, travel patterns, and behavior since **1956.**
4. The modal split between public transportation and automobile transportation in the Chicago area, reflects the presence of a relatively ubiquitous transit system-a condition not shared by many other parts of the country. However, it is a condition shared by the transit oriented of large metropolitan areas such as New York, Boston, San Francisco, Washington, D. C., and Philadelphia, and to a lesser extent some other cities. These large metropolitan areas do collectively include more than half of the transit ridership, but substantially less than half the urbanized area population,

TABLE 16

TRIP PRODUCTION PER DWELLING UNIT BY ALL MODES AND BY PUBLIC TRANSIT TYPICAL WEEKDAY CHICAGO AREA 1956 BY OCCUPATIONAL CLASS

Occupational Class	By All Modes	Estimated Number by Public Transit
Professional	7.07	1.36
Managers	7.29	.96
Clerical	4.90	1.75
Sales	7,40	1.35
Craftsmen	5.70	1.20
Operatives	5.04	1.50
Service	4.80	1.85
Laborers	4.61	1.95
Unemployed*	4,47	1.68
Unknown**	3.56	1.59
All Classes	5.59	1.42

● Actually is the "non-employed" category and includes housewives, students, retired, incapacitated for employment, and the unemployed.

● *A dwelling unit was assigned to this class in cases where the interviewer could not obtain sufficient information to classify the occupation of the head of the household in one of the other classes or in cases of errors or omissions by the interviewer.

SOURCE Stowers, Joseph R., *Occupational Status and Household Trip Production,* Master's Thesis, Northwestern University, Evanston, Ill., June 1962, page 12 and page 65.

In view of the difficulties described above, conclusions derived from the data in Table 16 must be interpreted with considerable caution and can only be considered suggestive of the order of magnitude.

Review of the data in Table 16 indicates that in terms of total trips per day per dwelling unit for all modes on a typical weekday, trip production ranged from a high of 7.4 trips a day for sales workers to a low of 3.6 for the "unknown" category. The average for all occupational groups combined was 5,6 trips per day. Using modal distribution data from the same study as a basis for estimating the number of trips by public transit (Table 17), it maybe seen that

TABLE 17

DISTRIBUTION OF TRIPS BY MODE OF TRAVEL AND BY OCCUPATION CLASS CHICAGO AREA 1956

	Auto-Drivers and Passengers and Truck Passengers Percent	Public Transit Percent	Taxi Per-cent	Total Percent
Sales	79.9	18.3	1.8	100
Managers	86.1	13.3	0.6	100
Professional	79.4	19.3	1.3	100
Craftsmen	78.8	21.1	0.1	100
Operatives	69.7	29.9	0.4	100
Clerical	64.0	35.8	0.2	100
Service	60.5	38.7	0.8	100
Laborers	57.3	42,5	0.2	100
Unemployed	59.7	37.5	2.8	100
Unknown	54.5	44.8	0.7	100
All Classes	73.3	25.5	0.8	100

SOURCE Stowers, Joseph R., Occupational Status and *Household Trip Production,* OP. Cit., Table 2, page 20.

the number of trips by public transit in 1956 in the Chicago metropolitan area was on the average about 25 percent of the total trips, although the proportion varied substantially by occupational class,

To the extent that (I) the "unemployed" may be representative of the degree to which trips, regardless of mode, would be reduced as a result of unemployment, and (2) all occupational classes as a whole can be characterized as being representative of the behavior pattern of the unemployed before they become unemployed, then Table 16 suggests a reduction of about 20 percent (i. e., 4.47 trips per dwelling unit for the unemployed as compared to 5.59 for all classes) in total trip making, However, in terms of transit trip reductions the situation is quite different, In the case of transit, the data in Table 16 show that the "unemployed" category in Chicago in 1956 made about 1.68 transit trips per dwelling unit on a typical weekday-almost 20 percent higher than the average for all occupational categories. The data in Table 16 suggest that the "unemployed" or nonemployed are important transit users and may not tend to reduce their transit trips at all—in fact they might even tend to increase them as they shift from employed to unemployed status.

However, to more accurately appraise the extent of transit trip" reductions or increases by the "unemployed" (nonemployed) group, it is desirable to examine trip purpose data since it is the work trip that is likely to be most affected as individuals become unemployed.

Table 18 shows, for the Chicago area in 1956, the percentage distribution of trips by trip purpose and compares the unemployed category with the distribution of aIl occupational classes combined, As may be seen the work trip accounts for only about 7 percent of all trips for the unemployed in contrast to about 26 percent of all occupations combined.1 Even slightly higher percentages of work trips are shown if the separate occupational classes are examined, ranging from a high of 35 percent for the sales category, 28 percent for the services, clerical, and operatives classes, and about 30 percent for laborers.

The data in Table 18 taken in conjunction with that in Table 17 suggest that, as far as nonwork trips are concerned, recessionary, or even depression, conditions may not result in much, if any, change in transit use (e.g., shopping and other trips may still be made) and that the sharpest cutbacks are likely to come in work trips.

TABLE 18

DISTRIBUTION OF TRIPS BY PURPOSE FOR THE "UNEMPLOYED" AND "ALL" OCCUPATION CLASSES, CHICAGO AREA 1956

(percent)

Trip Purpose	Unemployed	All Occupation Classes
Home	45.1	43.9
Work	7.3	25.8
Shop	13.8	7.0
School	2.3	2.6
Social/Recreation	14.1	8.6
Eat Meal	0.9	1.6
Personal Business	13.8	6.9
Serve Passenger	2.1	2.6
Ride	0.5	1.1
Total	99.9	100.1

SOURCE, Stowers, J. R., *Occupational* Status *and Househokl Trip Production,* Table 3, page *29.*

I Recalling that the classification of dwelling units is by occupation of the head of the household, it is possible for some household members to be employed despite the fact that the dwelling unit is in the "Unemployed" category.

In Stowers' thesis he essentially reached this conclusion, What he did was to relate the trip generation rates to various household characteristics and then to statistically hold the most important related factors, household size and auto ownership, constant. He found that, at constant household size and auto ownership, the unemployed actually made more nonwork trips than the population as a whole. Because of the reduction in work trips, however, they did make fewer total trips than all others, ceteris paribus.

The previous data also suggest, however, that in overall terms there are likely to be important cutbacks in trip making generally because of economic decline reflected in unemployment. Because of the importance of the private automobile in the modal split, however, many of these trip reductions (including work trips) are likely to result in reduced auto usage (i.e., decline in automobile work trips and, with lower incomes, perhaps reduced auto ownership). The data do not, of course, establish that there would be no reduction in transit usage, but there is a clear implication that if there were cutbacks in transit use, they might be quite small for nonwork trips and be concentrated largely in work trips. In addition, the public transit share of tripmaking in the Chicago area is unquestionably higher than the national average, and on a national basis, it might be anticipated that the decline in transit trips, associated with increasing unemployment is likely to be even smaller than indicated by the above analysis.

National Data Analysis

With the above conclusions in mind, an examination of national travel data was undertaken. In view of the importance of the work trip and the fact that nonwork trips are likely to be relatively unaffected, or affected only indirectly through income reduction and other secondary impacts, particularly in terms of transit usage and particularly in the short term, the analysis was focused largely on the work trip,

Using (I) national data on work trips and travel characteristics developed by the 1970 Census, (2) the Department of Transportation's Nationwide Personal Transportation Study and (3) data provided by the American Public Transportation Survey, two alternative approaches were taken for estimating the trip reduction in transit that might occur with rising unemployment.

Table 19 summarizes the key variables used in the two alternative estimating models along with the specific source from which the data were derived, Tables 20 and 21 summarize the method and results of each approach.

Using the factors shown in Table 19, this study estimated the number of work trips that would have been taken by the estimated **2.5** million incrementally unemployed; estimated the transit share of these trips (assuming a modal split of 8-10 percent for transit); and then related these transit work trips by the incrementally unemployed to total transit ridership in 1974.

The first set of calculations is summarized in Table 20. As shown, the range of transit work-trip reductions that would be associated with the incrementally unemployed was estimated to be between 280 and 450 thousand or between 1.2 and 2 percent of total transit ridership in 1974. This percentage is probably slightly overestimated since the method assumes that all of the daily work trips made by the incrementally unemployed (3.5 to 4.5 million) would be eliminated, and does not take into account the fact that many would have to make some new types of trips-e.g,, searching for employment, collecting unemployment checks, and even social and recreational trips not possible when employed,

As an alternative model to check the general order of magnitude of the results shown in Table 20, it was assumed that the 2.5 million incrementally unemployed persons since October 1973 roughly correspond to the number of households with an incrementally unemployed person. This assumption is, of course, not quite accurate since several of the unemployed may come from the same household. Using national household trip data shown in Table 19, an estimate was made of the total number of trips that would be made by the households of the incrementally unemployed, The work trip proportion was then estimated, along with the share of these work trips made by transit. The value thus derived (i.e., daily transit work trips) was related to total transit work trips to arrive at an estimated percentage measure of the reduction in work trips that potentially might be associated with the unemployment generated since October 1973.

These calculations are shown in Table 21. The estimate indicates a decline in transit trips between 1.5 and 1,9 percent, This estimated decline is probably slightly overestimated by the extent to which the 2.5 million incrementally unemployed do not correspond with households.

TABLE 19

FACTORS USED FOR ESTIMATING TRANSIT TRIP REDUCTIONS ASSOCIATED WITH INCREMENTAL UNEMPLOYMENT

Line No.	Variable	Period	Value	Source*
1.	Work Trips Per Employed Person/Day	1 969/70	1.0	N.P.T.S. No. 8 Tables A-1 and A-10
2.	Household Trip Rate, "To Earn a Living' '/Day	1969/70	1.4	N.P.T.S. No. 7
3.	Daily Trip Rate per Employed Person	1 969/70	5.6	Same as Line 1
4.	Daily Household Trip Rate	1 989/70	3.8	Same as line 2
5.	Incrementally Unemployed (million)	1973/74	2.5	Bureau of Labor Statistics
6.	Public Transit Usage for Work Trip (%)			
	SMSA'S of 250,000+	1970	11.8	1970 Census J.T.W. Table 2 page 233
	All Areas & Places (Home-to-Work)	1969/70	0.4	N.P.T.S. No. 8 Table 5, p. 23
7.	Work Trips as Percent of All Trips	1960/64	31.3%	W.B.S. Average of Ten Cities

● SOURCES shown in the table are as follows:

N.P.T.S. = U.S. Department of Transportation Federal Highway Administration," *Nationwide Personal Transportation Study,* Report No. 7 "Household Travel," published December 1972 and August 1973 respectively.

J.T.W. = U.S. Department of Commerce, Bureau of the Census, 1970 Census of Population, *Subject Reports: Journey To Work,* PC(2)-6D, June, 1973.

W.B.S. = Wilbur Smith Associates, Patterns *of Car Ownership, Trip Generation and Trip Sharing in Urbanized* Areas, June 1968, Table 2.1, page 7.

Comparison of the results of the two approaches indicates relatively close correspondence and tends to confirm the conclusion that the impact of rising unemployment on transit ridership is likely to be small. The major reason is, of course, the relatively high level of auto usage for work trips throughout the country-although it must be cautioned that for any specific location or urban area the impact could, of course, be substantial (e.g., in high transit usage areas such as New York City the impact of unemployment on transit could be much more serious).

On a national basis, however, it would appear that, at least at levels of unemployment of about 7.1 percent (e. g., 2.5 million incrementally unemployed), the impact on transit ridership is small, and even if unemployment were to rise to 12 percent (a 70 percent increase, and a level well above any that has been forecast by most economic analysts) the level of ridership losses for transit would not likely be over 4 percent.

The possibility exists that in the long run transit usage might increase if income declined and auto ownership and usage become difficult.

In summary, reductions in transit ridership due to recessionary or depression conditions, as assumed for this analysis, are not likeIy to have substantial impact on a national basis, although the impacts in the most transit-oriented cities will be more severe. Based on the previous analysis for the

TABLE 20

ESTIMATED REDUCTION IN TRANSIT TRIPS BY THE INCREMENTALLY UNEMPLOYED

Work Trip Method

Line No.	Description of Computational Step (1)	Source or Calculation (2)	Results (Range) (3)
1.	Incrementally Unemployed × Work Trips per Day	2.5 million × 1.4 and 1.8	3.5–4.5 million
2.	Transit Share of Work Trips	Line No. 2 above × 8% and 10%	280,000–360,000 350,000–450,000
3.	Total 1974 Transit Revenue Trips	From APTA	21.54 million
4.	Percentage Ratio of Transit Work Trips Not Made by Incrementally Unemployed to Total 1974 Transit Trips (Upper and Lower Limit)	280,000 and 450,000 = Line 3	1.2%-2.0%

TABLE 21

ESTIMATED REDUCTION IN TRANSIT TRIPS BY THE INCREMENTALLY UNEMPLOYED

Household Trip Method

Line No.	Description of Computational Step (1)	Source or Calculation (2)	Results (Range) (3)
1.	Estimated number of households represented by 2.5 million incrementally unemployed	Bureau of Labor Statistics	2.5 million
2.	Number of daily trips by the incrementally unemployed household (IUH)	Line 1 × 5 trip/household (Table 19, Avg. of 3 lines 3 and 4)	12.5 million trips per day
	umber of work trips by IUH	Line 2 × 31% (Table 19, line 7)	3.9 million work trips per day
4.	Percentage ratio of transit work trips not made by IUH to total 1974 transit trips	312,000 and 390,000, (Table 20, line 3)	1.5%–1.9%

2.5 million incrementally unemployed since October 1973, representing an approximate unemployment rate of 7.1 percent, it would appear unlikely that transit ridership will decline by more than 4 percent even at levels of 12 percent unemployment, Furthermore, since some trips by the unemployed that would not otherwise be made (e.g., searching for jobs and other personal business trips) might be during transit's off-peak period, there could be some favorable cost impacts.

Experience of the Thirties

Table 22 summarizes key economic and transit ridership data for the ***1930's.*** As may be readily seen, transit ridership declined from a peak of 13.9 million revenue passengers in 1926 to a low of 9.1 by 1933, after which point there was an upturn, When compared to changes in GNP and unemployment over the period, it appears that the percentage change in transit ridership roughly corresponds, in general direction and approximate magnitude, to the percentage declines in GNP in real terms. However, critically significant in the changes in transit ridership is the fact that (1) some declining trend may have set in before 1929, (2) automobile ownership during the early thirties was considerably lower than the present period, (3) transit ridership was considerably higher (more than double the 5.3 million in 1973) and (4) perhaps most significant of all the unemployment rates in the 1920's were far higher than any forecast for the present period, in the range of well over 20 percent during the period 1929-33, In light of these unemployment rates and the relatively high transit dependence of that period, transit ridership declines of 9-10 percent do not seem unreasonable. With unemployment rates of as much as 12 percent and GNP declines of 2 to 5 percent, and with the substantially reduced transit usage and greater auto dependence of the present period, a forecast impact of a transit ridership reduction of under 4 percent also seems reasonable and realistic. Similarly, an estimate of under 2 percent loss in ridership developed in Tables 20 and 21 appears reasonable with unemployment at the December 1974 level of 7.1 percent.

Income Elasticity of Local Public Transportation Expenditures

Income elasticity of local public transit expenditures, in the straightforward sense, measures the relationship between the percent change in personal expenditures on local public transit and the percent change of income. The nature of this relationship is important to determine whether there is

TABLE 22

TRANSIT RIDERSHIP AND SELECTED ECONOMIC VARIABLES UNITED STATES—[illegible]

Year	Revenue Passengers (Millions)	Annual Change (Year-to-Year) (Percent)	GNP in 1958 $ (Billions)	Annual Change (Year-to-Year) (%)	Unemployment (Rate)	Annual % Change in Rate
9928	13.9	—	—	—	—	—
1027	13.9	—	—	—	—	—
1928	13.6	− 2.2	—	—	—	—
1929	13.6	—	[illegible]	—	3.2	—
1930	12.5	− 8.1	183.5	[illegible]	8.7	+171.9
1931	11.2	−10.4	169.3	− 7.2	[illegible]	+ 82.8
f932	9.6	−14.3	144.2	[illegible]	[illegible]	+ 48.4
1933	9.1	− 5.3	141.5	[illegible]	[illegible]	+ 6.5
1934	9.6	+ 5.4	[illegible]	[illegible]	[illegible]	− 12.9
1935	9.8	+ 2.0	[illegible]	[illegible]	[illegible]	− 7.4
1936	10.5	+ 7.1	[illegible]	[illegible]	16.9	− 15.9
Annual Average Rate of Change 1929-1933 (%)	− 9.5	—	−8.7	[illegible]	15.3*	5.3*

Unwelghted average of unemployment rates for 1929-33 inclusive.

SOURCE: Council of Economic Advisors, *Economic Report of the President, February 1970*, Government Printing Office: 1970, Table C-22, page 302 and Table C-5, page 183; American Public Transit Association.

any significant impact of economic conditions on expenditures for transit, which are highly correlated to transit ridership in the short run,

Two analyses have been conducted for this general approach to determine the effect upon transit ridership of income changes (the income elasticity of transit expenditures). The first analysis examined the expenditures on local public transit for a cross-section of households at different income levels. These raw cross-sectional data were analyzed and income elasticities calculated. These elasticities supplemented the information gathered in the second analysis, which calculated the income elasticity of transit expenditures by comparing the changes in total personal consumption expenditures on transit (assumed to equal transit passenger revenue) with changes in total disposable personal income over time.

The basic assumption of the cross-sectional analysis is that as income levels decline (as in a depression) the household expenditures on local transit would tend to resemble the expenditure patterns of lower income households, Thus a family making $10,000 which has its income reduced to $5,000 during a depression would tend to change its transit expenditures to resemble a $5,000/year family. ‘

The difficulty with this assumption is that life style and behavior patterns are unlikely to be modified to resemble the behavior of the lower income group in the short term. For example, a former $15,00()/year family with three cars will not behave like a $5,00()/year family with no cars, even if the unemployment payments for the former $15,000 family total only $5,000. Over the long run families with lowered income levels may tend to modify their behavior to resemble more the behavior of the families who have been at the lower income level all along. This long-term assumption must be qualified with the standard qualifier—’’All other factors being equal” (which they never are in the long run).

Table 23 indicates the amount of household expenditures on local public transit by income level. The data in this table are derived from the 1960/61 Survey of Consumer Expenditures, the only available data of good quality,

These data confirm the common assumption that as income goes up the percent spent on transit declines. It also shows a weak and erratic trend of increasing absolute amounts of transit expenditure as income rises. However, the most significant information, so far as this study is concerned, is that over a very wide range of income levels the expenditures on transit remain almost the same. The average transit expenditures for families in the five earning categories between $2,000 and $7,500/year varied only between $26.91 and $34.o7. It can be concluded that any shift in household income levels within this range would result in very little, if any, change in transit expenditures. The majority of the population fell within these five income categories in 1961. Note also that the amount of the increases and decreases at the upper and lower income levels is quite modest. These conclusions tend to indicate that a change in income would tend to have very little effect on expenditures on local public transit.

From these data, and the time series data used in our second analysis conducted under this general approach, the income elasticity of transit expenditures has been calculated.

Income elasticity is the percent change in expenditures for a particular good or service for a unit percent change in income. An income elasticity of +1.00 (unit elasticity) indicates 1 percent increase in transit expenditures for every 1 percent increase in income. Goods and services which are in increasing demand as income rises, such as most luxury goods, will have income elasticities of more than +1.00. Expenditures for some goods and services (called inferior goods) actually decline as income rises and result in negative elasticities. It should be noted that based upon this relationship, declines in income should result in increases in expenditures for these inferior goods. Thus, if transit is an “inferior good,” it would experience increased demand during periods of income declines.

The results of income elasticity of local transit expenditures as derived from cross-sectional analysis are shown in Table 24 “Income Elasticity of Transportation Expenditures by Urban Household Size.” As expected, the income elasticity of local public transportation expenditures is less than unity for all household sizes. The income elasticity coefficient is about 0.5 for all household sizes except for households with six or more persons, for whom the elasticity jumps 0.7. A 10 percent increase in household income results in expected increases of between 4.3 and 5.1 percent in local public transit outlays for the various categories of household size from one to five persons.

This would indicate that under conditions of household income growth, transit expenditures do not keep pace with the percentage increase in income. On the other hand, in periods of recession,

TABLE 23

HOUSEHOLD EXPENDITURES ON LOCAL, PUBLIC AND TOTAL TRANSPORTATION BY INCOME LEVEL AND FAMILY SIZE, 1961

Money Income After Taxes	ALL URBAN FAMILY UNITS					URBAN FAMILIES OF 2 PERSONS					URBAN FAMILIES OF 4 PERSONS				
	Total Transportation		Local Public Transportation			Total Transportation		Local Public Transportation			Total Transportation		Local Public Transportation		
	Expenditures	Percent of Income*	Expenditures	Percent of Income*	Percent of Transportation Expenditures	Expenditures	Percent of Income*	Expenditures	Percent of Income	Percent of Transportation Expenditures	Expenditures	Percent of Income*	Expenditures	Percent of Income*	Percent of Transportation Expenditures
$ 1,000-$ 1,999	$ 90.53	6.0	$21.94	1.5	24.2	$ 133.91	8.9	$24.92	1.7	18.6	$ 248.28	16.6	$10.37	0.7	4.2
$ 2,000-$ 2,999	222.29	8.9	32.14	1.3	14.5	212.05	8.5	26.06	1.0	12.3	384.46	15.4	16.88	0.7	4.4
$ 3,000-$ 3,999	459.54	13.1	33.18	0.9	7.2	529.30	15.4	31.80	0.9	6.0	522.69	14.9	35.09	1.0	6.7
$ 4,000-$ 4,999	672.63	14.9	34.07	0.8	5.1	725.75	16.1	34.41	0.8	4.7	642.99	14.3	22.44	0.5	3.5
$ 5,000-$ 5,999	848.78	15.4	26.91	0.5	3.2	768.52	14.0	36.45	0.7	4.7	918.01	16.7	22.12	0.4	2.4
$ 6,000-$ 7,499	947.47	14.0	30.93	0.5	3.3	1,013.71	15.0	32.47	0.5	3.2	1,003.84	14.9	23.80	0.4	2.4
$ 7.500-$ 9,000	1,132.70	12.9	42.45	0.5	3.8	1,215.64	13.9	41.72	0.5	3.4	1,179.17	13.5	31.73	0.4	2.7
$10,000-$15,000	1,558.39	12.5	65.44	0.5	4.2	1,514.56	12.1	55.87	0.4	3.7	1,619.04	13.0	75.04	0.6	4.6
Average ($6,050.51)	781.50	12.9	35.37	0.6	4.5	742.83	12.3	34.84	0.6	4.7	1,019.00	16.8	32.24	0.5	3.2

when household income declines, expenditures on transit do not decline as fast, e.g., a 2 percent decline in household income results in only a 1 percent or less decline in transit expenditures. The data used here were collected during a period of national economic decline (the recession of 1960), thus adding validity to findings based upon assumptions of declining income, These data tend to indicate that recessionary declines in income on the order of 2 percent have only a minor effect on transit expenditures—less than 1 percent,

The second analysis uses National Income Account data to estimate elasticity of local public transit expenditures, using total United States local transit passenger revenues as a proxy. Table **2 5** presents annual series data for Disposable Personal Income, Public Transit Expenditures, and Income Elasticity of Local Public Transit Expenditures, as derived from the annual percent changes in Income and Transit Revenues, for 1952 through 1973.

Two conclusions can be reached from an examination of the income elasticity figures in Table 25, First, to the extent that any general observation can be made from this apparently erratic series, the income elasticity of public transit expenditures appears to be less than unity (the average of all of the 22 values is 0,04). Second, the income elasticity shows no consistency over the years. The inference from the second conclusion is that other factors besides national Disposable Personal Income are more significant in affecting transit ridership,

In conclusion, with the absence of fuel shortages (i.e., pre-l974 conditions) the number of transit riders is significantly not responsive to recession conditions. The transportation expenditures represent on the average 13 to 15 percent of household budgets, while local transit expenditures represent much less than 1 percent. A decline in personal income of 2 percent during a recession will result in a decrease in transit expenditures of about I percent,

TABLE 24

INCOME ELASTICITY OF TRANSPORTATION EXPENDITURES BY URBAN HOUSEHOLD SIZE

1960/61

Transportation Expenditure Items	Number of Persons in Household					
	1	2	3	4	5	6+
All Transportation Expenditures	1.57 (0.14)	1.16 (0.12)	1.09 (0.12)	0.85 (0.11)	0.96 (0.15)	1.12 (0.05)
1. automobile purchases	2.70 (0.16j	 (0.20)	t *28 (0.16)	0,91 (0.15)	1.20 (0.33)	1.27 (0.17)
2. automoblle variable costs	1.68 (0.23}	 (0.15)	 (0.14)	0.69 (0.18)	0.79 (0.19)	0.92 (0.09)
3. gasoline	1.67 (0.23)	1.01 (0.16)	0.90 (0.14]	0.68 (0.17)	0.76 (0.18)	0.95 (0.10)
4. boat public transportation	0.51 (0.12)	.0.49 (0.06)	0.4$ ' (0.10}	&47 (0.22)	0.43 (0.19)	0.71 (0.17)
5 non-local public transportation	0.94 (0.16)	1.02 (0.21)	1.58 (0.21)	1.20 (0.47)	1.59 (0.48)	1. 52 (0.36)
6. car pool	0.16	0.18	0.15	0.16	0.20	0.14

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Survey of Consumer Expenditures 1960/61, Consumer Expenditures and Income, Detail of Expenditures and Income, Urban United States, 1961*, Supplement 3, Part C to BLS Report 237-28 (July 1964)

Standard errors of income elasticity are shown in parentheses under each estimate of elasticity except for car pools.

TABLE 25

DISPOSABLE PERSONAL INCOME, PUBLIC TRANSIT PASSENGER REVENUES, AND INCOME ELASTICITY OF LOCAL PUBLIC TRANSIT EXPENDITURES: 1951-74

Year	Disposable Personal Income			Public Transit Passenger Revenues			Income Elasticity of Local Public Transit Expenditures
	Amount	Absolute Change [$ Billion]	Percent Change	Amount	Absolute Change [$ Million]	Percent Change	
1951	226.6			1*41 1.6			
1952	238.3	11.7	5.16	1,438.1	26.5	1.88	0.3643
1953	252.6	14.3	6.00	1,448.6	10.5	0.73	0.1217
1954	257.4	4.8	1.90	1,410.0	-38.6	-2.66	-1.4000
1255	275.3	17.9	6.36	1,358,9	-51.1	-3.62	-0.5201
1956	293.2	17.9	6.50	1,351,1	- 7.8	-0.57	-0.0877
1357	306.5	15.3	5.22	1,319.6	-31.3	-2.32	-0.4444
1958	318.8	10.3	3.34	1,262.2	-37.6	-2.86	-0.8533
1959	337.3	16.5	5.80	1,308.3	26.1	2.04	0.3517
1960	350.0	12.7	3.63	1,334.9	28.6	2.03	0.5592
1961	364.4	14.4	4.11	1,320.9	-14.0	-1.05	-0.2555
1382	385.3	20.9	5.74	1,330.2	9.3	0.70	0.1222
1263	404.6	19.3	5.01	1,318.3	-13.9	-1.04	-0.2076
1964	436.1	33.5	8.28	1,326.0	0.7	0.74	0.0894
1265	473.2	35.1	8.01	1,340.1	14.1	1.06	0.1323
1286	511.9	36.7	8.18	1,385.4	45.3	3.38	0.4132
1967	5463	34.4	8.72	1,457.4	72.0	5.20	0.7738
1968	591.0	44.7	8.18	1,470.2	12.8	0.38	0.1076
1969	634.4	43.4	7.34	1,564.7	84.5	5.75	0.7834
1970	691.7	57.3	9.03	1,639.1	84.4	8.43	0.6013
1971	746.4	64.7	7.91	1,881.9	22.8	1.39	0.1757
1972	802.5	58.1	7.52	1,660.7	-11.2	-0.87	-0.0891
1973	903.7	101.2	12.61	1,683.7	33.0	2.00	0.1586
1974	979.7	76.0	8.41	N/A			NIA

SOURCES . U.S. Department of Commerce, Bureau of Economic Analysis. *1973 Business Statistics,* 19th Biennial Edition, GPO, Washington. D. C., 1973, page 7 for Disposable Personal Income during 1951-70 period.

2. Ibid. *Survey of Current Business, volume* 54. No. 11 (November 1974), page S-2 for Disposable Personal Income in 1971 through 1973.
3. U.S. Department of Commerce, Bureau of Economic Analysis, Personal Income Division, for Disposable Personal Income in 1974.
4. American Transit Association, *Transit* Fact *Book,* Washington. D.C., various years, Tabfe 7.

which, assuming no change in fares, will result in a decrease in transit ridership of about 1 percent.

Multiple Regression Analysis

Two time series analyses were carried out to assess the relationship between transit ridership and energy and economic conditions. These are discussed in detail in Appendix A. The first used quarterly data from ***1952*** to ***1974*** and the second used monthly data from 1971 to 1974. The intent of these analyses was to determine which energy and economic variables are most closely related to transit ridership and to develop equations using these variables to predict transit ridership under various assumed future conditions.

The analytic procedure used for this purpose was **a** computer-based stepwise regression analysis. The computer tested equations of the form

$$Y = (x_1)^{b_1} (x_2)^{b_2} \ldots\ldots$$

where Y represents the annual growth or decline in transit ridership and the X's represent the ***annual*** growth or decline in other variables. The variables with the strongest (positive or negative) relationship to transit ridership were then selected using statistical criteria. z

The need for two different time series was based on the assumption that energy conditions have exerted a significant influence on transit ridership only in the recent past, particularly during and after the oil embargo, while the effects of economic conditions could be better estimated over a longer time period which included the several post-war recessions. Energy and economic variables were input to both the shortrun (1971-74) and longrun (1952-74) analyses. In the shortrun, highway vehicle miles of travel was found to be the variable most strongly

[2] An F-ratio was calculated at each step for each variable not currently in the equation and the variable with the largest F-ratio was entered.

related to transit ridership;[3] This analysis is discussed in Chapter VII. In the longrun analysis, average fare and the unemployment rate were found to be most significant as indicated below:

Longrun Analysis (1952-74)

Step) No.	Variable Entered	Resulting Equation	R^2
1	Average Fare (AF)	$TRP = (AF)^{-.708}$	.56
2	Unemployment Rate (UR)	$TRP = (AF)^{-,,640}(UR)^{-,,04g}$	.60

TRP = Transit Revenue Passengers

Equations produced by subsequent steps of the regression procedure were suspect for use in interpreting historical trends due to the high degree of colinearity between the variables entered, the lower levels of significance of the coefficients and because the direction and magnitude of some of the coefficients were questionable.

From 1952 to 1974, the variable most strongly related to transit ridership was average fare, The negative coefficient indicates that increases in average fare are associated with decreases in ridership, as would be expected, However, the magnitude of the coefficient is larger than expected, It suggests that the price elasticity of transit ridership is –.64 while other studies have indicated a price elasticity of about –.3 or slightly higher. A likely reason for this discrepancy is that the computer procedure does not distinguish ridership declines due to fare increases from fare increases by transit agencies to compensate for declining revenues. Thus, the decline in ridership actually caused by a 1 percent fare increase should be less than the .64 percent indicated in the above equation.

After average fare, the unemployment rate proved to be the variable most strongly related to transit ridership. However, despite the (statistical) significance of the relationship between unemployment and transit ridership, the actual decrease in ridership which would be predicted from an increase in unemployment is relatively small. Assuming that the fare remains constant, an increase in the unemployment rate from 5.o percent to 7.5 percent would cause a decline in transit ridership of about 2 percent.

[3]Highway vehicle miles of travel were used as a proxy for gasoline consumption to measure the effects of energy shortages on transit ridership. Gasoline consumption data were not used because the only available data are based on wholesale sales which tend to lead consumption by an unknown and variable amount and **because** the series tends to be somewhat erratic at the monthly level. The vehicle miles of travel data do not have these problems.

Impact of Economic Futures on Transit

The equation used to forecast the effect upon transit ridership of alternative economic conditions is:

$$TRP = (UR)^{-0,,4g}$$

where

TRP = the year-to-year growth (or decline) factor for transit revenue passengers and

UR · the year-to-year growth (or decline) factor for the unemployment rate.

This relationship between transit ridership and the unemployment rate was taken directly from the second step of the long run regression (1952-74) analysis, assuming the average fare remains constant (i.e., AF=l), When this relationship is applied to estimate the effect of the increase in unemployment which occurred between October 1973 and December 1974, the result is virtually identical to the result of the analysis of national data using incremental unemployment described earlier in this chapter. Both the multiple regression analysis and the analysis using incremental unemployment indicate that the increase in the unemployment rate from 4.6 percent to 7,1 percent caused about a 2 percent decrease in transit ridership,

With the recession future, the unemployment rate was assumed to increase to 8 percent by April 1976. This increase in unemployment is predicted to cause a slightly greater than 2 percent decline in transit ridership from 1974 to 1976,

With the depression future, the employment rate was assumed to increase to 9.o percent by November 1976. This increase in unemployment is predicted to cause a 2.5 percent decline in transit ridership.

The declines in ridership of about 2.5 percent which are expected under recession and depression conditions will worsen the financial position of the United States transit industry, Revenues can be expected to decline proportionately to ridership loses; operating costs will probably rise compared to current conditions, due to the current inflationary trend, The net effect of the economic conditions on costs of operations, would probably be to cause a very slight decrease in operating costs, assuming some curtailment of peak service, but probably less than in proportion to the revenue losses due to ridership declines. The net effect on overall transit fiscal conditions is likely to be a loss of about 2 percent i.e., slightly under the 2.5 percent ridership loss.

Buses would not be replaced quite as fast, thus impacting negatively on the bus manufacturing industry to a moderate extent. These conditions are similar to past trends in the industry.

Based upon these assumptions it would be somewhat more difficult to justify new fixed rail systems because of the net ridership losses caused. Justification would have to rely more on the employment created. The recession or depression effects on the transit operator, however, would only be temporary, and therefore would have no effect on traffic, revenue, or operating costs by the time any new fixed guideway system would be complete and open to traffic. The jobs created in the construction of such a system would be substantial locally, as discussed in the next chapter. It should also be noted that the short-run ridership forecasts are national ones and are based on a transit service level approximating past service levels. Obviously, a new fixed guideway system would be a significant improvement in the level of service in a metropolitan area and might be justified on the basis of local patronage resulting from the improved service.

SUMMARY

Several analyses of changes in transit ridership as a function of changes in economic conditions (expressed as the unemployment rate) have revealed a relationship between the two. However, this relationship indicates that only a very small change in transit ridership results from rather large changes in the unemployment rate. The significance of these economically induced changes in ridership is far overshadowed by the changes in ridership induced by changing energy conditions.

Three different analyses were conducted to determine the effect on ridership of large increases in the level of unemployment. The three analyses yielded surprisingly similar results. An increase of 2.5 percent in the unemployment rate (i.e., from 5 percent to 7.5 percent unemployed) is accompanied by a decline in transit ridership of 2 percent or less,

In the first analysis, it was assumed that newly unemployed individuals would reduce their work trips to zero, and thus the proportion of those work trips formerly made on transit would be eliminated. The elimination of these transit work trips on transit results in a decline in national transit ridership of between 1.2 and 2.0 percent for a 2.5 percent increase in unemployment.

The second analysis examined the income elasticity of transit expenditures. This analysis indicated that, on a national level, a decline in personal income of about 2 percent during a recession (which is roughly equal to a 2.5 percent increase in unemployment) will result in a decrease in transit expenditures of about 1 percent. Assuming no change in fares, this will result in a decrease in transit ridership of about 1 percent.

The third analysis calculated the relationship between the change in national transit ridership and the change in the national unemployment rate (and other factors) using regression analysis techniques. The annual change in national transit ridership was the factor to be predicted. Among the variables considered which could influence transit ridership were change in average fare, several measures of changes in economic conditions (including gross national product, personal consumption expenditures, number of unemployed, and unemployment rate), and several measures of changes in transportation energy consumption (including vehicle miles traveled, urban vehicle miles traveled, and highway fuel consumed).

The analysis revealed that the factor statistically most significant for changes in transit ridership was the change in average fare with change in the national unemployment rate next in importance,

Using the equation derived from this regression analysis, the predicted change in transit ridership would decrease about 2.5 percent for both the recession and depression futures. This slight change in ridership wouId have little effect on transit operations.

Chapter VI

Analysis of the Capacity of Industry To Respond to Major Changes in the Transit Program

This chapter comprises an assessment of the capacity of the transit industry and its principal suppliers to respond to major changes in the transit program, and estimates the employment impacts of such major changes in the industry. Major changes in the transit program are described in terms of changes in the levels of operating and capital assistance.

Chapter VI completes the discussion of the relationship of transit and the economy. Subsequent chapters examine transit and energy and national policy issues.

INTRODUCTION

In order to determine the effects of major program changes on the transit industry, the analysis was directed toward answering the following questions:

(a) What industries are most affected by the transit industry and by changes in the level of transit operations or capital investments?

(b) What is the current condition of these industries?

(c) How would employment in these industries be affected by major changes in the funding levels for transit operations and capital investments?

(d) To what extent would these industries be hurt by cutbacks in transit operations? Capital investment?

(e) To what extent could these industries respond to decisions to significantly expand current levels of transit operations and capital investments? What are the current limitations on expansion capability?

(f) How much would it take to expand the capacity of these industries to respond to substantially increased demands?

(g) What would be the inflationary impact of major expansions or reductions of the transit industry?

The answer to these questions and a discussion of the analytical approach used are contained in the body of this chapter.

The following section describes the Input/Output Analysis and the results including:

(1) Identification of the industries which supply the transit industry.

(2) Estimation of the employment generated by the transit industry and its major capital goods suppliers (bus and rail car manufacturers and subway contractors) per million dollars of production.

A complete technical description of the Input/Output Analysis and its results are included in Appendix C.

The third section of this chapter examines the capacity of the transit supplying industry groups and their ability to respond to major increases in transit operations.

The fourth section contains the results of discussions with key officials of the major suppliers of transit rolling stock (bus and rail). Among the data contained in this section are:

(1) The current condition of the transit rolling stock manufacturing portion of these firms.

(2) The ability of these firms to expand production in response to major changes in the transit capital program.

(3) The time required to significantly expand production.

The fifth section discusses the ability of the construction industry (specifically rapid rail construction) to respond to major changes in the transit program.

The sixth section explains the relationship between changes in the transit program and inflation. A summary concludes this chapter.

Results of Input/Output Analysis

Approximately every 5 years the Bureau of Economic Analysis (BEA) of the Department of Commerce, examines the interindustry relationships (i.e., sales and purchases between industries) in the United States and publishes the results in Input/Output Structure of the U.S. Economy The latest edition examined the U.S. Economy in 1967, but was not published until the latter half of 1974.

For the Input/Output Analysis the BEA broke the United States economy into 367 industries, ranging from fruits and tree nuts to safes and vaults. The Input/Output structure of the United States records all operating transactions (purchases and sales) between all of these industries, as well as capital outlays of each industry. Tables in the BEA's publications show the dollar value of the purchases (inputs) of each industry from every other industry, as well as the "value added" (employee compensation, profit, indirect business sales of each industry, etc.), These tables also show the 1967 sales (outputs) of each industry to every other industry and other consumers of their products, such as individuals and governments.

The four Input/Output industries identified below most closely represent the transit industry and its major capital goods suppliers. These are:

Local Government Passenger Transport	= Public Transit
Motor Vehicles and Parts	= Bus Manufacturing
Railroad and Street Cars	= Rapid Transit Vehicles
New Construction, Public Utilities[2]	= Subway Construction

These four industries will be the main industries investigated.

Although the industries as defined for the Input/Output Tables do not correspond exactly to the transit industry and its major capital goods suppliers, the distribution of materials purchases of these industries is approximately the same. For example, the Input/Output industries "railroad and street cars" uses approximately the same proportion of steel, iron, plastics, wages, salaries, etc. as the rapid transit car manufacturers, such as Rohr and Pullman. Thus, both industries will purchase from the same industries and generate the same amount of employment per dollar of production.

In order to use the **1967** 1/0 analysis today, it has been assumed that the technological relationships of these four industries have remained the same between 1967 and the present. In other words, the producers of rail cars, transit services, etc., are operating in approximately the same manner today as they did in 1967 and consume approximately the same amount and type of materials and labor.

The 1967 Input/Output tables contain the dollar values for:

(1) the final production in each of the four main industries,

(2) the production from direct suppliers purchased by each of the four industries, and

(3) the indirect production attributable to each main industry.

One dollar of increased production in one of the four main industries will generate additional purchases by its direct suppliers, increase production in the direct supplying industries, and indirectly impact the economy through the expenditure of additional wages and salaries. Thus, one additional dollar is spent several times, multiplying the economic impact beyond its original value.

By transforming these monetary increases into employment, an employment multiplier has been calculated. This employment multiplier is the sum of its three components: (see Table 26)

(1) Employment generated in the main industry in production;

(2) Employment generated in the direct supplier industries (including some employment in the main industry if it purchases supplies from itself) and;

(3) Indirect employment.

The employment in each main industry was determined from the total wages and salaries paid

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[1] U.S. Department of Commerce, Bureau of Economic Analysis input/Output Structure of the U.S. *Economy, 3* volumes, USPO, Washington, D.C. 1974.

[2] The "new construction, public utilities" has been used by the Bureau of Economic Analysis internally to approximate subway construction in evaluating the impact of UMTA grants.

TABLE 26

TOTAL EMPLOYMENT GENERATED BY PUBLIC TRANSIT AND SELECTED TRANSIT CAPITAL GOODS SUPPLYING INDUSTRIES INDUSTRIES

(Based on 1967 U.S. Input/Output Table)

INDUSTRY CATEGORY	EMPLOYMENT GENERATED 8Y PRODUCTION IN THE MAIN INDUSTRY: MAIN INDUSTRY[1]	DIRECT[2]	INDIRECT[3]	TOTAL	TOTAL OUTPUT (Millions of 1967 dollars)
Local Government, Passenger Transit	79,470 (81 .6)	11,798 (12.1)	27,278 (28.0)	118.s40 (121.7)	974.2
Transit Capital Goods Suppliers:					
• Motor Vehicles and Parts	802,547 (19.0)	994,116 (23.5)	3,332,0$1 (78.7)	6,128,714 (121.2)	42,316.5
• Railroad and Street Cars	32,634 (18.3)	41,736 (23.4)	134,435 (75.3)	208,805 (116.9)	1,786.0
• New Construction, Public Utilities	328,617 (30.1)	243,046 (22.3)	695,464 (63.7)	-1,267,127 (116.0)	10,919.0

NOTE: Numbers in parentheses are the employees per $1 million in total output in 1967. Employment per $1 million in 1974 is shown in tables 28 and 29.

[1]The Main Industry is the industry itself, i.e., public transit, bus manufacturers, rail car manufacturers, and rapid transit construction. Employment refers to the employment generated in final production.

[2]Direct refers to the employment which can be attributed to the production of goods and services directly purchased by the main industry for final production.

[3]Indirect refers to the employment which can be attributed indirectly to the main industry from such things as: the expenditure of wages and salaries, and the purchases of direct suppliers, etc.

SOURCE: System Design Concepts, Inc.

by each, and was confirmed (where possible) from other sources such as the American Public Transit Association and the Bureau of Labor Statistics.

Employment in the direct supplying industries attributable to the four main industries was assumed to equal the same proportion of the supplying industry's employment as the proportion of the main industry's purchases to total supplier production. For example, government-owned public transit purchased $6.1 million worth of commercial printing in 1967. These purchases represented 0.086 percent of total commercial printing output. Thus, 0.086 percent or 283 of the 329,055 employees in the commercial printing industry owe their jobs to the government-owned transit industry. Table 27 shows the number of employees in the industries directly supplying transit which can be attributed to the government-owned transit industry.

The indirect employment generated by the four main industries was calculated by first determining the total indirect economic impact of those four industries, determining the amount of that indirect economic impact comprised of wages and salaries, and then dividing that amount by the average national wage.

Table 26 indicates the total employment generated by each of the four Input/Output industries. *In* order to determine the employment attributable to each million dollars of output, the employment figures have been divided by the millions of dollars of output of each industry and shown in parenthesis in Table 26 and in Tables 28 and 29. A second column in Table 28 indicates the number of employees which could be attributed to $1 million of production in 1974. The decline in the number of jobs created by $1 million between 1967 and 1974 is due solely to the decline in the value of the dollar between those years. The number of employees generated per million dollars of production in each of these industries is very similar, ranging from 79 to 83 in 1974.

While total employment (direct plus indirect) generated per million dollars in each of these main industries is nearly the same, the distribution of these jobs among the main industry itself, the direct suppliers and the indirect suppliers varies considerably among the industries as shown in Table

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TABLE 27

TOTAL U.S. EMPLOYMENT DIRECTLY ATTRIBUTABLE TO THE GOVERNMENT-OWNED PUBLIC TRANSIT INDUSTRY BY SELECTED INDUSTRY GROUP, 1967

Industry	Total Employment[1] Attributable to Government-Owned Transit Industry
NON-DURABLE GOODS:	
Commercial Printing	283
Miscellaneous Chemical Production	92
Petroleum Refining	148
Tires and Tubes	319
Miscellaneous Plastics	264
DURABLE GOODS:	
Iron and Steel Foundries	347
Metal Stampings	103
Internal Combustion Engines	342
Electric Lamps	133
NONMANUFACTURING:	
Railroads and Related Services	125
Motor Freight Transportation	418
Wholesale Trade	1,390
Insurance Carriers	1,280
Miscellaneous Business Services	2,139

[1] This does not include employment by private transit industry which uses about 35% of the total transit industry.

SOURCE System Design Concepts, Inc. based upon 1967 Input/Output data, 1967 National Income Account, and 1967 Census of Manufacturers figures.

TABLE 28

TOTAL EMPLOYMENT MULTIPLIER OF PUBLIC TRANSIT AND TRANSIT CAPITAL GOODS SUPPLYING INDUSTRIES (Based on 1967 U.S. Input/Output Table)

Industry	Estimated Employment Generated Per $1 Million of Total Production (1967)[5]	(1974)[5]
Public Transit[1]	121.7	83.2
Transit Capital Goods Suppliers:		
• Bus Manufacturers[2]	121.2	82.9
• Rail Car Manufacturers[3]	116.9	79.9
• Rapid Transit Construction[4]	116.0	79.4

[1] Calculated from I/0 Industry 79.01 “Local Government Passenger Transit.”

2 Calculated from I/0 Industry 59.03 “Motor Vehicles and Parts.”

3 Calculated from I/O Industry 61.04 “Railroad and Street Cars.”

[4] Calculated from I/0 Industry 11.03 “New Construction, Public Utilities.”

5 The decrease in jobs per million dollars between 1967 and 1974 is due to the decrease in value of the dollar over that period.

SOURCE: System Design Concepts, Inc.

29, The public transit industry, which is the most labor-intensive (i.e., requires the highest proportion of labor per dollar of production) of the four industries, generates the greatest number of employees (56) in the main industry itself. Subway construction, which is also labor intensive (but less so than the transit industry), generates a large number of employees in the main industry itself (21) compared with the bus and rail car manufacturers (I3 and 12.5 respectively),

On the other hand, the bus and rail car manufacturers produced the greatest number of indirect employees (54 and 51), Subway construction also produces a respectable number of indirect employees (44), while the transit industry itself produces only 19. These differences are due primarily to the degree of labor intensiveness of each of the industries.

Labor intensive industries such as construction and public transit are likely to create employment opportunities in the localities where the money is spent, while the capital intensive industry, such as bus and rail vehicle manufacturing, is likely to distribute the employment generated throughout the country. Thus, the expansion of transit operations or subway construction in Baltimore is likely to have significant employment effects in that city and little effect elsewhere. However, the purchase of replacement buses by that same city will have little employment impact in the local area (unless the area is oriented toward the bus manufacturing industry), but will distribute its employment effect across the country as a whole.

The Capacity of Transit Related Industries at the Macro Level

This section briefly examines the ability of the industries which supply goods and services for transit operations to respond to major changes in transit service levels. The section does not examine the capital goods suppliers such as bus and rail car manufacturers and subway contractors, which are discussed in the next two sections.

TABLE 29

MAIN INDUSTRY, DIRECT, INDIRECT, AND EMPLOYMENT GENERATED BY TRANSIT AND RELATED INDUSTRIES
(Based on 1967 U.S. Input/Output Table)

INDUSTRY	EMPLOYMENT GENERATED: MAIN INDUSTRY[1]	DIRECT[2]	INDIRECT[3]
	(Estimated employment per $1 million of output in main industry in 1974)		
• Public Transit	55.8	8.3	19.1
• Bus Manufacturers	13.0	16.1	53.8
• Rail Car Manufacturers	12.5	16.0	51.4
• Rapid Transit Construction	20.6	15.2	43.5

[1] The Main Industry is the industry itself, i.e., public transit, bus manufacturers, rail car manufacturers, and rapid transit construction. Employment refers to the employment generated in final production.

[2] Direct refers to the employment which can be attributed to the production of goods and services directly purchased by the main industry for final production.

[3] Indirect refers to the employment which can be attributed indirectly to the main industry from such things as: the expenditure of wages and salaries, and the purchases of direct suppliers, etc.

SOURCE: System Design Concepts, Inc.

TABLE 30

MANUFACTURERS' CAPACITY UTILIZATION RATES: RATIOS OF OPERATING TO PREFERRED RATES MARCH, JUNE, SEPTEMBER, AND DECEMBER 1974
(Seasonally adjusted)

	Ratio of Operating Rate to Preferred Rates: March	June	September	December
ALL MANUFACTURERS	.88	.88	.88	.83
NONDURABLE GOODS:	.90	.90	.89	.86
Chemical	.92	.93	.93	.88
Petroleum	.89	.96	.93	.94
Rubber and Miscellaneous Plastics	.93	.92	.90	.82
DURABLE GOODS:	.86	.88	.88	.79
Primary Metals	.93	.94	.94	.85
Machinery, except Electrical	.84	.93	.94	.92
Transportation Equipment	.76	.78	.82	.70
Motor Vehicles and Parts	.78	.81	.87	.66

SOURCE: *Survey of Current Business,* Volume 55, No. 3 (March 1975), table 7, page 18.

None of the industries which supply transit operations (excluding capital goods such as buses) sell more than one percent of their production to transit according to an analysis of the 1967 Input/Output tables. Since transit consumes such a minor portion of the production of its supplier industries, even a many-fold increase or decrease in transit operations is not likely to strain the supplier's capacity,

This is confirmed by Table 30 which shows that there is excess capacity in all of the major industry groups which contain industries that supply transit. The table shows the ratio of existing production to the production level preferred by industry officials. In these industries which supply transit there is between 6 and 34 percent in unused capacity, which is more than adequate to serve even a greatly expanded transit industry.

Microanalysis of Key Suppliers of Rolling Stock

The manufacturers of transit rolling stock have the basic manufacturing capacity to significantly increase production above the presently predicted 1975-76 market demand.

The two factors most frequently cited by manufacturers which would influence how rapidly they could gear up and sustain increased production are:

(1) The lack of a foreseeable long term market for rail transit equipment, other than the replacement market and a few new or expanded rail transit systems.

(2) The lack of availability of certain component parts which presently, and in the short term, handicap bus transit manufacturers in expanding production.

Transit bus manufacturers more than tripled production during 1974 with deliveries of more than 4,800 units from a low point of less than 1,450 units in 1970.[3] These new transit buses delivered represented either the replacement or net addition to the national transit bus fleet of about 10 percent during the year. The estimated total number of transit buses operated nationally is 48,700.[4]

[3] 1974-75 *Transit Fact Book*, American Public Transit Association.

[4] Ibid.

Basic capacity as reported in detail by the primary transit bus manufacturers would permit a production rate of 7,500 units per year during 1975-76 and a rate of 10,000 units per year by 1976-77—assuming the availability of certain component parts. The estimated market for 1975-76, assuming no major changes in public transit policy including funding, is about 5,500 units of which about 4,250 are expected to be buses with 40 or more seats and the remainder is various smaller sizes.

Rail transit vehicle manufacturers are expected to have a banner year during 1975-76 after hitting a low point in deliveries of less than 100 rail transit car deliveries during 1974.[4] It should be noted, however, that 1974 was an unusually low year in comparison with the previous 5-year average of more than 350 rail transit car deliveries per year. The reason for high deliveries expected in 1975-76 and somewhat beyond is a backlog of orders including 745 R-46 cars for the New York City subway system, 300 new cars for Washington's METRO, 200 cars for the Chicago Transit Authority, 175 light rail cars for Boston's MBTA, and 100 cars for the San Francisco Muni System. This does not include outstanding orders for both commuter and intercity rail passenger cars.

A clearly defined capacity for rail transit equipment is difficult to estimate because all manufacturers also are suppliers or potential suppliers of both commuter and intercity rail equipment, and some also manufacture rail freight equipment. An indication of the spare capacity for greater production, however, is the plan of Rohr Industries to close down its Chula Vista, Calif. transit car line in June or July 1975, with the completion of production for the San Francisco area's BART system.

Thus, transit rolling stock manufacturers, both bus and rail, could significantly increase production over a relatively short period of time if they could realistically predict sharp rises in market demand which would allow them to make the business decision to utilize capacity that is readily available,

The most immediate threat to increased or even level production is the rapid escalation in transit rolling stock costs without a commensurate increase in Federal capital grant funds. Bid prices on transit buses have increased from approximately $45,000 per unit to about $65,000 per unit over the last year to 18 months. A similar escalation has occurred in rail transit cars with present prices estimated at about $500,000 per car as compared with about $300,000 per car in the recent past. Meanwhile, UMTA is projecting a capital grant total of about $1.1 billion for the 1976 Fiscal Year as compared with $1.05 billion for the 1975 Fiscal Year.

Factors Influencing Bus Manufacturing Capacity

The three major manufacturers of transit buses were interviewed at length in order to obtain data on manufacturing capability and primary constraints on increased production. The three are General Motors' Truck and Coach Division, AM General, and Rohr Industries' Flexible Coach Division.

All three manufacturers, in varying degrees, cited four primary factors which heavily influence their projections of market demand and production scheduling. They are:

- Availability of critical component parts.
- Proliferation of specification options.
- The uneven flow of capital grant funds from the Urban Mass Transportation Administration to transit operators and local governments.
- The decision by transit operators and local governments to use funds made available by section 5 of the National Mass Transportation Assistance Act of 1974 for operating expenses instead of capital equipment investment.

Component Parts

Total production capacity for transit buses and the time necessary to achieve capacity production are, in part, controlled by the capability of suppliers of critical components.

The ten most critical components, in no specific order, are: lighting equipment, seats, fan-drive gears, steering shafts, brake fittings, brake air compressors, slack adjusters, transmissions, axles, and engines. Each of the ten components is manufactured by single-source suppliers or suppliers who dominate the particular component field in which they specialize.

Increasing capacity for critical components is determined by the time it would take to obtain tools and fixtures for higher production. Some component manufacturers already have made that investment or are in the process of making the investment, and increased production is showing up in deliveries for final assembly. In addition, some expansion of capacity is possible with present plant and tools through the training of additional work force and expansion to two or three work shifts.

All manufacturers agree that alternate suppliers for at least some components could be secured if there were sufficient flexibility in the specifications deveIoped by the buying transit operators, In addition, the prime bus manufacturers can develop the capability and capacity to manufacture certain components themselves. One manufacturer has made this decision for certain parts,

Effects of Bus Specifications

All three principal transit bus manufacturers have expressed strong concerns that transit bus operators are moving farther and farther away from standardized specifications. This has resulted in longer lead times to produce orders and higher unit costs. Manufacturers cited numerous examples of modifications or options written into specifications which resulted in custom building each order,

There are approximately 20,000 parts in a bus supplied by about 1,200 potential manufacturers, There are nearly 1,600 options that can be exercised on regular production and special equipment parts and configurations. There is an almost unlimited number of options when interior configuration and finishes are added.

The significance of the proliferation of options is that no manufacturer can build buses on speculation and no production runs can be planned and material ordered until after bids are awarded. Planning a production run and obtaining all the materials, including special option parts, takes approximately 6 months, with an additional 3 months to fit medium to large orders into the production schedule and complete an order.

The manufacturers have in some instances declined a bid on transit buses because the delivery time set as a part of the specifications was too short for them to meet. Manufacturers stated that the proliferation of options in bus specifications has resulted in significant increases in price. AM General estimated the cost increase to be at least 15 to 20 percent. General Motors generally concurred in this estimate and stated that there were a few instances in which the cost increase was as much as 30 percent. GM stated added options or variances from specifications in prior years had added about 5 to 10 percent to prices.

The additional costs of option proliferation, not considering the longer lead times, must be considered in light of the dramatic increases in the costs of transit buses. As recently as 1971 and *1972,* low bids on significant orders of buses were between **$40,000** and **$45,000.** Recent low bids were for $64,000 and $67,000 respectively. The dramatic increase in cost, of course, is not attributable solely to option proliferation, but is part of the overall inflation problem of higher labor and material costs. It is significant, however, that the manufacturers estimated that a bus of standardized specifications could reduce unit prices by as much as $10,000 to $15,000.

Even Flow of Capital Grant Funds

With few exceptions, bus transit operators are buying new equipment with capital grant funds made available from the Urban Mass Transportation Administration. In the last 4 years, and continuing into Fiscal Year **1975,** UMTA has not approved the majority of capital grant applications before it until the second half of the fiscal year, with a large concentration of approvals in the last 3 months of the fiscal year.

The experience during Fiscal Year 1974 was that few and small capital grants were made during the first 6 months of the fiscal year, with a gradually increasing rate until capital grants hit a peak during the last month of the year. This, in turn, affected the time in which transit operators could advertise for bids, and subsequently resulted in further stretch-outs of actual deliveries. A relatively even flow of capital grant funds throughout the fiscal year would be of substantial assistance, since manufacturers cannot plan production and order materials until after bids are awarded.

Effects of Capital Versus Operating Funds

All manufacturers expressed the opinion that there would be a gradual and relatively slow increase in the transit bus market unless transit operators chose to utilize all available Federal funds for capital equipment purposes instead of operating expenses.

A survey of the major transit operators in the Nation reveals that most of them have already made the decision to utilize funds made available by section 5 of the National Mass Transportation Assistance Act of **1974** for operating expense purposes.

Thus, the amount of Federal funds for capital equipment use will be approximately the same in the **1976** Fiscal Year as during **1975.**

UMTA officials have expressed the hope that transit operators would use significant amounts of the new section 5 money for capital purposes, but this decision is not likely based upon a survey of the operators.

The combination of a relatively stable amount of available capital funds and the substantial increase in unit prices for transit buses may, in fact, reduce the number of new buses purchased.

The Capacity of The Rapid Transit Construction Industry

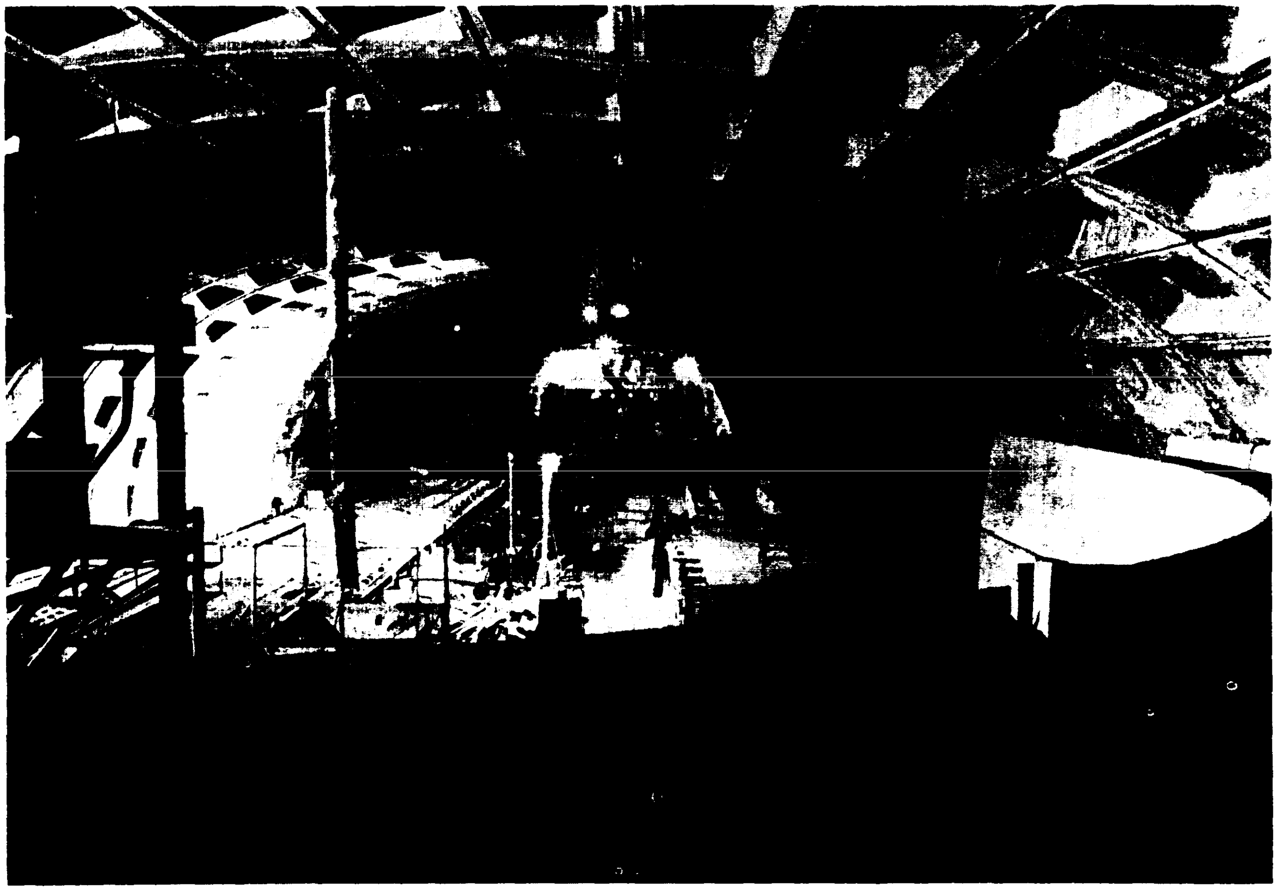
The rapid transit construction industry could easily double its current level of activity and probably achieve even higher levels of activity. This great ability to expand rapid transit construction is due largely to the substitutability of most aspects of rapid transit construction with other activities such as highway and major building construction, and to the current high levels of unemployment in the whole construction industry,

The current unemployment in the contract construction industry is 19.9 percent nationwide.[5] With such a large amount of excess capacity in the construction industry as a whole there would be no difficulty finding the labor and contractors necessary to drastically expand rapid transit construction,

Most of the components of rapid transit construction are easily compatible with other construction activities. For example, the construction of elevated and at-grade rapid rail transit lines is easily compatible with the construction techniques used on highways, Cut-and-cover construction is quite similar to and uses the same equipment and manpower as the excavation work performed for large buildings,

Of all the major aspects of rapid transit construction only tunneling does not have a large counterpart construction activity from which to draw machinery and manpower, Tunneling requires special job skills and equipment and is carried out in a difficult environment requiring higher levels of safety consciousness. It is possible that if the subway construction activity in the United States were significantly expanded to include large amounts of tunneling work that the capacity of the firms performing this type of work would be strained in the short run. This would probably result in higher

[5] *Engineering News* Record, October 2, 1975. p. 55.



Metro Tunnel Construction, Washington, D.C.

costs of construction, due to the limited supply of this service. However, only a small proportion of the mileage of new and proposed rapid transit systems is to be constructed in tunnels. Most of the mileage is either at-grade or in cut-and-cover trenches. With careful planning and coordination at the national level the timing of tunneling activities could be so arranged that the resources could be shifted from one city to another without significantly straining the capacity of this industry.

In conclusion, with proper coordination and direction at a national level to ensure that tunneling activity is staggered, there is no reason why the construction of rapid transit systems could not be drastically increased.

Inflationary Impact of Major Changes in the Transit Program

At the present time all of the major industries supplying transit with capital equipment (buses, rail cars, rapid transit facilities) are operating well below capacity. This indicates that major increases in transit purchases could be easily accommodated within existing capacities. Thus excess demand for scarce resources would not be generated and the pressures on the economy which have traditionally caused inflation would not be experienced,

A similar situation exists in the transit industry itself. An increase in the demand for bus drivers (which makes up the largest portion of expenses of transit operators) is not likely to result in significant pressure for higher wages. This is because the skills required by drivers are easily mastered by a large number of potential employees, Thus transit can draw new drivers from a large labor pool, decreasing the likelihood of anything but a temporary shortage of skilled drivers which would lead to large wage increases accompanying this expansion of the industry. Thus, expansion of the transit industry can be made without inflationary ***pressures*** on the economy,

While it is therefore unlikely that major increases in transit operations would contribute to inflation, it is equally unlikely that a major reduction in the transit program would have a significant impact on the rate of inflation. This is due to two factors. First, transit is very small size when compared to the economy as a whole. The transit industry accounted for only $3 billion out of a total GNP of $1.4 trillion in 1974. The second factor which would make it unlikely that a cut back in transit expenditures would reduce inflation, is the current operating capacity of the industry and its major capital equipment suppliers. All are operating at well below capacity (especially the bus and auto industry, and the rapid transit construction industry) and thus not contributing significantly to the traditional strains on the economy associated with inflationary pressures,

SUMMARY

This analysis indicates that the transit industry could easily increase its level of activity in response to major increases in funding of the transit program.

- Bus production could be doubled to a production level which would equal 20 percent of the existing transit bus fleet within 2 years,
- The rail car industry could meet or exceed this year's exceptionally high production of light and heavy rail cars in the future.
- The rapid transit system construction industry could easily draw upon related construction industries to drastically increase its level of activity if the tunneling (as opposed to cut-and-cover, at-grade, and elevated) work was a small portion of the total or was staggered over time.
- Initial responses from major metropolitan areas (see Chapter X) indicate that the manpower and supplies could easily be obtained to increase transit service as quickly as additional rolling stock could be obtained.

The analysis also shows that the employment generated per dollar of production of buses, rail cars, subways, or increased transit service is about the same. Approximately 80 individuals would be employed or unemployed if production in any of these industries is increased or decreased by $1 million.

Since the transit industry and its capital equipment suppliers are operating at well below capacity, they are not likely to be contributing to traditional inflationary pressures. Even if a major expansion of the transit industry were to take place in the near future the industry and its suppliers are likely to expand production without straining existing resources, thus not contributing to inflationary pressures even under these circumstances.

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.

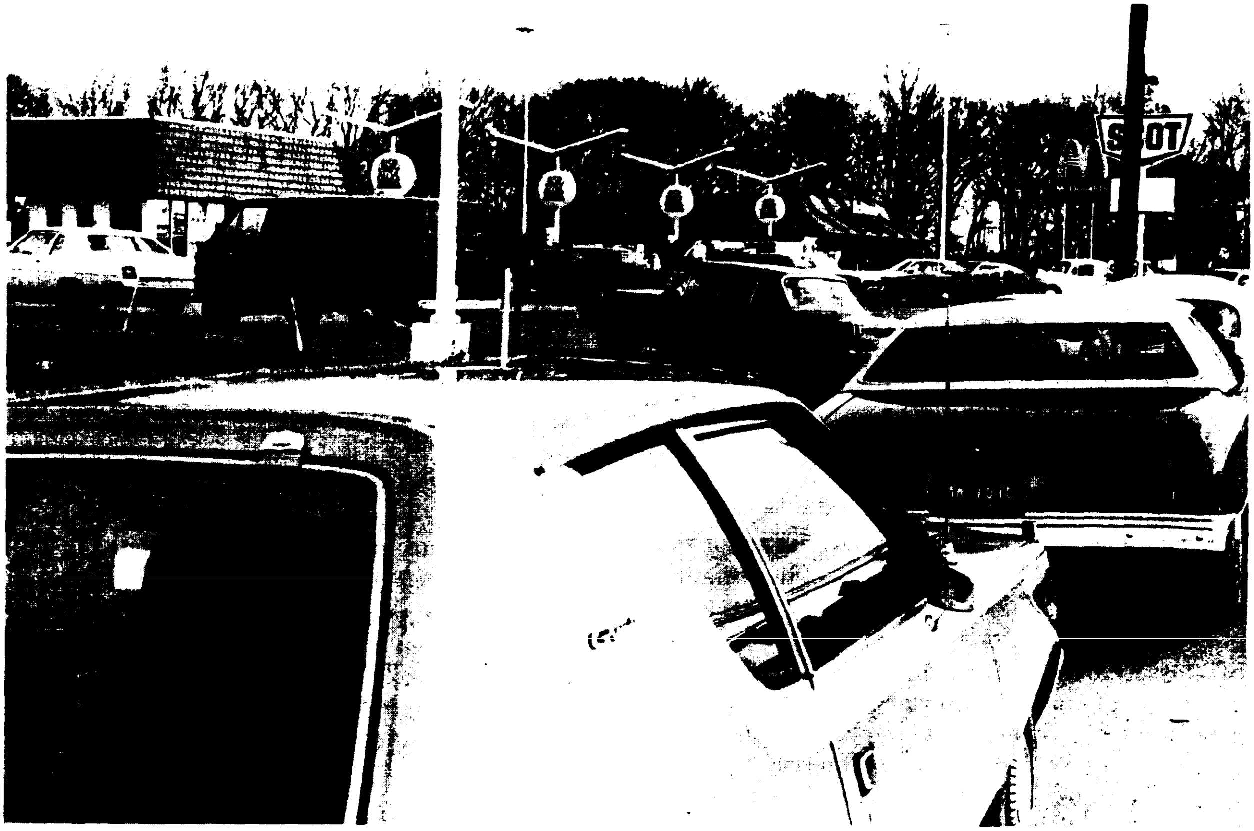
This relationship was then used to forecast the effects on transit of the three energy futures,

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] Hajj and 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	

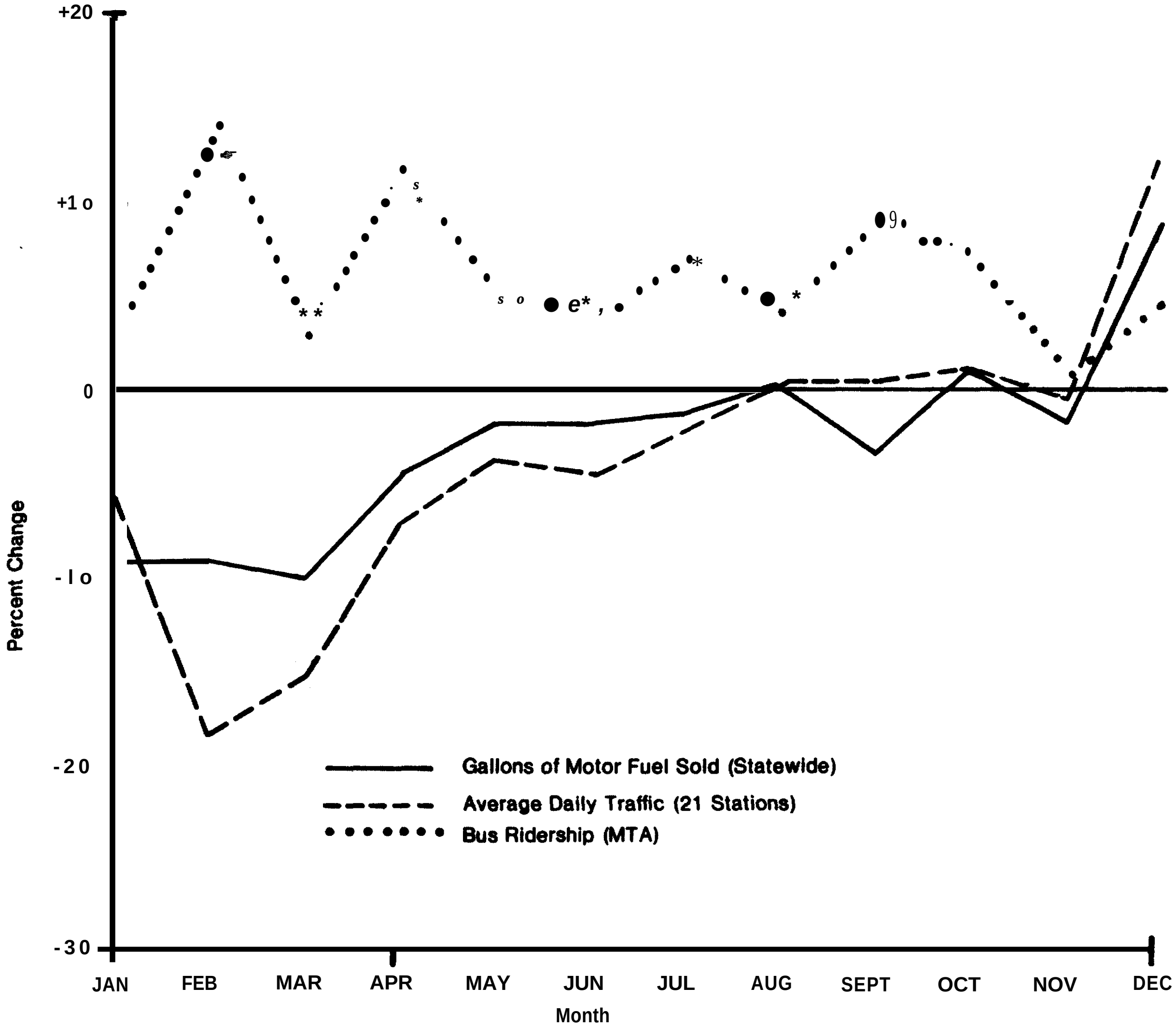
*Same number of working days in months compared.

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

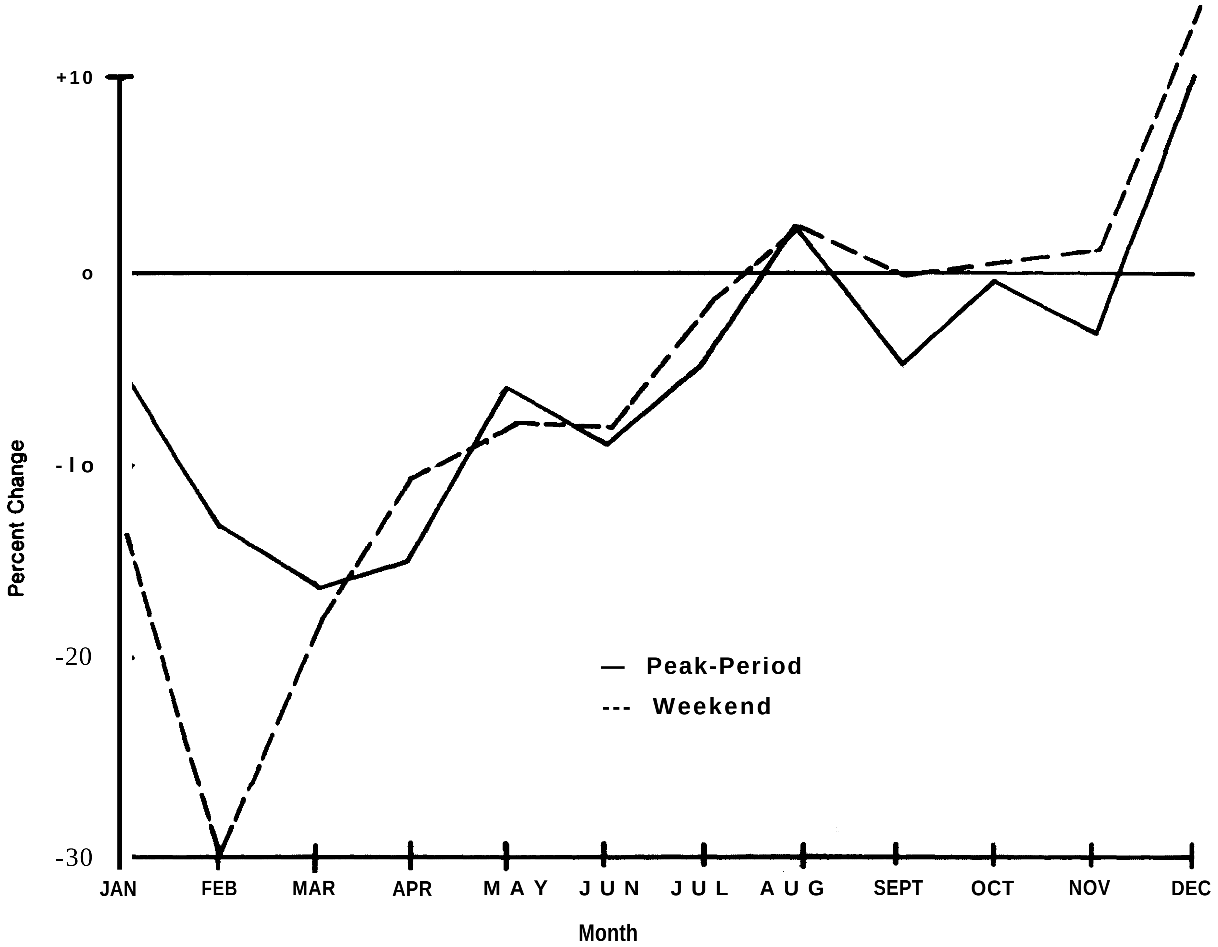


SOURCE: State Comptroller, State Highway Admin., Mass Transit Administration,

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.

TABLE 32

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	200,671	200,601	−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	725,687	−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 II. 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,

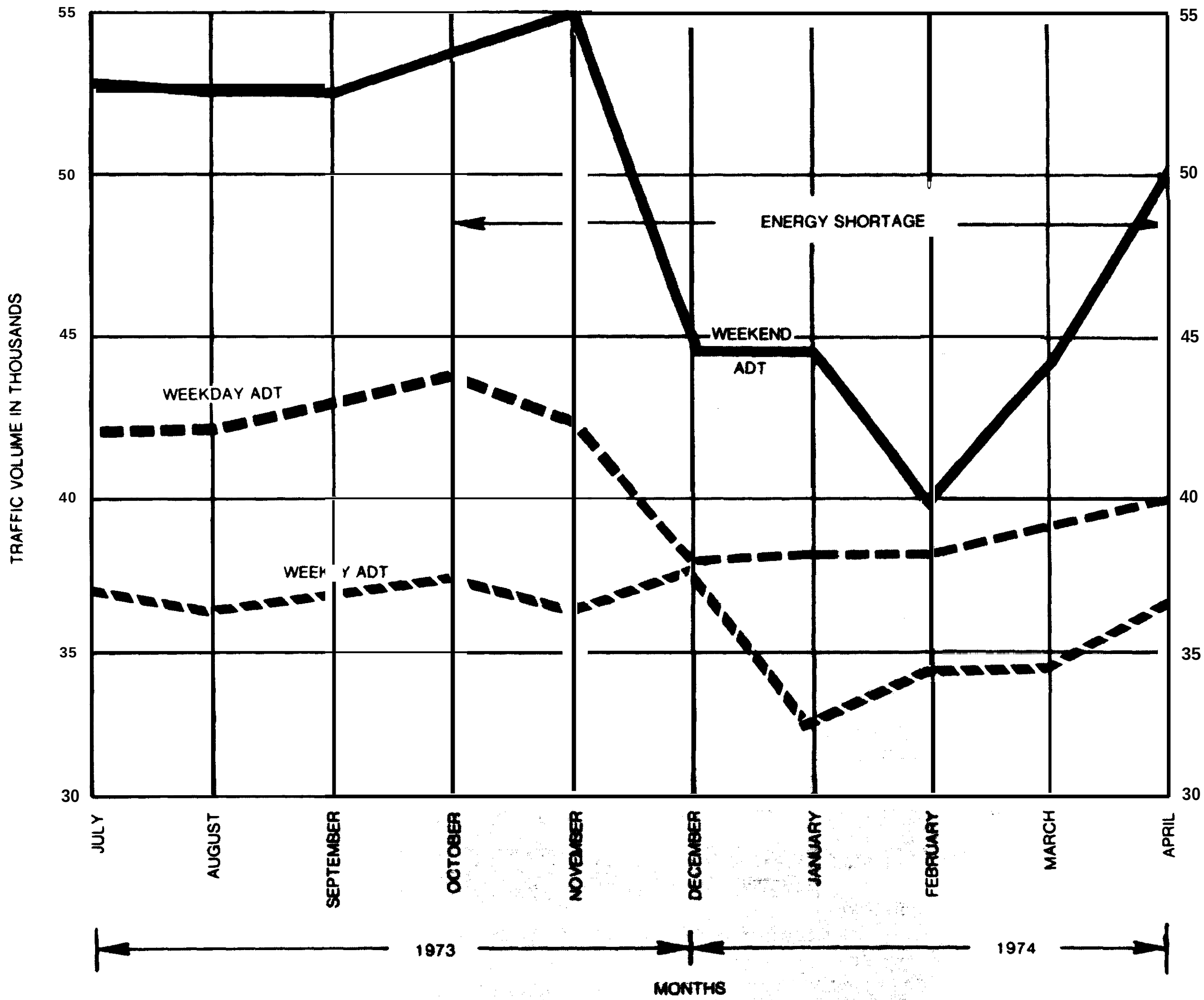
The proportion of work trips increased and shopping and "other" decreased (see Table 33). Only one percent of the trips in this table were made by transit in the 1974 study period. The transit service had not commenced in the 1972-73 study period. The proportionate effect on transit was, however, dramatic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

Trip Purpose	Percent of Total 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)-.8BB (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

Method	Percentages 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	1 2*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

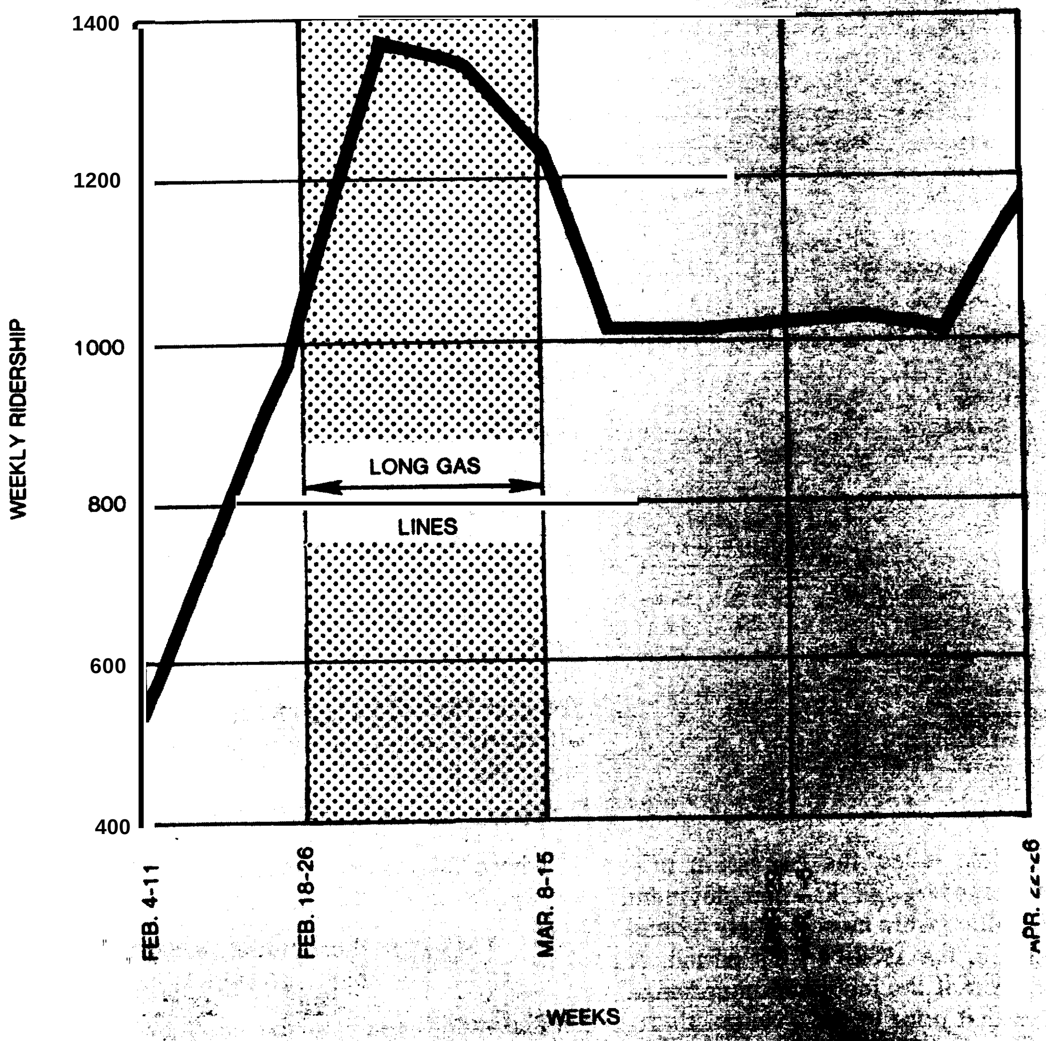


TABLE 35

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 Gasoline Prices 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	15.4
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 vehicle 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 mild 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 less 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 27

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%)	6798 (+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%)	6838 (+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,

Chapter VIII

Consideration of Possible Types of Actions To Achieve Increases in Transit Ridership and Decreases in Energy Consumption

Chapters VII and VIII present the relationship between transit and energy conditions. Chapter VII approached the relationship by analyzing the effect on transit of energy conditions. This chapter examines how energy can be saved through increased transit ridership resulting from various transit and auto restraint actions. Several transit incentives and auto restraint actions have been analyzed to determine their effect on ridership and energy consumption.

The following chapter incorporates the findings of the previous four chapters and compares the national impacts of the economic and energy futures as well as the transit incentive and autorestraint actions.

The next chapter examines the experience of metropolitan area during recessions and energy shortages, and the ability of the transit systems to respond to the changes in ridership induced by these conditions.

The final chapter presents policy issues and possible initiatives to deal with the points raised in the first 10 chapters.

INTRODUCTION

Up to this point the question of how best to achieve oil conservation in relation to transit has been largely ignored. In Chapter III it was shown that a pure transit-oriented strategy would be one of the least effective ways of conserving oil. Auto-oriented strategies are most effective. Yet it was noted that if substantial decreases in auto use result, then transit must be improved to provide at least a partial substitute for this travel demand.

It was also noted that although transit incentives alone may have only limited effectiveness on energy conservation, in combination with auto disincentives, they could have significant impacts.

In light of these conclusions subsequent analysis has shown that substantial cutbacks in oil consumption can have major effects on transit ridership. The levels of oil-consumption cutbacks that have been analyzed could be achieved through a variety of mechanisms or combinations of mechanisms that have been debated in public policy discussions over the last year: restrictions in oil imports, taxes on imports, rationing, taxes on wholesale or retail sales, and perhaps other means. The cutback levels might also result from future embargos. As noted previously it has not been the purpose of this study to analyze or evaluate any of these mechanisms. However, it does seem appropriate to evaluate the effectiveness of mechanisms that have a direct relationship to transit. These include actions that can be taken to attract riders to transit as well as actions that discourage auto use in areas where transit service can provide an alternative. Specifically excluded from this "evaluation are actions aimed at discouraging auto ownership, auto use in rural areas, truck use, and measures to increase fuel economy.

This chapter will categorize and summarize a variety of actions that can be taken and the present state of knowledge or experience in the application of these actions. These actions will be dealt with under the following headings:

- Transit Fare Reduction
- Tax Incentives
- Transit and Traffic Management
- Transit Service Improvements
- Transit Capital Improvements
- Auto Restraint
- Land Use Controls
- Marketing
- Staggering Work Hours
- New Technology

More detailed documentation is provided in Appendix D, Also in this chapter are rough estimates of the effect on transit ridership and automobile energy consumption of major transit incentive and auto restraint actions which can be implemented on a national scale. These estimates were made by first estimating changes in the time and cost of auto and transit travel for an action and then applying a forecasting technique based on empirical studies of the responses of travelers to such changes.

This technique and its applications are documented in Appendix A.

In the next chapter some alternative combinations of these actions will be evaluated, in approximate terms, as to their impacts on transit ridership, the transit industry, related industries and energy consumption~all in comparison with the effects of the alternative assumptions regarding future economic and energy conditions defined in Chapter IV and assessed in Chapter VII.

TRANSIT FARE REDUCTION

Reduced Fare

Fare reductions in numerous American and European cities have nearly always resulted in ridership increases, but to a lesser degree than would be anticipated with a free fare policy. The most conclusive data thus far presented is the Atlanta experience where reduction in fares from 40 cents to 15 cents increased ridership by roughly 28 percent. Experiences in other cities such as San Diego and Los Angeles where fares were reduced to a flat 25cents rate produced ridership increases of approximately 22 percent.

A pooling of experience from fare changes in a large number of cities has indicated that a fare change of 1 percent causes a ridership change of .33 percent. However, most of the experience used in developing this relationship consisted of small fare changes and would tend to underestimate the effect of large fare reductions. For example, applying the .33 percent figure would have underestimated the ridership increase due to the fare reduction in Atlanta.

It should be noted that holding fares at a constant current dollar level actually represents a fare decrease in real terms as the price of other goods and services increase relative to transit.

Assuming an 8-10 percent rate of inflation, holding fares at a constant level in current dollars could cause a ridership increase of 15-20 percent by 1980.

A desirable feature of generating ridership increases through fare reductions is that proportionally larger increases occur in the off-peak period when there is substantial excess capacity. For example, a major fare reduction in Atlanta from 40cents to 15cents, along with service improvements, caused a 19 percent increase in system ridership from 6:00 a.m. to 9:00 a.m. on weekdays as compared with a 37 percent increase from 9:00 a.m. to 3:00 p.m. on weekdays and a 79 percent increase on Sundays. Thus, it is estimated that the size of the transit fleet could be increased by less than 10 percent to 1980 and still accommodate the 15-20 percent ridership increase without noticeable deterioration in the quality of transit service, However, despite the favorable impact on the "peak-to-base" ridership ratio, it should be noted that holding the transit fare constant in current dollars implies a significant increase in transit subsidies. In rough terms, holding the transit fare at a constant level while operating expenses increase at more than 10 percent/year (a very conservative assumption based on past experience) will require all of the UMTA Formula Grant Funds with 50 percent local matching, without allowing any funds for service improvements.

In considering the energy implications of holding transit fares at a constant dollar level, it should be noted that without complementary auto restraints less than 50 percent of the riders attracted to transit by fare reductions would have otherwise been automobile drivers.

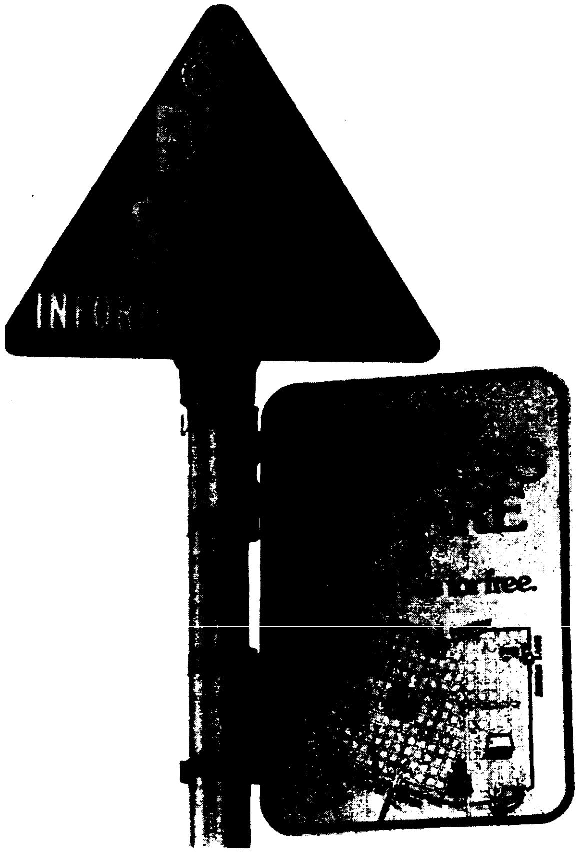
Auto driver diversion estimates range from 28 percent of new riders for a no-fare zone in Dayton, Ohio to 42 percent of the new riders in Atlanta,Ga.

No Fare Transit

As noted in the previous section, past experience has indicated that a 1 percent change in transit fare causes a .33 percent change in transit ridership. However, this relationship should be viewed as accurate only for small fare changes—it will underestimate the effect of large fare changes. The rough analysis presented in Appendix A suggests that 40-60 percent increases in transit ridership may be anticipated by eliminating the out-of-pocket cost of transit travel—rather than the 33 percent increase implied by past experience with small fare changes.

In addition to the effect of eliminating the out-of-pocket expense of a transit trip, system service to users would be further improved by eliminating the time and inconvenience associated with fare collection.

Man running coinage collection through counting equipment



Fareless Square sign

As with constant fare in current dollars, the effect of fare transit will be proportionally greater in the off-peak period. However, despite the larger growth in off-peak period, a significant expansion in the size of the transit fleet—roughly 30-50 percent—will be required to handle the increase in ridership associated with transit.

No fare transit would reduce per passenger operating costs and promote more efficient use of manpower and equipment, because: (I) a greater percentage of riders would be in the off-peak, and (2) riders would board buses faster.

As discussed in Appendix A. The increase in the fleet size will promote an additional ridership increase by improving the frequency of transit service. The net effect of no-fare transit and the related service improvements is estimated to be a 60-80 percent increase in transit ridership.

The number of auto driver trips eliminated per transit rider attracted with no-fare transit will be even lower than with smaller fare reductions. This is because no-fare transit would attract more short trips which would otherwise be walking trips,

Prepaid Pass and Discounts

Currently, no conclusive evidence exists as to the effect of prepaid fare. In the past, the implementation of prepaid fare programs has always been accompanied by fare reductions and service improvements and it is difficult to separate out the specific effect of prepayment. However, it is unlikely that the specific impact of prepayment would yield more than a 3 percent increase in ridership.

Tax Incentives

Several transit experts have suggested that transit fare deductions from Federal, State, and local income taxes, combined with the elimination of the standard deduction for gasoline taxes, could provide a positive inducement for increasing transit ridership. This deduction could be primarily aimed at middle-income taxpayers who currently use their automobile for work trips that could otherwise be made by transit. A direct transit fare rebate could be granted to the transit dependent and all income groups who do not itemize deductions or file income taxes. The upper limit for such a rebate might be based on existing fare levels in each locality. For example, assuming 260 work days per year at a 35-cent fare level, the maximum transit rebate might be $182.00. The effect of such a policy on transit ridership is difficult to determine without any empirical experience, but it seems reasonable to assume that it would have less effect than actual free-fare transit for those to whom it applied because the association between the actual transit trip and the tax rebate would be much less clear than a no-fare policy. It also has difficulties of enforceability. If the tax rebate policy were applied to about one half the working population, and if the policy had about one-half the effectiveness of a free-fare policy then it would have about one quarter as much effect on transit trips made for work purposes. Since work trips are about half of all transit trips, the overall effect would be about one-eighth as effective as free transit, i.e., it would result in a national transit ridership increase of about 4 to 9 percent.

TRANSIT AND TRAFFIC MANAGEMENT

Priority Transit Lanes

Granting transit vehicles priority over other vehicles on existing facilities covers a range of actions such as: (I) reserving an arterial street traffic lane for buses, (2) reserving one or more freeway lanes either in the normal direction of traffic flow or contra-flow, a reserved lane that would normally serve light traffic in the opposite direction, and (3) preferential treatment for transit vehicles at freeway access points. Over 200 bus priority treatments have been implemented or proposed in the United States and elsewhere during the past decade. The results of these experiments have generally shown that priority transit lanes have a high potential for increasing transit ridership and diverting auto users to transit at relatively low cost, but in order to realize this potential, careful planning, implementation, and operation must be conducted over a sustained period. Specifically, past experiments have demonstrated that priority treatments can:

- Create time savings to transit passengers equal to or in excess of those achieved by rail transit improvements, but sometimes at the expense of auto drivers.
- Substantially improve bus service reliability. For example, the Shirley Busway has reduced the fraction of buses arriving more than 6 minutes late in Washington from 67 percent to about 10 percent.
- Assist in the efficient utilization of existing facilities by providing substantial additional capacity. A single freeway lane can carry between 2,000 and 3,000 persons per hour in automobiles. This lane can carry at least 40,000 persons per hour in buses assuming no stops in the lane. Similarly, a lane on an arterial street can accommodate at most about 1,500 persons per hour by car, but can carry 3,50O more persons per hour by bus. However, in practical terms there are likely to be very few corridors in U.S. cities not already served by rail that would provide over 20,000 riders for more than 500 buses per hour.

In very rough terms the following assumptions and approximations provide an indication of an upper limit to what can practically be achieved nationally with a commuter-oriented bus priority traffic management program.

There are about 30 metropolitan areas in the country with "metropolitan populations of a million or more. With few exceptions it is only in these areas where traffic volumes and employment density are sufficient to warrant the reservation of lanes for buses, In these areas it is generally only feasible to do so on routes which have ***6*** lanes at present or 4-lane arterials which could be widened without great difficulty to provide a bus lane. Inspection of maps and traffic data for representative metropolitan areas indicates that roughly five routes of an average of 5 miles in length might be good candidates for reservation of **a** lane for buses-good candidates in that:

- they have the requisite widths
- have current traffic congestion levels high enough so that bus speeds could be substantially increased,
- are not already well served by rapid transit routes,
- have transit market areas sufficient to potentially generate bus volumes on the order of 100 buses per hour, and

Contra-Flow Bus Lane in Seattle, Washington

- overall bus passenger time savings could be significantly greater than overall auto-user time losses due to reservation of the lane for buses.

To the extent that these assumptions and judgments are reasonable, the conclusion can be reached that a maximum bus priority program could involve about 750 miles of busways nationally, serving perhaps 18,000 daily passengers on each of about 150 routes, or about 2.7 mtllion passengers total per day. An average travel time savings of about IS percent would be a moderate expectation—reducing a typical trip of 25-minutes duration by about 4 minutes; this could be expected to increase national transit ridership by about 2 percent using rough estimates of the impact of time savings on transit ridership as described in Appendix A.

Signalization and Control Systems

Studies have shown that buses spend more time waiting at traffic signals than in picking up and discharging passengers. Similarly, buses operating in mixed traffic on arterials, freeways, and freeway access ramps often suffer substantial delays because of congestion and limited lane capacity. Bus actuated signals, and metering or monitoring traffic control devices are being used to improve the flow of high-occupancy vehicles in these situations, as well as to separate cars from buses in priority lane treatments. Although these devices offer only marginal benefits in terms of affecting transit ridership, they are important to the operational success, especially in terms of time savings, of most transit line haul improvements. They could also contribute substantially to maximizing the utilization of existing facilities. Such measures would be assumed to be used extensively in a program of the magnitude discussed above.

TRANSIT SERVICE IMPROVEMENTS

Fleet Expansion and Conventional Services

Unless transit systems have adequate vehicular capacity and can offer travel times, costs, and services that are attractive relative to the automobile, ridership increases and diversion of auto drivers is unlikely. Many existing systems are constrained from meeting current demand simply by the lack of sufficient rolling stock. For these systems, crowding conditions in the peak periods is a major deterrent to transit use. Good reliable equipment is also an essential component of successful transit development programs aimed at attracting new demand by increasing frequencies and extending routes to new areas. For example, the Seattle "Magic Carpet" program combined metropolitanwide fare reductions and a no-fare CBD zone with fleet expansion and exclusive bus lanes.

Recent EPA reports estimate that in order to achieve a 10 to 20 percent reduction in auto use, existing bus fleets would have to be expanded from 50 to 500 percent, depending on the city and other variables.

Increases in the number of transit vehicles operated can enable ridership increases by allowing more frequent service on existing lines and enabling the development of new lines. While opportunities do exist for increasing the average number of passengers/vehicle, at least in offpeak periods (as noted in the discussion of reduced fare), growth in transit ridership with a fixed supply of rolling stock is ultimately limited by the service deterioration associated with increased crowding in vehicles.

The rate at which the transit vehicle fleet can be increased can be an important determinant of the extent to which various levels of service improvements can be achieved.

The micro-analysis of key suppliers of rolling stock in chapter VI indicated that production could be increased to a rate of 10,000 new units per year during 1976 if the market warranted and if suppliers of key components can improve production as readily as the prime manufacturers. The production rate could continue to be increased in subsequent years. It is not unreasonable to estimate that new buses could be produced at an average rate of 12,000/year from 1975 to 1980 (say 5,000, 8,000, 12,000, 15,000, 16,000, and 16,000 per year for each of the 6 years). Buses currently in service might be retired at a rate of 4,t)()()/year-a reasonable assumption which would result in replacement of about one-twelfth of the current fleet per year. Thus the number of buses that could reasonably be expected to be in operation by ***1980*** would be about l00,000-double" the current fleet.

If the number of vehicles operating at any given time is doubled, the time riders spend waiting would be approximately cut in half. Based on empirical studies of travel behavior described in Appendix A, this could produce ridership increases of **10-25** percent in the peak period and 30-50 percent in the offpeak periods. The larger percentage in the offpeak period is due to the fact that offpeak wait times are considerably longer than peak wait times and thus the impact of halving wait times would be greater in the offpeak period.

The reduction in auto driver trips associated with a 1 percent increase in transit ridership generated through reduced wait times may exceed slightly the reduction in auto driver trips associated with a 1 percent increase in transit ridership generated through a fare reduction, This is because auto drivers are typically paying higher dollar costs per trip than transit users for the speed and convenience of the automobile and thus would be expected to be proportionally more responsive to travel time reductions than to transit fare reductions. Another way of looking at this is that the wait time reductions will tend to be more effective in attracting higher income travelers out of autos. The same number of persons attracted to transit by fare reductions will tend to be made up more from lower income groups on the whole and a slightly lower proportion of these would otherwise be auto drivers—more would have been walkers, auto passengers or would not have made the trip at higher transit fares.

Transit ridership can also be increased by the development of new lines. However, opportunities for realizing significant increases in ridership by expanding conventional service to new lines are limited by the current high density of coverage in most urban areas, Thus, rather than providing service to individuals currently not served by transit, the primary effect of developing new lines is to provide reductions in system access time. A preliminary analysis indicates that these reductions would not provide increases in transit ridership significantly in excess of those which might be generated by increasing the frequency of service on existing lines.

Express and Feeder Bus Systems

Many cities are operating or plan to inaugurate express bus services such as the "Blue Streak" project in Seattle and the "Capital Flyer" in Washington, D.C. These services involve high speed buses between the CBD and outlying areas utilizing urban freeways for the line-haul portion of the trip and local streets for collection and distribution. The residential end of such services usually include park and ride facilities, and in rare cases, feeder bus lines. Most cities have reported significant ridership increases on express bus routes, and as in Portland, Oreg., many new lines are contemplated when additional equipment is available. Express service is a relatively low cost transit improvement which is very popular and can be implemented in the short term if only existing facilities are utilized. Current experience with this type of improvement is summarized below:

- Express bus services supplemented by free or low-cost ~ parking has attracted significant ridership in cities already committed to public transit usage. Ridership increases of from 10 to 30 percent have been reported on individual routes on which express service has been initiated, depending on the quality of the service, fares, and parking fees.
- Express services have also been successful in diverting auto travelers to transit, but the variables associated with reported diversion figures are numerous. Existing demonstrations support the conclusion that over 50 percent of new transit riders may be diverted from automobile on certain routes.
- It is apparent that any large-scale usage of express bus service will require either a good system of free or inexpensive fringe parking or feeder bus services to the express bus route. Feeder services could provide a desirable alternative to park -and-ride/kiss-and-ride facilities which require substantial space and often attract an undesirable amount of traffic. To the extent that feeder bus services can also be made to serve local public transportation needs, especially during the offpeak hours, the financial viability of line-haul access systems could be considerably enhanced.

Special Services

Special transit services include a number of traditional services and more recent innovations which are designed to fill the gap between conventional transit and the private automobile. Demand-actuated systems, referred to as dial-a-bus, are now fairly common, having been initiated in roughly 75 communities across the country. Other "para-transit" modes such as taxis, jitneys, "van-pools," and limousines are also included in this category. These services are primarily aimed at the offpeak, transit-dependent market and the mobility needs of particular user groups. It is now understood that the potential transit market for such services, including existing and latent demand, is quite large. Therefore, increases in transit patronage would be substantial if a nationwide special service program were initiated. In one metropolitan area it was estimated that a 15-percent increase in transit ridership would result from a carefully designed metropolitanwide program of this type.

TRANSIT CAPITAL IMPROVEMENTS

Rail and Fixed Guideways Systems

Three kinds of capital intensive transit improvements of existing technology fall within this category:

- conventional rail rapid transit lines,
- light rail transit, and
- people mover and personal rapid transit systems.

In the short-to-medium term only light rail transit, utilizing inexpensive or existing rights-of-way can be viewed as having a high potential impact on transit ridership because the implementation period of new, fully grade-separated rapid systems is 10 to 20 years. As indicated in a recent transit study of the Portland, Oreg. metropolitan area, in a medium capacity, light rail operation (6,000 to 9,000 one-way riders per hour) could compete successfully in terms of cost and time savings, with a busway system of comparable cost and extent. Light rail technology in both the United States and Europe is at a comparatively advanced stage and could be implemented with good probabilities for high ridership levels in selected situations within 3 to 5 years.

Exclusive Busways

This type of transit improvement requires the construction of a permanent, exclusive right-of-way for buses, which can be part of an existing

E us e Bus and Ca poo anes on Sa F a s o Oak and B dge

highway facility, or an entirely new, separate facility. Busways may involve long segments such as the 8,8-mile Shirley Highway Project, or short on-and-off exclusive bus ramps combined with a mainline bus priority treatment. Like their rapid rail transit counterparts, line-haul busways cannot be viewed as having significant potential short term impacts on ridership despite high capacity and excellent service characteristics. There are not more than a handful of corridors nationally which could generate the high volumes required to justify the high construction costs of new exclusive grade-separated busways. However, exclusive bus ramps on freeways offer good potential short term advantages in terms of both cost effectiveness and ridership impacts in combination with other transit service improvements,

Shelters, Stations, and Park-and-Ride Facilities

Because of their direct effect on the transit patron’s perception of service quality and essential role in the efficient operation of all existing and proposed transit systems, these low-cost capital improvements have a high payoff in terms of attracting new riders per dollar of investment. Investments in facilities that will improve the interface between different transit modes such as occurs at airports and CBD terminals, can have significant short term impacts. Shelters at all major local transit stops provide a degree of comfort, an opportunity to provide transit system information and they provide a visual symbol of permanence otherwise lacking with bus transit service. The amount of transit ridership increase that could be attracted by a major program of this type is quite limited, however, by way of comparison with other actions—a 5 percent increase would probably be optimistic.

AUTO RESTRAINT

Pricing Mechanisms

The application of pricing mechanisms such as road-user charges and parking taxes have been widely advocated as a powerful means of restraining the automobile and shifting auto travel to transit modes.

Road-user charges, as considered here, are primarily designed to restrict access to either the CBD or to congested roadways by means of tolls at key entry points, special stickers or licenses, or scanning or metering devices. While all of these systems appear to be sound in theory, no full-scale road pricing demonstration has yet been implemented for the purposes of rationing CBD entry or encouraging transit use. The necessary technology is available, but serious problems remain in the collection of charges, administration, and enforcement. Almost all data concerning the effects of user charges has come from tolls on bridges and tunnels which were implemented to raise revenues, not to control traffic. This data indicates that in areas where alternatives to the automobile are poor, extremely heavy charges would be required to make any impact on auto use. However, if road charges or congestion tolls are accompanied by the expansion of competitive transit services, relatively light charges could result in substantial diversion of auto traffic. Although there is virtually no empirical evidence as to the effectiveness of road-user changes in the form of tolls or other direct charges on CBD entry, the concept is essentially similar to the use of selectively applied gasoline taxes or parking charges, which are dealt with more quantitatively below.

Fuel ***taxes,*** a particular type of road-user charge, can be used as a method of restraining automobile use or conserving fuel as well as a major means for raising revenue to support transit improvements. There has been a great deal of resistance to the use of substantial fuel taxes on the order of 20cents to 40cents per gallon, based largely ***on*** the burden it would cause low and moderate income households who are dependent on automobile transportation for essential travel. This burden could be alleviated by selective tax rebates, as has been seriously proposed in draft legislation. What may not have been clearly recognized, however, is the direct substitutability of transit, particularly if transit is substantially improved, within metropolitan areas. Full rebates of new fuel taxes could be provided within rural areas and small, nonmetropolitan communities where public transit could not be provided at substantial savings in cost and energy consumption, as is the case in metropolitan areas.

In analyzing the effects of gasoline prices on consumption, there are three effects that should be distinguished:

- The short terms effect on the number and length of automobile trips made.
- The long term effect which takes into account the effect of such items as changes in the fuel economy of automobiles and shifts in housing or job location.
- The effect of a shortage of fuel available at a given price—which some have ignored and consequently overestimated the price effect.

Efforts to estimate the effect of price changes on the amount of gasoline consumed suggested short term (3 month) price elasticities of –.07 to –.14 and long term (30 month) price elasticities of –.26 to –,30, Thus, the response to a 10 percent increase in the price of gasoline would be less than a 1.5 percent decrease in gasoline consumption in the first 3 months. However, after 30 months have elapsed, declines of twice that size may be expected. The long term effect is due primarily to the purchase of more fuel-efficient automobiles.

As a result of gasoline prices becoming stabilized at levels considerably higher than those experienced prior to 1973, it is estimated that the average fuel efficiency of the passenger car fIeet will increase from 13.3 mpg in 1974 to 16.5 mpg in 1980.

The annual growth in passenger car vehicle miles of travel will be about 4 percent, which is 1 percent less than the rate observed in the 1969-72 time period, However, despite the 4 percent annual growth in VMT, gasoline consumption wilI increase by less than 1 percent/year, with the increase in VMT aImost compensated for by increased fuel efficiency.

Based on the relationship between VMT and transit ridership developed in the short run regression analysis described in chapter V, at a 4 percent annual growth in VMT, transit ridership will remain roughly constant.

If gasoline prices increase by 50 percent in 1975 and remain constant in real terms thereafter, further increases in fuel efficiency will occur (to more than 18 mpg by 1980) and annual growth in VMT will decline to about 3 percent/year. With this action, transit ridership will increase by 3-5 percent from 1974 to 1980.

***Parking* taxes** in particular have been advocated as a specific means for controlling motor vehicle use. They are relatively easy to administer and require little or no investment.

In considering parking taxes, a distinction must be made between short term and long term parking. Opposition to increases in short term rates by downtown merchants is quite understandable since they compete with suburban merchants who are not affected by proposals to raise CBD parking charges. It is practically infeasible for many reasons to place parking taxes on all suburban parking spaces used for shopping and related purposes. Therefore, serious harm might be done to downtown merchants if substantial short term parking taxes were levied.

On the other hand long term parking taxes in the CBD and in other areas where good quality transit service is available to the commuter would not have the same negative effects, but could have a substantial direct effect on choice of mode for work trips.

Experience has shown that, unless parking taxes are extended to cover those employees who currently park for free in Central Business Districts, the reduction in auto travel to the CBD and corresponding transit ridership increases will be minimal. This is because, in most major metropolitan areas, more than 40 percent of employees currently park for free and it is this group which would be most affected by increased parking charges.

A very rough analysis presented in appendix A was carried out to determine the effect of a $1.50/day increase in the cost of commuter parking in employment areas currently well served by transit.

For a typical SMSA, 20 percent of the total employment might be located in these areas.

Despite the fact that this parking charge would bear upon less than 5 percent of the total SMSA automobile trips, it would have a significant effect on transit ridership-the rough analysis suggests a 15-20 percent increase in total transit ridership.

A disadvantage of this action is that the increase in transit ridership would be concentrated in the peak period, necessitating a 20-30 percent increase in the size of the transit fleet. However, in terms of energy conservation, this action represents a very efficient use of public transit--since more than 80 percent of the new transit riders would otherwise have been automobile drivers.

Regulatory Mechanisms

The concept of regulating parking supply and the use of private automobiles in selected auto-free zones is being experimented with on a worldwide basis. These relatively new auto restraint tools can be effective in promoting transit ridership, depending on their application in specific urban situation.

Parking regulations or regulations that control the supply of available parking capacity can be used to influence the mode of travel to selected parts of a city, if they are aimed at that portion of the parking market which has a reasonable transit alternative, namely commuters. Most metropolitan areas have three types of parking which could be regulated:

- on-street metered parking,
- off-street municipal facilities, and
- off-street private facilities.

Limiting the supply of CBD off-street parking in combination with incentives such as low cost peripheral parking at suburban transit stations might significantly increase transit usage by commuters. However, the most common parking regulations thus far implemented have been to reduce the number of CBD on-street (short term) parking which may have little or no positive effect on transit ridership in most cities. Many practical and political constraints work against the effective, widespread application of parking supply regulations to achieve transit and energy conservation objectives.

Auto-Free Zones can be used to influence the mode of travel to an area, as well as restrict vehicular access, when planned as part of a comprehensive traffic management/transit improvement program. Experience to date indicates that the extent of auto-to-transit diversion depends on many variables such as the size of the zone, transit alternatives, parking facilities and enforcement policies, most of which are peculiar to each auto-free zone application. Almost all existing zones have been implemented either to preserve the environment or eliminate traffic congestion, not as an impetus to public transit. Current data indicates that total trip-making to such areas does not decrease, and in the case of shopping malls, may result in significant increases.

Land Use Controls

While land use controls, such as zoning to achieve higher densities or to encourage mixed-use cluster development, can have a profound effect on both traffic generation and potential transit ridership, these measures require an extended period of years to achieve results. The potential long term effects of major changes in land use controls are discussed in Chapter XL In the short term, however, municipal standards such as building codes, could be effective immediately to reduce the supply of off-street parking in all new construction in CBD'S and other areas where the alternative of good public transportation service is available.

Marketing

Transit marketing is usually perceived in terms of informational and promotional programs which are designed to attract new riders or increase the frequency of use by existing riders. There is currently little evidence to support the hypothesis that greater marketing efforts alone will result in significantly increased ridership. However, marketing programs are undoubtedly a major factor in favorable public perception of transit systems and might be instrumental in attracting new ridership when used with the introduction of new services and facilities. Under fairly typical current metropolitan circumstances it is doubtful that a major marketing effort could produce transit ridership increases of more than 2 to 4 percent.

Staggered Work Hours

Staggered or flexible work hours is a low cost method for reducing peak hour traffic congestion that could also have marginal benefits for transit ridership. Recent data collected in Ottawa indicates that staggered work hours can slightly alter auto/bus modal split, and can improve the balance between peak hour transit demand and capacity, thus enhancing service quality. Nonetheless, unless staggering of work hours is carefuIly planned in conjunction with transit service adjustments there is a danger that transit ridership will decrease as a result of decreased street and highway congestion. In any event, transit ridership increases due to staggering would probably be limited to no more than about 5 percent.

New Technology

In the short term the application of new technology, as distinct from its development, is the im - portant consideration in relation to transit ridership. Computerized monitoring, routing, scheduling, and dispatching are promising innovations which may greatly increase transit reliability and service.

Summary Assessment of Actions

In this chapter, a variety of transit incentive and auto-restraint actions were described and their effectiveness in increasing transit ridership and decreasing energy consumption was assessed.

Particular actions which could have a major effect on either transit ridership or energy consumption or both include:

- transit fare reductions or no fare transit
- increases in the size of the transit vehicle fleet
- gasoline price increases or reductions in gasoline availability
- increased commuter parking charges.

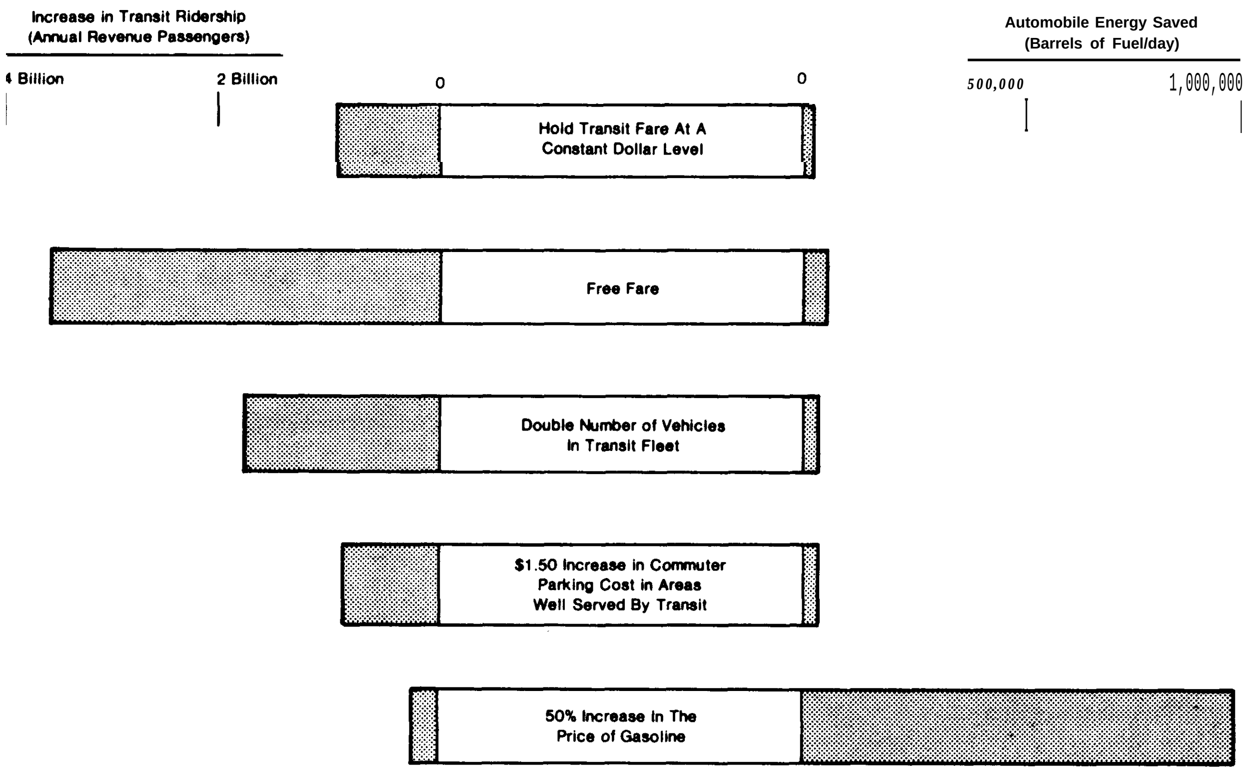
Exclusion of particular actions from this list should not be taken to imply that programs pursuing their implementations are not worthwhile—rather, it implies that, in and of themselves, these actions do not have the potential to significantly affect national transit ridership or energy consumption. A good example of this is the implementation of bus priority lanes. Bus priority lanes provide improved transit service and attract additional riders with very little capital cost. However, rough analysis indicates that an extensive nationwide program of bus priority lanes would increase total transit ridership by less than 5 percent.

For these actions which can significantly affect ridership or energy consumption, assumptions were made regarding levels at which these programs might be implemented on a national basis and rough estimates of their effects were developed. These assumptions and the methods used to make the estimates are described in Appendix A. The results of these analyses are shown in Figure 13,

The energy savings shown in Figure 13 include only motor gasoline saved through a reduction in automobile travel or through increases in the fuel efficiency of automobile engines. To assess the net effect—including energy consumed by transit—it is necessary to form packages of actions in which changes in transit operations associated with transit demand changes can be taken into account. This is done in Chapter IX.

FIGURE 13

EFFECTIVENESS OF TRANSIT INCENTIVE AND AUTO RESTRAINT ACTIONS



source: System Design Concepts, Inc.

Chapter IX

Summary of Impacts on Transit Ridership, The Transit Industry, Related Industries, and Energy Consumption

INTRODUCTION

Chapter VIII reviewed the impact of various transit incentive and auto restraint actions on transit riders hip and energy consumption by automobiles. In this chapter, packages of actions are identified and analyzed. Their impacts are compared with the impacts of the alternative economic and energy futures analyzed in Chapters V and VII.

Three packages of transit related actions were developed: a maximum transit incentive package, a maximum auto restraint package, and a combination package incorporating maximum transit incentives and auto restraints.

The maximum transit incentive package includes:

- free fare transit;
- doubling the transit vehicle fleet by 1980; and
- no significant auto restraints—the price of gasoline was assumed to stay constant in real dollar terms.

The maximum auto restraint package includes:

- a 50 percent increase in the price of gasoline in real dollar terms;
- a $1.50/day increase in the cost of commuter parking in employment areas currently well served by transit; and
- no significant transit incentive actions—the transit fleet would increase in size only as necessary to cover 90 percent of the increase in peak period ridership,

The combination package includes:

- no fare transit;
- doubling the transit vehicle fleet by 1980;
- a 50 percent increase in the real price of gasoline; and
- a $1.50/day increase in the cost of commuter parking in employment areas currently well served by transit.

In each of these packages, it is assumed that there is no limitation on the availability of gasoline at the assumed price. The effects of limitations on the supply of crude oil were considered in Chapter VII,

Specifically, three alternative energy decrease futures were considered:

Mild-decrease of 1 million barrels of crude oil/day by 1976 followed by 3 percent/year growth in oil consumption.

Moderate-decrease of 3 million barrels of crude oil/day by 1977 followed by a 1.5 percent/year growth rate.

Severe-decrease of 6 million barrels of crude oil/day by 1980.

Two different futures about economic conditions were also considered:

Recession—9 percent unemployment in 1975.

Depression—10+ percent unemployment through 1975.

Impacts on Transit Ridership of Packages of Transit-Related Actions and Energy and Economic Futures

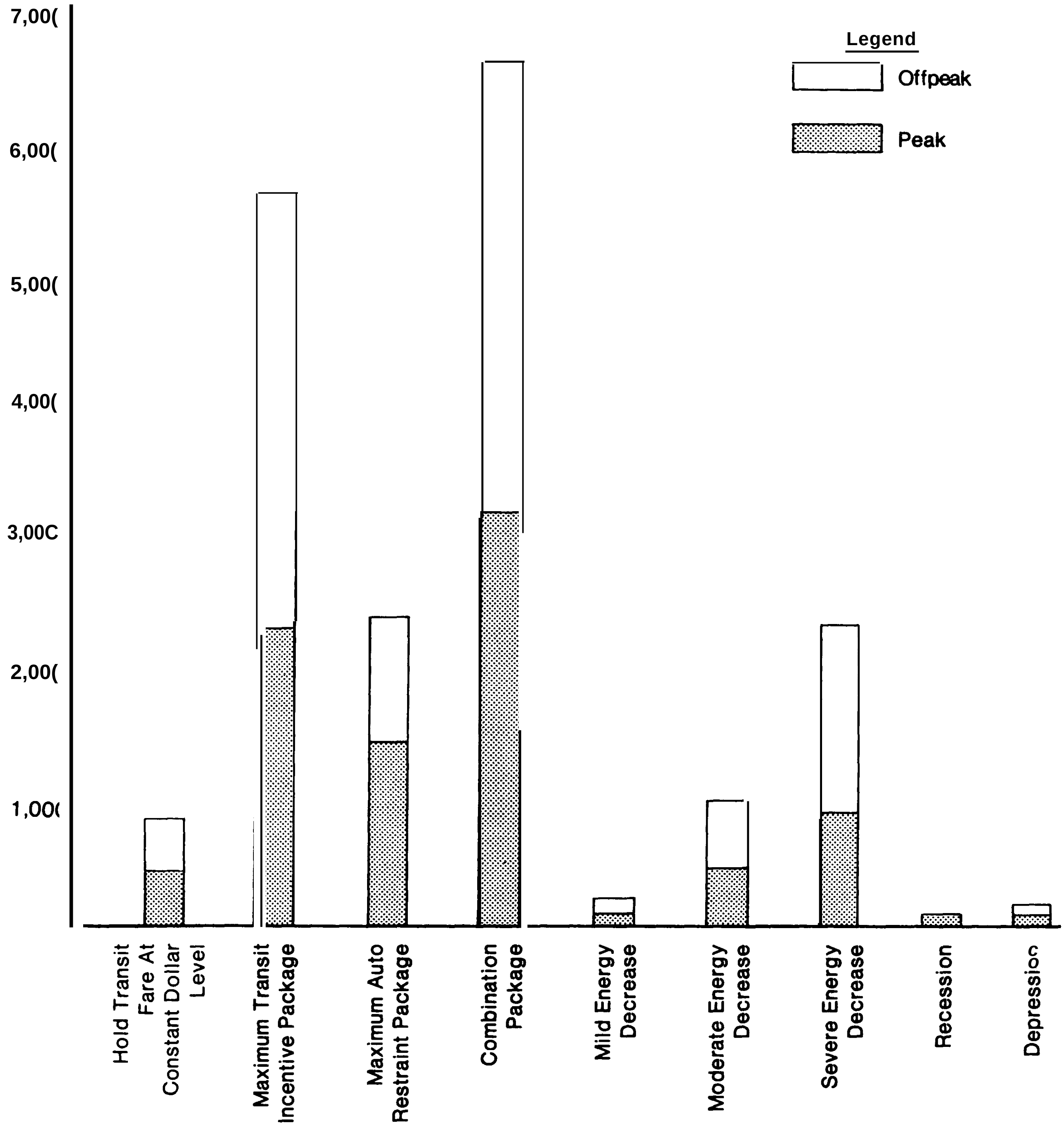
The impacts on 1980 transit ridership of the three packages of transit-related actions and the alternative energy and economic conditions are illustrated in figure 14,

The transit ridership increases were disaggregate into “peak” period and “offpeak” period increases. This is because of the importance of the peak-to-base ratio in determining needs for rolling stock--as will be discussed in the next section.

The estimates of the transit ridership increases associated with the three energy decrease/futures

FIGURE 14

INCREASES IN TRANSIT RIDERSHIP ASSOCIATED WITH PACKAGES OF ACTIONS AND ECONOMIC AND ENERGY FUTURES
(millions of passengers annually)



presented in Figure 14 each incorporate the assumptions that transit fares will be held at a constant dollar level and that passenger car engine efficiencies will increase from 13.3 miles per gallon in 1974 to 17,0 miles per gallon in 1980. As can be seen by comparing the bar at the far left of Figure 14 with the bars for the three energy decrease assumptions, the assumption of constant dollar level fare contributed a major portion of the ridership increases associated with the energy decrease futures. Alternatively, had it been assumed that transit fares will grow at the same rate as the consumer price index through 1980 (i.e.. remain constant in real dollar terms), the forecasts of 1980 total annual transit passenger would be as follows:

Mild Decrease—13 percent decline from 1974 to 1980;

Moderate Decrease—3 percent increase from 1974 to 1980; and

Severe Decrease—23 percent increase from 1974 to 1980.

The improvement in fuel efficiency assumed for each of the energy decrease futures (from 13.3 miles per gallon ,in 1974 to 17 miles per gallon in 1980) is roughly the same as the automobile market response to a so percent increase in the price of gasoline. If the reduction in demand for gasoline required for the mild energy decrease future is brought about through an increase in the retail price of gasoline and there are no other incentives for the purchase of more fuel efficient automobiles (such as a horsepower tax), then the automobile market response to the mild energy decrease future would be a smaller improvement in fuel efficiency than that assumed. In this case, the transit ridership increase for the mild energy decrease future with constant dollar level fares would be greater than that shown in Figure 19. on the other hand, if fuel efficiency improvements larger than that assumed occur (such as would probably be the case with the severe decrease future), then the transit ridership increases would be less than those shown in Figure 14 for the energy decrease futures with constant dollar level fares.

Comparative Impacts of Assumed Alternative Economic and Energy Futures and Selected Packages of Actions on Transit-Related Industries

This section will briefly examine some of the effects of transit ridership changes induced by the changes in economic and energy conditions (see Chapters V and VII) and by the selected packages of actions (discussed above). The effects of these ridership changes will be discussed in terms of transit operating costs, revenues, deficits, labor required for transit operation, additional vehicles required, employment generated in vehicle production, and potential justification for fixed guideway systems.

The alternative futures and packages of actions to be discussed are listed below:

- Recession and Depression Futures;
- Combined Energy Reductions with Recession and Depression Futures;
- Maximum Transit Incentive Package;
- Maximum Auto Restraint Package; and
- Combination of Transit Incentive and Auto Restraint Package.

The effects on energy consumption of these futures and packages are discussed in the next section,

Impacts on Transit and Related Industries of Economic and Energy Futures

This section will briefly examine some of the effects of transit ridership changes induced by the changes in economic and energy conditions which have been summarized earlier in this chapter,

The discussion of the effects will treat the recession and depression conditions separately from the energy and combined energy/economic conditions, The recession and depression conditions have rather minor effects on the transit industry and will be only briefly described. The effects of the various energy assumptions will be quite significant on the transit industry. These energy related effects so far outweigh the recession and depression related effects that the combination of the energy and economic conditions creates net conditions so similar to the energy effects alone that they are treated together here.

Impacts on Transit of Ridership Reductions Attributed to Recession and Depression Futures

The declines in ridership of 2.5 percent which are expected under recession and depression conditions will worsen the financial position of the U.S. transit industry. Revenues can be expected to decline proportionately to ridership losses; operating costs will probably rise compared to current conditions, due to the current inflationary trend. The net effect of the economic conditions on costs of operations would probably be to cause a very slight decrease in operating costs, assuming some curtailment of peak service, but probably less than in proportion to the revenue losses due to transit ridership declines. The net effect on overall transit fiscal conditions is likely to be an additional loss of about 2 percent, i.e., slightly under the 2.5 percent ridership losses.

Buses would not be replaced quite as fast, thus impacting negatively on the bus manufacturing industry to a moderate extent. These conditions are similar to past trends in the industry.

Based upon these assumptions it would be somewhat more difficult to justify new fixed rail systems because of the net ridership losses caused. Justification would have to rely more on the employment created. The recession or depression effects on the transit operator, however, would only be temporary, and therefore would have no effect on traffic revenue or operating costs by the time any new fixed guideway system would be complete and open to traffic. The jobs created in the construction of such a system would be substantial. In Chapter X of this report it is estimated that in both Atlanta and Washington construction-related jobs would be at least 1 percent of the regional labor force. It should also be noted that our shortrun ridership forecasts are national ones and are based on a transit service level approximating past service levels on a national basis. Obviously a new fixed guideway system would be a significant improvement in the level of service in that metropolitan area and would be justified to a large extent on the basis of local patronage expected rather than on trends in ridership resulting from national conditions.

Impacts on the Transit Industry Associated with Ridership Changes of Assumed Energy and Combined Energy/Economic Futures

One of the worsening problems within the transit industry in recent decades is the peak-to-base ratio—the ratio of peak hour ridership to the base period ridership. Manpower and capital requirements (bus-driver units on the street) must be large enough to meet the short peak hour demand.

In the offpeak period buses stand idle or make runs nearly empty, and drivers collect wage bonuses for split shifts. Any shifts in ridership which reduce the peak-to-base ratio will improve the financial picture of a transit operation.

It is very likely that small increases in transit ridership will continue to come during peak periods. These additional trips will probably be largely work trips to CBD'S, using the existing transit service which is already oriented to this type of travel. Other types of trips (social, shopping, non-CBD, etc.) are less well served by most transit operations and thus are not likely to be among the first to be attracted to transit even under a noticeable fuel shortage. Severe energy shortage conditions would presumably be so disruptive to all types of auto trips, that large increases in transit ridership would be experienced in the peak and moderate increases on the weekends and workday offpeak.

The 6 to 8 percent increase in transit ridership forecast for 1975 (if any of the three energy and combined energy/economic assumptions materialize) would create some immediate shortrun problems for the transit industry, It is unlikely that within this year the agencies and industries would be able to finance, produce, and buy the additional rolling stock or train additional drivers required to meet the additional demand over and above replacements already planned for the year. It is likely that peak load factors would have to be increased to handle additional riders. While this is uncomfortable for passengers, it is a financial blessing to operators. Revenues should increase proportionately to ridership while operating and capital costs should remain close to the level that would otherwise occur in 1975.

The transit patronage increases after 1975 associated with mild decreases in highway fuel would be of little help to the transit industry financially. Revenues would increase in proportion to ridership advances (and decline from 1977 on), but operating costs would probably increase at a faster rate due to inflation and increased peak-to-base ratios in the first and second years. Few additional new buses (old buses could be kept in service longer) can be justified to serve temporary increases in ridership. A few more drivers and mechanics could be justified in 1975 and 1976, but in 1978, 1979, and 1980 fewer drivers would be required and the number of transit employees could be reduced. By 1980, service, employees, and rolling stock would have increased by about 5 percent, while the deficit will increase by about 5 percent (plus inflation) over the 1974 levels.

A moderate decrease in highway fuel will generate additional revenues in proportion with ridership increases. It may even be possible that the large ridership increases in 1975, 1976, and 1977 may include a reasonable number of offpeak riders. However, most of the increases will occur in the peak periods.

By 1980 the ridership increase would average about 20 percent with the peak period increase likely to reach 25" percent, exceeding the average ridership increase. A 20 percent increase in service, operating costs, vehicles, and manpower should be sufficient to handle the peak period increase, assuming that transit systems couId be operated more efficiently under conditions of increased ridership and fewer vehicles on the roads.

Since operating costs and revenues (ridership) would increase by the same percent, the deficit from transit operations would increase by about the same 20 percent (before the effects of inflation are added).

The 20 percent increase in transit employees would add about 30,000 jobs to the transit labor force, and add about another 15,000 jobs to the labor force in general through the multiplier effect.

The 10,000 new buses required to serve the new riders would cost about $650 million at today's prices and generate about 54,000 man-years of employment in the bus and related industries. (In Chapter VI it was estimated that about 83 jobs were created per $1 million in bus production.)

The severe energy condition with its 40 percent increase in ridership by 1980 would be good for transit. Such a severe energy shortage is likely to attract substantial offpeak as well as peak riders, thereby lowering the peak-to-base ratio compared to the milder energy reduction conditions. The energy-caused dislocations would also justify measures to force spreading of the peak period so that transit's full capacity could be used over 2 or 3 hours in the morning and evening rush period instead of today's 1- or 2-hour rush periods. Furthermore, the increase in transit ridership might justify exclusive use of more streets for transit, and this, in combination with fewer autos on the shared streets, would improve transit operating speeds, in turn allowing shorter turnaround times and more efficient use of manpower and equipment.

In order to accommodate the 40 percent increase in ridership that would occur under a severe energy shortage, an increase of about 35 percent would be required in the level of transit service, operating costs, rolling stock, and transit personnel, Since the increased ridership will generate about a 40 percent increase in operating revenue, whereas operating expenses will only increase by about 35 percent, the increase in the deficit would be only about 27 percent. Thus, the systems in the United States would increase ridership by about 40 percent, but require a subsidy increase of only 27 percent, In 1974 a subsidy increase of 27 percent would equal about $340 million. By 1980 the subsidy would be considerably higher due to the effects of inflation,

The increase in operations would create about 53,000 jobs in the transit industry. Added to that would be about 27,000 more jobs due to the multiplier effect, for a total of about 80,000 new jobs directly and indirectly attributable to a 35 percent increase in transit activity alone (not including jobs required to produce more rolling stock).

Both rail capacity and buses might have to be increased to handle the increase in ridership, The required increase in rail capacity can be achieved through the implementation of already programed rail extensions or new systems in Washington, Atlanta, Baltimore, Boston, New York, Philadelphia, and possibly in other areas about to make commitments to new rail systems.

The bus fleet would require an increase of about 35 percent or about 17,500 new buses. At $65,000 for each bus, the total cost of these additional buses would be $1,138 million. In Chapter VI, an investigation of the employment generating ability of the bus industry indicated that for every $1 million increase in bus production about 83 jobs (including all jobs directly or indirectly attributed to bus manufacturing) would be created,

The total employment impact of the production of 17,500 buses more than current production rates would be about 94,000 man-years of employment. Due to the capacity constraints in the bus manufacturing industry, this increased production would have to be spread over 4 years (see Chapter VI).

The large increases in ridership will increase the likelihood that additional fixed guideway systems will be built. However, only those new rail facilities already under construction (Washington, Baltimore, Atlanta, New York, Boston, San Francisco, etc.) are likely to be in even limited operation before 1980.

Impacts on Transit and Related Industries of Selected Packages of Actions

Of the three packages discussed above, two have very similar effects on the transit industry. These two, Maximum Transit Incentive and the combined, are discussed together following the Maximum Auto Restraint Package.

Impacts on the Transit Industry Associated with Ridership Increases Resulting from the Maximum Auto Restraint Package

The overall increase in ridership of about 39 percent in 1980 associated with this package is quite similar to the increase associated with the increase estimated for severe energy conditions; however, due to the large increase in peak period riders, the financial picture is worse and the rolling stock and manpower requirements are greater.

In order to handle the 48 percent increase in the peak period ridership, a 43 percent increase in service and operating costs has been assumed. The increase in service does not equal the peak period patronage increase because of assumed faster running speeds on the less crowded highways (more efficient use of manpower and equipment) and higher vehicle occupancy. Since the percentage increase in costs (43 percent) exceeds the percentage increase in overall ridership and revenues (39 percent), the difference between them (i.e., the deficit) would increase by an even greater percentage. The deficit in this package would increase by 49 percent. In 1974 the national transit operating deficit was $1,271,275,000,[1] a 49 percent increase would add over $600 million. By 1980, this deficit will be increased even further by inflationary pressures. However, because fares have been assumed to increase with the rate of inflation in this package, some of the effects of inflation on the deficit will be offset by increases in revenues due to the higher fares,

A comparison of this package with the severe energy decrease future reveals that although they both generate about the same percentage increase in ridership, the increase in the deficit is remarkably different (49 percent for the auto restraint versus only 27 percent for the severe energy decrease future). Because the auto restraint package restricts auto work trips through its parking tax, a much greater number of work trips are diverted to transit, requiring much greater increases in service during peak periods. The severe energy decrease future will create shortages of energy for all types of auto trips, thus resulting in a lesser increase in peak trips (compared with the auto restraint package) and a greater number of offpeak trips, and thus requiring a smaller expansion for the more costly peak hour service.

Therefore, under the severe energy decrease conditions, transit can handle the increase in ridership in a less costly manner, and can probably incur a significantly smaller deficit.

of course, two of the actions in the auto restraint package generate revenue which could be used to offset-the transit deficit. A very rough calculation indicates that the gas tax could "generate about $12 billion[2] and the parking tax could possibly generate up to $1 billion,[3]

The 43 percent increase in transit operations will require about an additional 65,000 employees. With another 33,000 added by the multiplier, the total employment effect is about 100,000 jobs.

Additional rolling stock will also be required. It has been assumed that the already programed rail improvements will sufficiently increase the rapid rail rolling stock; however, 43 percent more buses will be required. These 20,000 new buses would cost about $1,300 million in 1974 (at $65,000 each). The employment estimate developed in Chapter VI indicated that for every $1 million in bus production, about 83 jobs are created in industries directly and indirectly affected by bus production. Thus, about 107,77o man-years of employment (above that which would be required for current production levels) could be credited to the production of 20,000 more buses. The capacity constraints of the bus manufacturers would limit additional production to an average of about 5,000 per year, over the next 4 years, thus spreading the delivery of these additional buses and the employment generated over the same time period.

The 48 percent increase in peak hour ridership will certainly increase interest in additional fixed guideway systems. However, only those facilities already under construction (Washington, Baltimore, Atlanta, New York, Boston, San Francisco, etc.) are likely to be providing even limited service by 1980.

The very large increase in the transit deficit resulting from this package, is likely to increase interest in the development of systems with low operating costs, Thus, a significant increase in R & D funds for proposed low operating cost systems would be justified,

[1] APTA, '74. '75 Transit Fact Book.

[2] 60 billion gallons of gas sold in the United States reduced to 42 billion by a 30¢ tax generates about $12.6 billion less taxes lost on the 16 billion gallons not sold.

[3] Of the 50 million U.S. workers, 20 percent would be in parking tax areas, 25 percent of the affected employees would pay up to $1.50 which generates about $938 million.

TABLE 38

SUMMARY OF APPROXIMATE EFFECTS ON TRANSIT AND RELATED INDUSTRIES OF ALTERNATIVE ASSUMED ECONOMIC AND ENERGY FUTURES AND PACKAGES OF TRANSIT-RELATED ACTIONS

Assumed Economics and Energy Future or Packages of Transit–Related Actions	Percent Transit Ridership Change: 1974-80	Percent Increase in Operations: 1974-80	Percent Increase in Deficit (Excludes Inflation) 1974 = $1,271,275,000	1980 Employment Generated by Changes in Transit Operations (Includes Multiplier)	Additional Buses in Operation by 1980	Cost in Millions by 1974 Dollars (At $65,000 each)	Total Man Years of Employment Generated by Additional Bus Production (Includes Multiplier)	Additional Rail Cars Required (Above Those Already Programed)	Cost in Millions of 1974 Dollars (At $500,000 each)	Total Man-years of Employment Generated by Additional Bus Production (Includes Multiplier)
Depression Future	–3	0	2	0	0	—	—	0	—	—
Mild Energy Decrease Future	+5	5	5	10,500	2,500	162	13,430	0	—	—
Moderate Energy Decrease Future	+20	20	20	45,000	10,000	650	53,885	0	—	—
Severe Energy Decrease Future	+40	35	27	80,000	17,500	1,138	94,340	0	—	—
Maximum Auto Restraint Program	+39	43	[1]49	98,000	20,000	1,300	107,770	0	—	—
Maximum Transit Incentive Package	+100	100	470	225,000	50,000	3,250	269,425	3,000	1,500	119,850
Combined Package	+120	100	470	225,000	50,000	3,250	269,425	3,000	1,500	119,850

[1] Inflationary increases will have less impact on the Auto Restraint Package deficit than on the deficits of the other packages and futures. Only in the Auto Restraint Package are fares assumed to increase with inflation, thus somewhat offsetting the inflationary increases in operating costs.

SOURCE: System Design Concepts, Inc.

Impacts on the Transit Industry Associated with Ridership Increases Resulting from the Maximum Transit Incentive and the Combined Packages

The Maximum Transit Incentive Package and the Combined Packages have very similar impacts on the transit industry. Costs, deficits, manpower, and rolling stock requirements are identical in both packages. The only differences which are discussed here are that the Combined Packages have higher ridership and also have the potential for use of gas and parking tax revenues to cover transit deficits.

Both packages assume a doubling of transit service and the elimination of fares. These assumptions double the operating costs and eliminate fare box revenue, thus making the entire cost of operations equal to the deficit. In 1974, the national transit operating expenses were just over $3 billion.A In 1974 a doubling of operations while eliminating fares would have created a $6 billion deficit, compared to the $1,271 million deficit in 1974 which is about a 47o percent increase in the deficit.

Deficits of these proportions would justify extensive increases in funding for research and development of techniques and systems with lower operating costs. In addition, the very large increases in ridership (100-120 percent) which accompany these packages would increase the market for fixed guideway systems, especially if they could handle high volumes of passengers at low operating costs.

The Combined Packages incorporate the two revenue producing actions used in the auto restraint package. As mentioned in the preceding section, these restraints could produce about $13 billion dollars annually, more than enough to cover the transit deficit.

The doubling of transit service will require a doubling of the transit labor force or an addition of about 150,000 employees. With the addition of the employment multiplier, the total employment impact of this expansion of transit service is an increase of about 225,000 jobs.

The additional rolling stock required will equal 3,000 new rail cars (plus those already programed) and 50,000 new buses by 1980. Orders for these additional vehicles will strain the capacity of both the rail and bus manufacturers.

However, with an increase in bus plant capacity and significantly greater production in the latter years, these vehicles could be produced and in operation by 1980,

4AmA, op. cit.

Today’s cost of 50,000 buses and 3,000 heavy rail cars is $3,250 million for the buses (at $65,000 each) and $1,500 million for the rail cars (at $500,000 each), for a total of $4,75o million. Using the employment generating ability of these industries (see chapter VI), the man-years required to produce these vehicles is 269,425 for the buses and 119,850 for rail cars for a total of about 390,000. Since this production would be spread over 6 years, the average additional annual employment generated by these increases in transit’s rolling stock would be about 65,000 jobs for the 6 years of production.

Impacts on Energy Consumption of Packages of Transit-Related Actions

The impacts on 1980 total energy consumption (including fuel consumed by transit) of each of the packages of transit-related assumptions is shown in Figure 15. For the Auto Restraint and Combination Packages, only a small share of the energy savings are due to auto drivers shifting to transit. The primary effect is the reduction in gasoline consumption due to improvements in engine efficiency.

SUMMARY

The admittedly rough analyses summarized in Chapters VIII and IX lead to conclusions which, if shown to be correct in more detailed analyses, have major implications for public policy regarding energy, the economy, and mass transit:

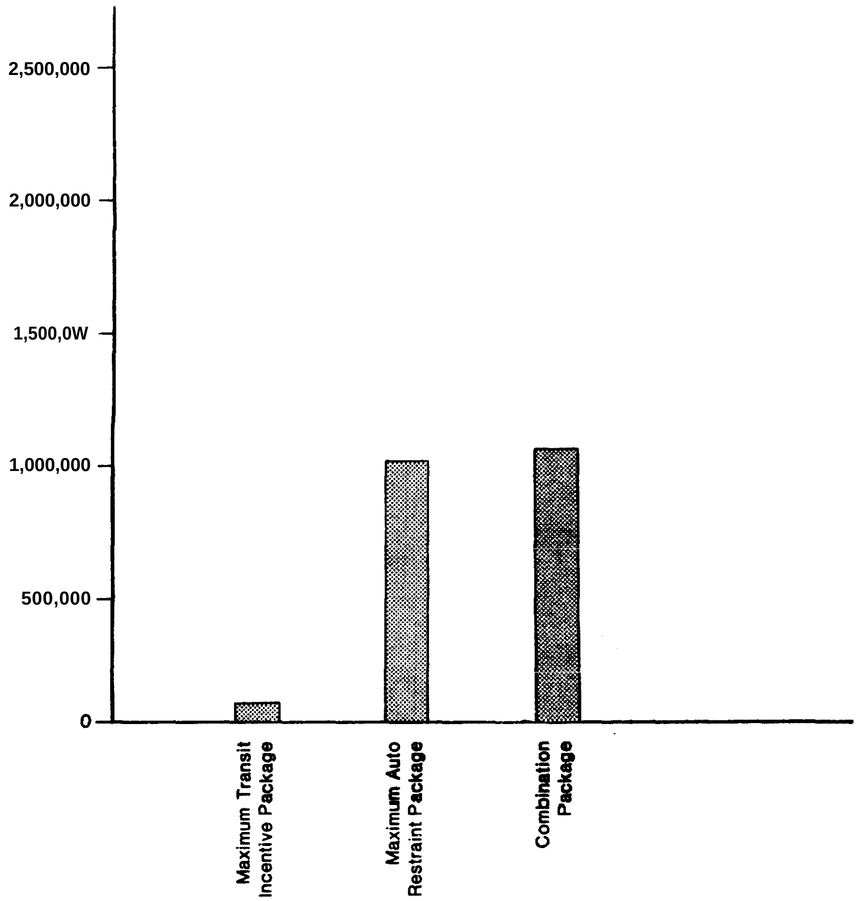
- The impact on 1980 energy consumption of a 50 percent increase in the price of gasoline is an order of magnitude greater than the impact of any transit incentive action.

- However, considering its impact on energy consumption, the impact of a 50 percent increase in the price of gasoline on transit ridership is relatively slight causing a less than 10 percent increase. This is because the primary long-term response of motorists to gasoline price increases is to purchase more fuel efficient automobiles rather than alter their travel behavior,

- An auto restraint action aimed at that sector of the travel market best served by transit—a $1.50/day increase in the price of commuter parking—has a far greater effect on transit ridership than does a 50 percent increase in the price of gasoline.
- In terms of energy saved per new rider attracted, generating additional ridership through auto restraints is more than twice as efficient as generating additional ridership through transit incentives.
- Transit ridership increases generated through auto restraint actions would have a negative impact on transit agency finances, since ridership increases would occur primarily in the peak period. As a result, required increases in rolling stock would be proportionally greater than ridership increases generated by auto restraint actions.
- A combined strategy incorporating both transit incentives and auto restraints should be implemented to promote energy conservation without lowering the efficiency (measured in passengers per vehicle) of the transit fleet.
- Opportunities exist for funding major transit improvements through revenue generated by auto restraints. For example, no fare transit fleet could be funded by a 50 percent increase in the price of gasoline.

FIGURE 15

NET 1980 ENERGY REDUCTIONS ASSOCIATED WITH PACKAGES OF ACTIONS
(Barrels of Gasoline Per Day)



Chapter X

Metropolitan Experience

Previous chapters have been national in perspective; this chapter presents a brief view from the metropolitan areas. This chapter contains a brief discussion of the experience of local transit operations during recessions and the energy crisis and also examines the ability of the operators to expand service.

Chapter X completes the evaluation of the relationship between transit, the economy, and energy. The last chapter discusses the national policy issues and possible initiatives which are appropriate to deal with the concerns raised by this evaluation.

INTRODUCTION

A limited sampling of the experience in several large metropolitan areas has revealed the following information, which is discussed below:

1. Ridership increases experienced during the energy crisis and the ridership decreases experienced during the recent recession conformed in general to the results of the national analyses discussed earlier.
2. Several transit operators in the cities sampled also revealed the existence of plans to increase transit service in order to respond to severe energy shortages.
3. Based upon the experience in Washington, D. C., and Atlanta, Ga., the construction of a rapid transit system can significantly reduce the levels of unemployment in a large metropolitan area.

This information was gathered largely through a questionnaire distributed to the transit planners and operators in the nine metropolitan areas included in this study. The questionnaire (see Appendix B for a copy) elicited information on the experience of the metropolitan areas during the energy crisis and the ability of the transit systems)0 respond to assumed future energy conditions. Responses to the questionnaire varied in completeness, with most respondents willing to share their past experience, but on] y a few willing to predict their requirements and ability to respond to future energy conditions,

Ridership Changes Due to Changing Energy and Economic Conditions

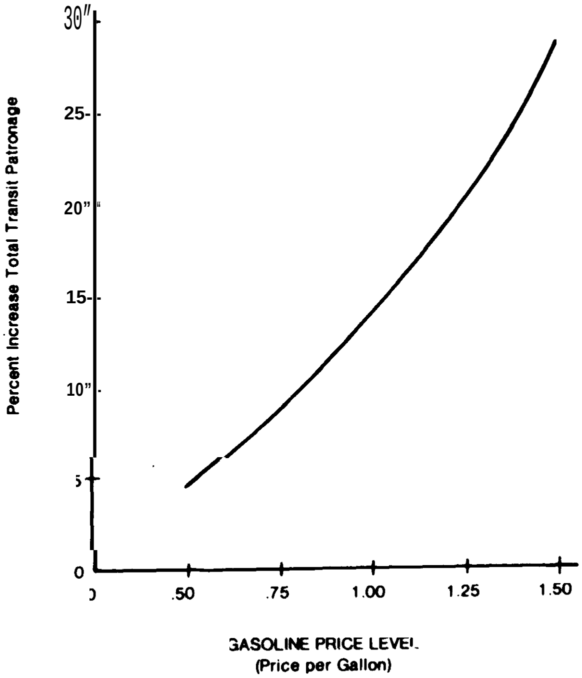
Recent changes in transit operations, such as increased service or decreased fares, in most metropolitan areas have a noticeable effect on ridership, which is difficult to distinguish from the effect of the energy crisis. Thus, it is difficult to establish a causal relationship between ridership changes and gasoline shortages and economic conditions, since so many other factors play a significant role in determining ridership in each metropolitan area. However several trends in ridership increases can be detected during the energy crisis (late 1973 and early 1974) which conform closely to the national trends which were observed and reported in previous chapters. Four cities provide excellent examples of the effect of the energy crisis on ridership.

Both Atlanta and Minneapolis have had ridership increases during the energy crisis which conformed to the national estimates. In both cities transit officials commented directly on the relationship of energy conditions and ridership. In Minneapolis, it was estimated that the energy crisis was responsible for a 6 percent increase in transit ridership, In Atlanta, it was hypothesized that the energy crisis was responsible for continuing a 10 percent annual growth in ridership for a longer period than would have been the case without the energy shortage.

Monthly ridership for Seattle's Metro and San Francisco's Muni, respectively, exceeded and fell short of the 6 percent national ridership increase of 1974. The annual ridership increase during the first 4 months of 1974 averaged 22 percent in Seattle, while a 16 percent average increase was experienced for the first 10 months[1] of the year. San Francisco's Muni also experienced much greater ridership increases during the energy-short first 4

[1] A strike in November 1974 makes increases for the full Year difficult.

FIGURE 16
EFFECT OF FUEL COSTS ON TRANSIT RIDERSHIP



Note Base gasoline cost is *35* per gallon

SOURCE "Impact of Pricing Policies on Transit Us " CATS *Research News,* vol 17 *#1,* April 1975

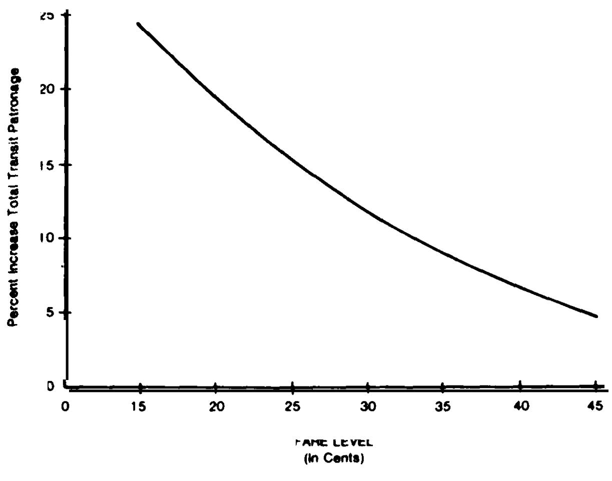
months of 1974 than the whole year. In the first 4 months of 1974 ridership increased by over 7 percent while for the whole year ridership averaged only a 4 percent increase.

Only the transit operator in the Twin Cities was willing to forecast the actual ridership changes they expected under the energy futures described in chapter 4. However, a Chicago study by CATS[2] provided forecasts of transit ridership increases in response to fare reductions and gasoline price increases which could be compared with the forecasts developed in this study. Both the Chicago and Twin Cities' forecasts are in conformance with the national forecasts discussed earlier.

Twin Cities' transit use was forecast to increase 5 percent by 1976, 8 percent by 1977, and 20 percent by 1980 for the mild, moderate, and severe energy futures. These forecasts are lower than the national estimates contained in Chapters VII and IX, however, they are in addition to sizeable transit ridership increases due to increases in transit service programed for the area. If energy conditions alone (without increases in the level of service) are considered, it can be assumed that many of those new riders forecast to be drawn to transit by improved service would have also been drawn to transit under energy shortage conditions. Thus, the effect of energy shortages alone would have attracted more riders, possibly as many as was forecast nationally.

The "Impact of Pricing Policies on Transit Use" by the CATS staff forecast changes in ridership due to increases in gasoline price and decreases in fares as shown in Figures 16 and 17. The CATS analysis indicated that a 50 percent increase in gasoline cost would result in about a 5 percent increase in transit ridership, which is the same approximate figure developed in Chapter IX. The CATS analysis of the relationship between fare reductions and ridership did not consider free fares, however, a very rough extrapolation of the relationship between fares and ridership increases would

FIGURE 17
EFFECT OF FARE ON TOTAL TRANSIT RIDERSHIP



Note Base is with existing fare structure
Revised fares ● pply 10 ● ll *CTA* service ● *d* suburban buses

sourcImpaact on Transit Use," CATS,e Research News, vol *17#1,* April 1975

[2] Chicago Area Transportation Study, ***Record News,*** **April 1975.** "Impact of Pricing Policies and Transit Use."

indicate a 30-35 percent increase in ridership with zero fare. If additional ridership can be expected due to the convenience of no fare (as opposed to the inconvenience of paying even the smallest fare), a ridership increase of 40-50 percent could be expected in conformity with this study's forecast of 40-60 percent increase.

In Atlanta, comments from MARTA presented the view that the ridership increases forecast by this study were low, if no restraints upon transit service were assumed. This study has assumed that energy shortage conditions accompanied by improvements in the level of transit service would result in increases in ridership above that expected from energy shortages alone. In addition, MARTA's recent experience in attracting new riders and its well run transit operations would lead the transit operators there to expect greater than average ridership increases.

The comment from Atlanta merits a comment about the forecasts developed for this study. These are average national figures. In response to local conditions, it can be expected that many cities will exceed the average ridership increases and others will experience less increases.

Although most cities could not estimate the effect of increased unemployment on transit ridership, some figures from Atlanta tend to support the national figures discussed above. In Atlanta in September 1974, the unemployment rate was 5.0 percent while transit ridership was increasing at a 9.1 percent annual rate. By March of 1975 the unemployment rate in Atlanta was over 10 percent, and the growth in transit ridership was reduced to 5.3 percent. Thus a very large (5 percent) increase in unemployment corresponds to only a relatively small (3.8 percent) decrease in the growth rate of transit ridership; these figures tend to confirm that the unemployment rate has only a small effect upon transit ridership.

Ability of Metropolitan Areas To Deal With Ridership Increases

Information was gathered on the ability of metropolitan transit operators to deal with ridership increases in four metropolitan areas: Atlanta, Seattle, Twin Cities, and Washington, D.C. Only Washington has developed plans for dealing with severe energy shortages, which are discussed following a summary of the abilities of the other cities. It should be cautioned that this is a verv limited sample of cities and their responses may not reflect national trends.

Transit operators in Atlanta, Seattle, and the Twin Cities responded to questions concerning their ability to handle increases in ridership due to each of the three assumed energy futures—mild, moderate, and severe.

All three agreed that the energy shortages would cause much greater peaking of demand for transit services, with the severe energy conditions being the most peaked. This assumption conflicts with this study's forecast. This study assumed that under the severe energy future significant numbers of off-peak as well as peak riders would be attracted to transit thus lessening somewhat the peak-to-base ratio, This study assumed that in an extended period of severe energy decreases, people would shift some of their discretionary offpeak trips to transit. This assumption is contrary to observations during the short-lived energy crisis of last year, when individuals gave up many discretionary trips. It is likely that the transit operators based their peak-to-base ratios on recent short term experience and did not consider the long term implications used in this study.

Any large increases in ridership, especially in the peak hours would severely erode the financial picture of the transit operators. MARTA estimated that the mild energy future would require more subsidy, the moderate energy future—much more subsidy and the severe energy future—very much more subsidy. Seattle's Metro stated that their financial picture would be "impossible" under any of the future energy conditions.

Each operator estimated that buses, drivers, and mechanics required would be roughly equivalent to peak hour increases, thus under the most severe conditions Seattle would require 1,000 buses; Atlanta, 358; and Twin Cities, 380.

The time required to meet the increased transit demand varied greatly. Under the mild energy conditions the acquisition of additional buses and the training of drivers would require about a year in both Atlanta and Seattle. In Minneapolis/St. Paul the increases in ridership could be handled in 2 months since 160 old buses are held in reserve, eliminating the delays of ordering new buses.

In response to a question on the ability of the metropolitan transit agency to expand its capital program in response to a Federal program to create employment opportunities, both Twin Cities and Seattle could not get construction underway for about 3 years. Twin Cities estimated that they could increase their capital program by about $5o million, including $10 million raised locally. Seattle indicated that they could possibly increase their program by 10 percent ($16 million) but could raise no additional local money. Atlanta indicated they could spend an additional $1 billion (2o percent local share), however, that additional $1 billion would be in the form of a Federal commitment to complete the whole Atlanta rail system, rather than the partial commitment which UMTA currently has offered.

The Washington Metropolitan Area Transit Authority has prepared two brief studies which outline the ability of the transit service to deal with conditions of severe energy shortages. While these studies do not respond directly to the questionnaire, they provide interesting examples of the actions which would be necessary to respond to significantly increased ridership.

The most recent of the two Washington Metropolitan Area Transit Agency (WMATA) energy crisis studies mentioned above was done in February of 1974.[3] This study was based on the assumption of "sudden notice of almost complete unavailability of gasoline for private automotive use," and was designed with the objective of "development of emergency action program to provide maximum transit service," In order to achieve the increased transit service several assumptions were required. One of the most important was that work hours would be much more staggered, resulting in rush hour **bus** service of 4-1/2 hours in both the morning and afternoon. (Currently the rush period bus service is 2 hours.) It was assumed that exclusive use of suburban arterials and city streets would be granted to transit buses. Load factors were to be increased on all transit buses. Additional buses would be required, some coming from the use of school buses, sightseeing buses, and military buses; and others coming through accelerated delivery of new buses. Although the study does not state so explicitly, it is assessed that these measures would result in the transit system being able to handle most of the work trips in the Washington area. It was assumed that these conditions could only be temporary. Thus the extensive use of overtime for drivers and mechanics was envisioned, without the use of additional drivers and mechanics, This extensive use of overtime labor, as well as the increase in peak hour traffic resulted in a severe increase in costs over revenues. The study's preliminary estimate of increased operating deficit was about $100,000 per day.

The second energy related study done by the WMATA Office of Planning in June 1973, was predicated on the assumption of reductions in auto driver trips of 10, 20, and 30 percent in the years 1975, 1980, 1985, and 1990. Unlike the other study, it was assumed that the transit agency would have at least a year to prepare for the reduction in auto trips. The factor which required the year delay in implementation of increased service was the training of new bus drivers. The study assumed that there would be increased occupancy on the buses, and under conditions of 20 and 30 percent reductions in auto trips the rush period was extended from 2 to 3 hours. These assumptions resulted in increased transit ridership of approximately 33, 44, and 67 percent in 1975 for auto trip reductions of 10, 20, and 30 percent respectively. For the years 1985 and 1990, transit ridership (bus plus rail) was forecast to increase, 22, 39, and 60 percent for the assumed set of auto trip reductions. The lesser increase in transit ridership for the later years is due to the fact that the subway system would be in operation and would be carrying a greater proportion of all trips under ordinary conditions, thus the additional number of passengers diverted from automobiles (the assumed 10, 20, and 30 percent reductions) would be a smaller percentage of total areawide trips and a smaller increase in ridership than for the presubway period. Additional buses would be required under all assumed conditions ranging from ***371*** to ***620*** buses for the entire 15-year period, and only under the 30 percent reduction in auto trips were any additional rail cars required. Operating deficits were reduced in nearly all of the years and under all of the assumptions, in fact, in some situations the transit operation actually made a profit.

These two studies indicate that it would not be difficult to increase the capacity of the transit system in the Washington, D.C, area. In the very short run, the limiting factor in increasing the capacity is the availability y of trained drivers and mechanics. Additional buses are probably of secondary importance, assuming that by staggering work hours more efficient use could be made of the existing fleet. If the bus system was given at least a year to prepare for significant increases in ridership this could be accomplished at a minimal cost, with a substantial decrease in the operating deficit after the full impact of the severe energy shortage is felt. In the

[3] Unpublished data from the Office of Planning, WMATA

short run, Federal assistance would probably be required to help absorb the operating deficit incurred. The magnitude of this required assistance depends primarily on the relative timing of the buildup of staff and equipment as compared with the rate of impact of the fuel shortage. If it were possible to optimally time the buildup (hiring, training, and acquisition of new equipment) with the timing of the fuel shortage impact, the additional operating deficit to WMATA would be very modest compared to the costs of either (1) having no warning and being forced to pay excessive overtime, etc., or (z) incurring the costs of building too early with respect to the fuel shortage impact before the substantial compensating revenues are realized. The Federal Government, as the major employer, would have to take the lead in changing to more staggered work hours, particularly during the transition period as transit operations are shifted to accommodate the fuel shortage.

The possibility of speeding up the construction of the Washington Metro subway system to meet increased transit ridership demands due to decreases in gasoline availability is not very great. It is very likely that the time required to complete construction of the system has been understated just as the cost of the system has been. The completion of the total system has already been moved back a couple of years, and currently additional money is required just to maintain the current construction schedule. It is likely that increases in Federal capital assistance in the Washington, 13. C. area will improve the chances of the construction schedule being met. However, it is not likely that the construction schedule could be significantly shortened unless additional amounts of Federal money were to become available at earlier dates. Even if this were to happen there would be serious constraints on the degree to which the speed up could be accomplished including:

a) inability of local and State governments to accelerate funding.

b) lack of qualified additional supervisory staff at WMATA,

c) capacity of suppliers to meet earlier delivery dates for certain critical materials and equipment,

d) capacity of local contractors to speed up operations.

In summary, in the Washington, D.C. area, the transit system could handle substantially increased ridership resulting from auto use reductions of up to 30 percent with moderate additional cost, if

(1) at least a year's notice is provided before increased capacity is required,

(2) the timing of the buildup can be dovetailed with the timing of the fuel shortage impact, and

(3) Federal responsibility for major staggering of working hours is achieved.

Employment Generated in Metropolitan Areas by Mass Transit Construction

Information indicates that the employment generated by the construction of regional rapid rail transit systems in both Washington, D,C,, and Atlanta could equal 3 percent of the regional labor force, In Washington, there are currently about 8,000 construction workers plus 1,000 WMATA employees and consultants working on the new rapid rail system. Assuming that the local multiplier adds 80 percent more jobs, the total number of Washington area jobs related to the subway construction is over 16,000. This is more than 1 percent of the total Washington, D.C. labor force and may be responsible for keeping the unemployment rate much lower than the national average, A senior official in a large engineering consulting firm working with WMATA indicated that the reason the unemployment level in the construction industry in Washington, D. C., is very low compared to the national average of 18 percent unemployed is because of the existence of the construction jobs on the new subway.

In Atlanta, a recent study[4] showed the increase of employment attributable to the construction of MARTA in the five-county Atlanta SMSA would be over 21,000 jobs for 10 years. This figure indicates that the construction of a rapid transit system in Atlanta would directly or indirectly employ 2 percent of the Atlanta labor force for 10 years.

The Atlanta figure is not based upon any actual construction and thus may be slightly high. The

[4] Larry D. Schroeder, David L. Sjoquist, and Paula E. Stephan, *Impact on Income and Employment Resulting /rem MARTA Construction Expenditures*, prepared at the request of Robert W. Nelson, Assistant General Manager for Finance and Administration, MARTA, February 1975,

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Chapter XI

National Policy Issues and Possible Initiatives

This final chapter draws upon the results of the analysis reported in the previous chapters, to present a discussion of national policy issues and initiatives appropriate to energy, the economy, and mass transit.

The discussion of policy initiatives in this chapter has three parts:

(I) Options within the framework of current UMTA and Related Programs. This contains a discussion of the types of actions that can be taken within the framework of the existing UMTA program to effectively respond to potential future energy shortages and/or economic downturns. Consideration is given to four basic types of actions which can be taken:

- Changes in funding! levels and distributions among program categories
- Changes in statutory and administrative regulations
- Adoption of special incentives
- New emphases in planning activities

(z) Possible New Initiatives.—A discussion of what Congress might consider beyond the scope of the present UMTA program to achieve substantially increased transit ridership, to conserve oil and other forms of energy, to achieve economic objectives and other national goals related to public transportation. The initiatives considered include:

- No fare and reduced fare transit
- Direct use of substantial new gasoline taxes to support major new transit initiatives
- Use of parking taxes to encourage a substantial shift to transit where feasible
- Doubling of transit operations within the near future
- Initiatives within the highway program to give priority to transit,

(3) Long-run Considerations.—A discussion of the potential energy, economic, and environmental benefits achievable in the long run if new transit and other transportation initiatives are directly linked with (as distinct from coordinated with) land development controls and community development programs, Mechanisms for achievement of these benefits are discussed.

Options Within the Framework of Current UMTA and Related Programs

There appear to be four types of potential Federal initiatives within the present public transportation program framework: (1) changes in funding levels and distributions among program categories; (2) changes in statutory and administrative regulations; (3) adoption of special incentives; and (4) new emphases in planning activities.

(I) Changes in Funding Levels and Distributions Among Program Categories. From the standpoint of UMTA'S ability to approve grants and disburse funds within the existing program structure, there is little possibility for major increases in the rate of spending for capital grants until F.Y. 1978 or possibly even F.Y. 1979 in view of the large carryover of unused authorizations. Any immediate increases in authorization over what is now provided by law should be coupled with congressional action which would significantly simplify UMTA'S administrative requirements.

The major change in distribution of funds which might be considered within the near term would be an increase in the statutory allocation to the Formula Grant funds which may be used for either capital or operating assistance. Indications are that the national level of demand for these funds for operating assistance will exceed the authorized levels easily for both F.Y. 1976 and 1975 at 50 percent matching.[1] Although the agency is just learning how to administer this new fund, the time requirements for disbursing these funds would not be increased if the amount distributed by formula was substantially increased,

[1] Authorized Federal funds for Formula Grants for F.Y. 1975 through 1980 are, in millions: $300, $500, $775, $850, and $900.

A major change which would accelerate the flow of funds would be either an across the board reduction in local matching ratios or authorization for UMTA to reduce the local match under specified conditions. This will be considered further below under "Adoption of Special Incentives. "

A permanent reduction in the 50 percent match for Formula Grants would escalate the issue of Federal versus State-local responsibilities for the scope of subsidized operations. However, a temporary reduction in the local match would provide a quick means of meeting new transit demands,

(2) ***Changes*** in Statutory and Administrative Regulations. The present limitation on maximum state participation in national funds is 12-1/2 percent. Several States could have need for capital grants in excess of this limit at particular times over the next several years.

A requirement which has been a problem for some smaller metropolitan areas making simple applications for bus purchases, etc., has been the need to demonstrate the existence of a continuous and coordinated comprehensive planning process. This is likely to be a problem again for many small cities as they now seek participation under the new Formula Grant program. UMTA could be authorized to waive this provision for small urban areas for simple actions such as the purchase of a few buses or for operating assistance.

UMTA should also be allowed to waive the requirements for public participation in the planning process and for the entire EIS process in cases involving no substantial construction or increase in the size of the bus fleet. If the transit operator serves only the central city it might be feasible to forego the A-95 coordination,

The above liberalizations would speed up projects, particularly in areas under 250,000 population where there is little experience or need for such planning and review requirements.

UMTA could be given authority to make these waivers for larger areas during emergency situations such as the oil crisis. However, experience indicates that the larger the area, the greater the need for the present planning requirements. The waiver should be based on evidence that a provision of the law is restrictive under emergency circumstances.

The present highly centralized structure of UMTA is frequently cited by transit planners and operators as an important and unnecessary cause of delays in implementing programs. It is wasteful to have virtually all routine approvals made in Washington, which is now the case, The program could be significantly accelerated by increasing the competence of field office staff, using FHWA field personnel in many instances, and delegating a large proportion of decision-making responsibility to them, including, for example, most contract approvals, action on operating subsidy grants, and capital grant applications involving bus purchases and other moderate size facilities not involving commitment to the construction of new fixed guideway routes, FHWA has operated this way for many years.

(3) Adoption of Special Incentives. By use of powers to waive some portion of the local match in return for adopting objectives which Congress believes should have a high priority, UMTA could break some local bottlenecks, accelerate desired improvements, or provide incentives for actions which would not otherwise be taken.

A wide array of actions which can be taken to increase ridership on transit were reviewed, Most could be applied immediately if the necessary incentives were offered, such as the reduction of local matching funds, The fact that the current Formula Grant program's local match requirement is so high (50 percent) provides a good opportunity to achieve desired national objectives through the incentive of increasing the Federal share for any projects which meet specified criteria which are otherwise hard to achieve. A change in the law would be required to permit UMTA to lower the local matching requirement. UMTA would need policy guidance from Congress on criteria to be used.

One desirable response to a severe fuel shortage would be an extension of coverage by use of innovations such as "paratransit" (e.g., jitneys) and "demand-responsive" or "Dial-A-Ride" services. A major cause of the slowness in adopting these innovations have been the institutional blocks, Once the incentive policy is accepted it can be used to obtain such ends as the use of existing operators (taxis, limousine services, and transit operators) to provide jitney services ***instead of fighting*** them.

At the opposite end of the service scale are large capital projects for grade-separated modes, The initiation of these projects has been hampered by State-local financing requirements—e,g,, bond issues which must be passed by several jurisdictions, Where plans were already fully adopted UMTA could often avoid these bottlenecks by raising the Federal share.

(4) New Emphases in Planning Activities. All metropolitan areas should prepare emergency fuel conservation plans, such as the Washington, D.C. effort. More detailed planning would be desirable in most cases. The plan should emphasize obtaining the maximum shortrun increases in effective public transportation capacity with available public and private vehicles.

Fortunately the evolution in understanding of the proper role for transportation planning has recently been toward greater emphasis on short-term planning-greater concentration on the resolution of current issues and on an incremental approach to planmaking. There is also growing awareness that important transit benefits can be obtained relatively quickly and at low cost through traffic engineering and traffic regulatory measures, particularly those which give priority to bus operations. Also many metropolitan areas have outmoded route structures which are in need of complete reassessment, making use of new concepts and tools to provide greater efficiency and quality of service. UMTA is beginning to encourage this type of planning. Substantially more planning funds can be devoted to these types of activities which will have much greater near term payoff and which will provide transit operators with a much greater capacity to respond to a future energy crisis or other emergencies.

If the time horizon is extended beyond 5 years there are compelling arguments for acceleration of planning work. Most urban areas do not have up-to-date comprehensive, coordinated plans based on recent, high quality ridership and traffic surveys. Additional funds could effectively be made available to reevaluate out-of-date transportation plans and to creatively develop plans which make better use of new understanding which has been gained in the last few years. This could be done by making available between one and two dollars per capita per year for every area with the expectation that this rate of expenditure could be productively utilized in most metropolitan areas within a relatively short period-about $150 to $300 million per year nationally.

As discussed in the final portion of this section, there are convincing arguments that a major reorientation of suburban and exurban land development patterns and trends should take place. Achievement of more orderly, coherent land development will require widespread changes in views on the future forms of land use by all levels of government. Any broad consensus will require several years to evolve and this type of planning research is greatly needed in each major metropolitan area to assist in shaping that consensus.

The Potential Applicability of the Above Actions to Near Future Economic and Energy Alternatives

(1) Economic Recession. Under this condition the economy is expected to begin recovery within the very near future, Increases in the rate of expenditures will require much more time for their effects to be felt in terms of creation of jobs because of the time requirements involved in grant approvals, project planning and engineering, etc. Hence the discussion becomes more applicable to future recessions.

Some moderate effects in creating jobs could begin to be felt within perhaps 6 months of a decision to increase the amount of Formula Grant funds so that the level of transit operations could be significantly increased, thereby creating more jobs for drivers, mechanics, etc. About 80 man-years of employment will be generated for each million dollars.

A policy of increasing UMTA expenditures for transit operations as opposed to capital improvements has two important advantages as an anti-recessionary policy:

- Its effect will be felt much more quickly, Once the program is in full operation it will be possible to affect employment through increases in operating assistance expenditure rates within perhaps as little as a single quarter.
- Because of the difference in matching ratios, the Formula Grant program can theoretically result in 60 percent greater impact for each Federal dollar spent than the Discretionary Grant Program, (This is somewhat of an exaggeration of the difference in effect because of the fact that local matching funds will tend to be partially shifted from other jobs creating expenditures rather than from net increases in expenditures.)

(2) Economic Depression. Since we are already well into a deep recession, which appears to have bottomed out in the third quarter of 1975, the needed response would be short run in character, with results required before mid-1977. Within this time frame the flow of Formula Grant funds could

effectively be increased substantially, either through additional transfers into the Formula Grant authorization or a reduction in the present 50 percent matching ratio requirement with an offsetting increase in the total Federal program level.

The types of special incentives discussed under "Changes in Statutory and Administrative Regulations" should be considered,

If the depression were to have the potential for running beyond 1977 as assumed in our worst case analysis, then the acceleration of capital grants could begin to have significant impact on employment in several metropolitan areas and in equipment supplying industries, but only if a policy of lessening Federal requirements were enunciated and energetically pursued along the lines discussed.

(3) Economic Recession Plus Mild Energy Decrease. Same as Economic Recession above.

(4) Recession Plus Moderate Energy Decrease. Same as Economic Recession plus application of the first special incentive—fostering expansion of ubiquitous, low capital cost, low capacity transportation systems in areas with little or no existing transit service. Jitney and Dial-a-Ride services on a scale proportionate to demand should make it much more practical to cope with significant reductions in private auto trips. Efforts should concentrate on the heavier, more aggregated trip flows where it would be most efficient to provide a good quality of substitute public service.

(5) Depression Plus Severe Energy decrease. This will place the maximum demands on the program. The Severe Energy Decrease, if introduced in the present period of recession, would lead to depression, and the length of the period of distress would be significantly longer than for the other alternatives so that long term considerations become more important. The present UMTA program framework could still be utilized but the overall funding levels should be substantially increased. UMTA'S speed and effectiveness of administrative action would have to be improved immediately to cope with increased program levels.

It would be desirable to implement three of the modifications to the present UMTA program outlined above: (a) reduce local matching shares, both capital and operating funds, (b) increase the relative proportion of all funds going to operating assistance, and (c) remove some of the constraints such as the maximum state participation ratio, the planning requirements for operating assistance and small capital expenditures for rolling stock purchases, and various project planning process requirements.

Special incentives should be adopted as described for increasing the coverage of transit services and for accelerating the start of major fixed investment systems.

The longrun implications of this most drastic of the alternatives call for a major, immediate effort to revise areawide transportation plans and to evaluate alternative land use transportation configurations and implementation measures.

Possible New Initiatives

The preceding discussion can be characterized as cautious because it asked only what might be done within the framework of the existing UMTA program to address potential problems. This section, by contrast, will explore several of the most promising initiatives that Congress might take beyond the current commitment to transit. This discussion assumes that it is preferable to take positive action now to reduce energy consumption and to increase transit ridership, rather than to merely be prepared to accommodate future emergencies when they occur.

Analysis shows that current policy will not result in energy conservation and will not result in any dramatic increases in transit use. A continuation of current policy, when viewed from an overall national perspective, will probably result in an approximate stabilization of transit's proportionate role in urban transportation. Unless there are future substantial energy shortages, automobile use will grow at roughly 3 percent or more per year. Transit systems will be improved in amenity level, but the overall extent of service will not change very much in percentage terms, nor will average transit fares as a whole. Thus transit improvements will be just sufficient to prevent further significant decline in patronage, but not enough to change transit's competitive position with respect to the auto/highway system.

Analysis also shows that there is a wide variety of actions that can be taken which can improve transit ridership and/or decrease energy consumption. Their effectiveness varies widely. Out of a large number of potential actions analyzed most actions are not likely to affect as much as a ten percent increase in ridership nationally and none could individually result in a doubling of transit use over the next 5 years. However, the most ambitious and effective actions could result in reaching and even exceeding the doubling of ridership benchmark if the actions are taken in combination with each other. Many of the actions when taken alone cause problems which can be offset by other actions considered.

The attractiveness of combining different major policy actions is, in fact, one of the major findings of this analysis. There are several aspects of this finding regarding the complementarily of different actions which will be brought out in the consideration of each of the more important policy actions below:

No Fare and Reduced Fare Transit. Moderate success in keeping fares down or achieving reductions has been achieved recently. The long term rate of increase in fares has been reduced to about the inflation rate or less. Making funds available for operating assistance will probably assure a stabilization of fares, over the next few years perhaps even in constant 1975 dollars—i. e., generally keeping the same cash fare despite inflating costs.

The NMTA Act of 1974 authorized $20 million per year for 2 years for no fare demonstrations in several cities, but no funds have been appropriated and none have yet been requested by UMTA.

Advertising 13us f-are Reduction On Tickets in Denver, Colorado

There may be a lack of recognition of the costs involved. The $20 million per year will not cover areawide no fare transit demonstrations except in the smallest metropolitan areas. It would cost several times that amount for the Washington, D.C. metropolitan area alone.

If there were no new ridership, no fare transit would have cost about $3 billion in 1974 nationally. About a 60 to 80 percent ridership increase could be expected, however, raising the cost of no fare transit to about $5 billion per year in 1974 dollars if it is assumed that transit operations would be increased to hold load factors approximately constant.

No fare transit in the offpeak periods only would cost substantially less—roughly one billion in 1974 dollars over current levels of operating assistance, and would provide many of the benefits of round-the-clock no fare transit,

No fare transit would produce the largest increase in transit ridership of any action that has been considered. Additional advantages of such an action include:

- Greater increases in offpeak ridership and therefore better utilization of manpower and equipment, This would be particularly true of an offpeak no fare program,
- Compared to most of the other actions considered, it could be implemented relatively easily on a national basis through Congressional action.
- Benefits would generally be greatest among those most in need of increased mobility—the young, the elderly, the poor, and many of the handicapped, Offpeak no fare transit would concentrate the benefits among these groups to an even greater extent.
- It would necessarily result in improvement of service, in part because it would do away with the inconvenience to users of having to have exact change, and in part because it would permit faster transit operations.
- The increase in ridership resulting from no fare in peak periods would require a 30 to 50 percent increase in transit operations thereby causing substantial increases in frequency and coverage of transit service—in itself one of the most effective actions which can be pursued. On the other hand an offpeak no fare program could be implemented without requiring increases in the transit fleet,
- No other action could produce such large scale results so quickly. Capital investment in rapid transit systems in the same order of magnitude ($5 billion/year) could probably produce similar ridership increases, but probably not within 10 to 15 years,

On the negative side, such a policy would be difficult to reverse—one good reason for demonstrations before making a national commitment.

Another objection is that unnecessary, frivolous travel will be encouraged causing unjustified public costs, To some extent this may happen, but limited experience indicates it would not be a serious problem. Frivolous use of transit is not likely to occur in peak periods when crowding might occur. Reduction of fares to low values (e.g., IOcents to 25cents) might accomplish much of the objectives of a free fare program while limiting these problems.

A third negative argument is that other types of public transit improvements are more effective in achieving the same objectives. This has much validity within a limited framework. Various types of service improvements can be more cost effective when the service improvements can be made at moderate marginal cost and in areas where demand is very sensitive to the level of service. However, there are many conditions under which it is more cost effective to lower or eliminate fares than to improve service. This occurs, for example, when costs of improving service are very high such as when it would be necessary to construct grade-separated rapid transit in order to improve service. It occurs also when service improvements will yield few additional riders because the level of service is already quite good, or when fares are very high. Fare reduction or elimination is also most cost effective in lower income areas. When considering very major potential investments in transit, many of these diminishing returns come into play.

More importantly, the combination of service improvements and fare reductions becomes quite clear when considering major improvements. Fare reductions without service improvements will cause greater crowding and hence make service improvements critical. Similarly, service improvements alone will effectively attract higher income transit users but will have little influence on lower income potential users if fares are high.

A no fare or substantially reduced fare program nationally would probably have to involve a higher Federal matching ratio than the current 50 percent, At that matching ratio, State and local governments would have to increase their subsidy for transit operations by about $2-1/2 billion to cover the full cost. They almost certainly would not, or could not do so. An increase to 80/20 matching, such as now used for the regular capital grant program, would approximately pay the total operating cost of a national no fare transit program (about $5 billion) with no substantial increase from the 1974 amount that State and local governments put into operating assistance. To cover the Federal share of an 80/20 no fare program an increase of the Formula Grant funds would be required (currently $3OO million, increasing to $900 million by 1980) to about $4 billion per year. A considerably lower Federal matching ratio and dollar amount would be sufficient to attract most metropolitan areas to a no fare program. As noted previously an offpeak no fare program would cost about one billion dollars per year over current operating assistance levels.

Something less than a complete national no fare program is likely to be justified by a careful cost effectiveness analysis. Offpeak free fares will affect ridership more and will benefit disadvantaged groups relatively more than peak period free fares. It would also encourage staggering of work hours, better utilization of equipment, and a reduction of capital requirements for increased rolling stock.

Demonstrations must be carefully planned, because they will be costly and because of the complexities of the research that is needed.

Origin-destination (OD) surveys should be taken before and during the experiment. OD surveys should probably involve onboard surveys, followed by indepth home interview surveys for relatively small subsamples of riders. Changes in travel habits should be carefully assessed including new trips not previously made as well as all changes in trip patterns. The demonstration should last at least a year to allow habits to change; the full effects will actually take longer to be felt through decisions on auto purchases, residential location, etc.

Consideration should be given to dividing a metropolitan area up into pie-shaped wedges differing as to fare policy, The service areas might include each of the following: (a) no fare at all, (b) offpeak no fare, (c) one or more low fares, and (d) no reduction, This could be difficult for local officials to do politically and may even be difficult for UMTA to achieve,

Use of ***Gasoline*** Taxes To Support Major New Transit Initiatives. The ***50*** percent gas tax (about 30cents gal.) analyzed would have far greater effect on oil consumption than any other action analyzed—about ten times as much effect as packages of ambitious pure transit incentive actions. It would have relatively little effect on transit ridership because gas price increases tend to have more effect on the long term fuel economy of autos than on short term “travel behavior. Nonetheless, this rather modest effect on transit ridership is fully complementary with other actions such as transit fare reductions and expansion of transit service,

The most important potential relationship between a major gasoline tax and transit, however, is not the effect on ridership but the potential it has for financing transit incentives.

A 30cents gasoline tax would generate roughly $12 billion/year nationally, taking into account the effects of the tax in reducing auto travel.

There has been a great deal of resistance to the application of gas taxes in this order of magnitude, based largely on the burden it would cause low and moderate income households who are dependent on automobile transportation for essential travel. This burden could be alleviated by selective tax rebates, as has been seriously proposed in draft legislation.

What may not have been widely recognized, however, is the direct substitutability of transit ***within*** metropolitan ***areas,*** particularly if transit is substantially improved.

A comprehensive legislative action might involve financing of some of the major new transit initiatives considered here from a major new gas tax that would affect only residents of metropolitan areas. To avoid the problems that would be caused by vastly differing retail prices from place to place, the tax could be applied nationwide but full (or partial) rebates of new fuel taxes could be provided to all residents of nonmetropolitan areas and to all with low or moderate incomes.

A 30cents **gas tax** applied to residents of metropolitan areas would generate roughly $8-1/2 billion annually. Half of this amount, over $4 billion, should be sufficient to finance the Federal share of a major transit incentive program of the scale analyzed. Only about 4cents per gallon tax would be required to finance an offpeak no fare program.

One simple mechanism to achieve a program of this type would be through the existing Highway Trust fund, channeling the funds added by the tax increase **to** the urban system program; comparatively moderate changes in the structure of the law would be required to achieve this.

Use of Parking Taxes to Encourage a Substantial ***Shift*** to ***Transit Where Feasible.*** Selectively applied parking taxes could be one of the most effective actions possible.

The specific action analyzed in this study was a parking tax of ***$1.50*** applied to auto commuters (long term parkers) working in those portions of metropolitan areas well served by transit,

This tax would directly affect only about 20 percent of all employment in metropolitan areas and less than 5 percent of all auto trips, yet it would have a significant effect on transit ridership—about a 15 percent increase, considerably greater than the 5 percent increase in transit ridership estimated as the impact of a 50 percent increase in the price of gasoline.

A disadvantage of this action taken alone is that the increase in transit ridership would be concentrated in the peak period, necessitating a 20 to 30 percent increase in the size of the transit fleet and comparable increases in operating costs. When coupled with a no fare program, however, this effect is offset, particularly if it were an offpeak no fare program.

The parking tax is very efficient from an energy conservation standpoint because more than 80 percent of the new transit riders would otherwise have been auto drivers. Additional fuel savings would be realized by substantial increases in carpooling—auto occupancy for affected trips is estimated to increase from about 1.17 to 1.40,

If the application of such a parking tax was directly Iinked to the substantial improvement of transit in the same area, the tax would be more palatable. This is an important feature because of the resistance that parking tax plans have received in the past. A second, related feature is that the tax would not apply to short term parking in the areas taxed. Short term parking is used largely for shopping, personal business, and the like. Downtown merchants, who must compete with suburban merchants, seriously oppose taxes on short term parking,

A nationally applied parking tax of the type analyzed could generate up to about $1 billion annually. However, the concept of a uniform $1.50 tax would be inappropriate in actual practice—a lesser amount would be justified in smaller metropolitan areas.

The parking tax would be difficult if not impossible to be applied directly by Congress. In addition to questions of authority and feasibility, there would be problems in defining precisely where the taxes would apply. An alternative approach would be for Congress to provide the incentive for State or local governments to implement such taxes by making Federal funds available for major transit improvements—provided that the parking tax is levied to generate additional funds for the local match.

Major Increases in the Level of Transit Operations. ● Doubling of the fleet of rolling stock by 1980 is about the practical upper limit on delivery by manufacturers, allowing for needed replacements of old vehicles.

Achievement of this objective would fully provide the capacity that would be needed to accommodate the demand for transit service generated by potential severe oil shortages in the future-more than 21/z times the level that would be required under a 6 million barrel per day reduction.

It would also provide about a 50 percent greater expansion of the transit fleet than would be required to accommodate the ridership that would be induced by a national program to no fare transit,

Doubling of transit service would increase peak period ridership by up to 25 percent and offpeak by up to **50** percent. The peak-to-base ridership ratio would thereby increase. If this were combined with the other major actions discussed, the utilization of drivers and vehicles would be improved in the peak period with the increase in load factor being greater in the offpeak.

The total national cost of doubling transit operations (excluding inflation) would be about $3 billion per year, $2 billion of which was included in the cost estimate stated above for no fare transit. To clarify:

Operating cost of current national transit operations:	$3 billion/yr.
Added cost of operations resulting from a no fare program due to increased ridership:	$2 billion/yr.
Added cost if operations are further expanded to double current levels:	$1 billion/yr.
TOTAL	$6 billion/yr.

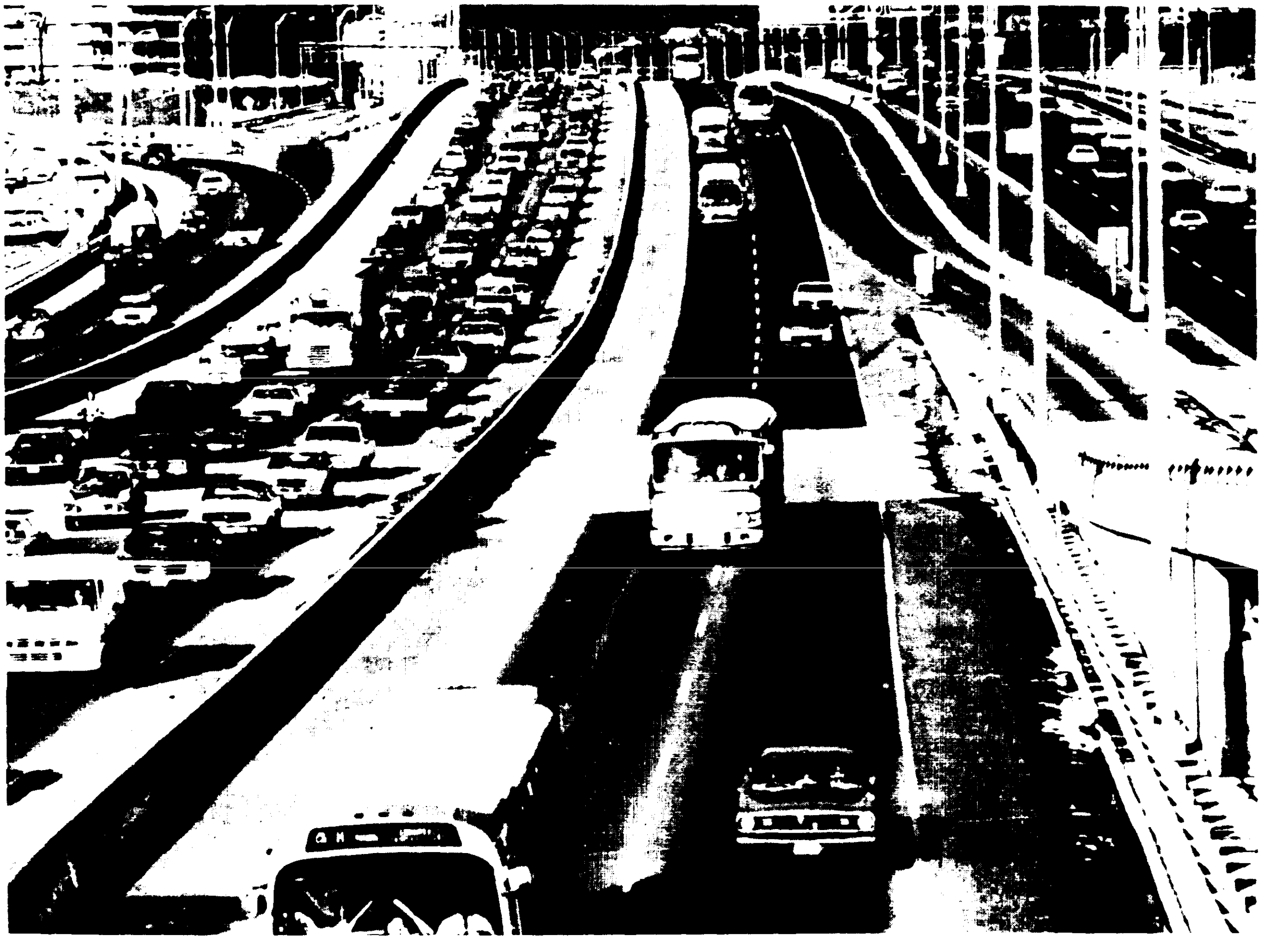
Washington, D.C. Bus Street

Initiatives Within the Highway Program To *Give* priority to Transit. A large number of individual actions can be cited as examples of significant measures that have been taken within the framework of the highway program to encourage public transportation, On the other hand, a great many more examples can be cited which have significant negative effects on transit. and energy consumption, The negative examples include all highway improvements in metropolitan areas which provide additional capacity or speed the flow of traffic for automobiles bound for destinations well served by transit, This includes a large percentage of highway improvements in metropolitan areas, In addition there are a great many more examples of missed opportunities to assist transit and conserve energy,

The basic problem is that the highway program has generally not been reoriented as a positive instrument of public policy to achieve today's widely accepted goals for urban transportation. The strong positive policy of encouraging the construction of the Interstate Highway System and other types oi general purpose highways, in urbanized areas and elsewhere, which developed in the 1950's, has generally been modified only to the extent of permitting States and localities to redirect this major thrust if they take contrary initiative.

Congress could achieve substantial short- and long-term objectives associated with the encouragement of transit and the conservation of energy if the urban highway program were positively reoriented to the achievement of these policies. This would mean that the emphasis would have to shift from the large scale construction of general purpose highways to construction of transit facilities and to operating measures to discourage auto use and encourage transit use, including the full array of actions which have proved effective:

- bus priority lanes on existing streets;
- construction of busways;



Transit and 4-Car Pool Riders Passing Frustrated Drivers, Washington Metropolitan Area

55-713 O - 75 - 8

- signalization and traffic engineering measures to give priority to transit;
- bus ramps on existing freeways;
- fringe parking;
- peak period tolls and other pricing mechanisms; and
- construction of transit shelters, stations, etc.

Strong incentives and restrictions to ensure achievement of these objectives could be built into the urban highway program in much the same way as the freeway construction incentives and restrictions were developed for the highway program a generation ago.

LONGRUN CONSIDERATIONS

Background

In order to achieve longrun national energy and conservation objectives, Federal policy affecting land development must be more closely tied to the provision of public transportation services. The patterns of metropolitan growth that exist today are neither conducive to transit usage nor to the reduction of energy consumption. Given the developed status of metropolitan areas, actions which could be undertaken to effect the short term appear to be minimal. However, in the long term, actions could be initiated which would shape and guide development into more positive relationships with transit and energy.

The predominant pattern of recent growth is sprawl, a distribution of single-use centers of activity dispersed at low densities in the metropolitan landscape. This is a pattern which has been encouraged by diverse, uncoordinated public sector actions. The interstate highway program, and FHA and VA mortgage programs contributed to the outmigration from central cities. The growth which occurred in fringe areas has been largely scattered at low densities, In addition, zoning practices separated different uses from each other, which has resulted in single use activity areas. Rarely have residential developments, shopping centers, campus office developments or industrial parks been combined in close proximity.

Because different activities are separated from each other, causing more and longer auto trips to be made, and because densities do not usually generate sufficient demand for transit service, the sprawl development pattern consumes a greater amount of energy for transportation purposes than any other pattern according to “The Cost of Sprawl,” a report issued by the Council of Environmental Quality.

The greater vehicle miles traveled associated with sprawl results in a minimum of 19 percent more air pollution than other patterns. Annually, there is at least 11 percent more sediment from erosion and 7 percent greater pollutants from storm runoffs. Economically, sprawl is the most costly development pattern to construct and operate. It is most inefficient in terms of utilities, sewers, roads, and other infrastructure.

Alternative Development Patterns and Their Relationship to Transit and Energy

There are alternative development patterns which public policy could help foster which could overcome some of today’s energy problems. For instance, “The Cost of Sprawl” examined the travel characteristics of different community prototypes comprised of various combinations of housing types. The findings indicate that with regard to gasoline consumption related only to transportation within prototypical communities of 10,000 dwelling units, the low density sprawl pattern consumed approximately 855 barrels per day as compared with 695 barrels per day for low density clustered developments, a saving of 19 percent or 160 barrels daily,

Based on Census Bureau projections, if 70 percent of the Nation’s growth occurs on “the fringe of metropolitan areas (as occurred between 1960-70), then by the year zooo the suburbs will experience an increase of approximately 10 million new dwelling units.

If these 10 million dwelling units were to be developed in low density clustered patterns rather than low density sprawl, the 25- year energy savings would amount to approximately 2,404,000 barrels of gasoline, assuming an equal number of units are built annually,

In effect, if growth could be accommodated in single family detached dwellings in clustered rather than sprawl patterns without any other initiatives, at the end of the 25-year period the daily savings in gasoline would be 160,000 barrels per day. This energy savings would be directly attributable to reduced automobile travel. It is therefore, possible to maintain the single family home, and by shaping development patterns to realize a 19 percent annual reduction in energy consumption. In addition, because these patterns do not account for the leapfrog impact of scatteration on a regional scale, the 19 percent is conservative.

In addition to this type of action to influence the pattern of residential land use, other patterns of development could be fostered. Combining residential, employment, recreational, and cultural uses in close proximity, alternative development patterns could become multiuse centers which contained a range and diversity of activities and physical characteristics. These compact, multiuse activity centers would be distributed in a regional setting, and organized into a network closely related to transportation facilities.

Policy Implications

In order to achieve the long-term benefits cited above, major public policy initiatives are required which would respond to the interrelationship between development and transit.

In particular, Federal actions could seek to establish strong linkages between existing community development programs and transit programs in order to effect a coordinated national urban growth management policy. This policy could provide a framework to integrate a number of programs, For example, capital grants for sewage systems and water supply systems could be tied to the availability of transit services in communities, and to specific development patterns. The HUD New Towns program could establish requirements for transit as a prerequisite for loan eligibility. Mortgages and subsidies for community development in fringe areas could be oriented toward multiuse, clustered activity centers related to transit. The street networks and infrastructure in new communities could be an expansion of the Federal Aid Highway program funded by the trust fund. In effect, organized and systematic policies for public investment in infrastructure within existing programs could serve as an effective lever to guide and manage growth.

SUMMARY

This chapter discussed options within the framework of current UMTA programs to respond effectively to future energy shortages or economic downturns, possible new initiatives beyond the scope of the present program, and energy, economic and environmental benefits achievable in the long run if new transportation initiatives are directly linked with land development controls and community development programs.

Possible options within current UMTA and related programs which were discussed included changes in funding levels and distribution among program categories, changes in statutory and administrative regulations, adoption of special incentives, and new emphases in planning activities. It was noted that an increase in the statutory allocation to the Formula Grant funds would be useful in achieving a number of national objectives. Also, a number of instances were identified where modification of existing statutory or administrative regulations could eliminate unnecessary delays in program implementation. How these options might be applied and their effectiveness in responding to economic downturns and energy shortages was also discussed,

Possible new initiatives were identified which go beyond the current commitment to transit in promoting transit ridership increases and in achieving other energy and economic objectives. It is noted that current policy will neither result in energy conservation nor promote dramatic ridership increases, The discussion assumes that it is preferable to take positive actions now rather than to merely be prepared to accommodate future economic and energy emergencies.

The range of initiatives assessed includes no fare and reduced fare transit, direct use of new gasoline taxes to support transit, use of parking taxes to encourage shifts of auto drivers to transit, a substantial increase in transit operations, and initiatives within the highway program to give priority to transit.

It is noted that strategies incorporating disincentives to auto use are far more effective than pure transit incentive strategies involving actions such as fare reductions and service improvements. However, it is further noted that transit ridership increases generated solely through auto disincentives would have an adverse effect on transit agency finances. As a result, special emphasis is placed on the need for a combined strategy as a means for promoting energy conservation without adversely affecting transit agency finances and without lowering the efficiency of the transit fleet.

The discussion of long-run considerations examined development patterns and their relationship to transit and energy. It is noted that existing patterns of metropolitan growth are not conducive to achieving major increases in the use of transit and energy conservation and that substantial long-term benefits could be achieved through actions which encourage alternative development patterns. In this regard, a number of public policy initiatives which respond to the interrelationship between development and transit were discussed.

Appendix A

Documentation of Forecasting Techniques

This appendix provides technical documentation of two special studies carried out as part of this research effort. The intent of the first study was to determine which energy and economic variables were most closely correlated with past changes in transit ridership as a basis for analyzing past trends and predicting the impact on transit ridership of assumed economic and energy futures. For this purpose, two sets of national time series data (1952-74 quarterly data and 1971-74 monthly data) were analyzed using a computer based stepwise regression technique. The relationship between transit ridership and the unemployment rate taken from the regression analysis of 1952-74 national time series data was used to predict the effect of the recession and depression economic futures on transit ridership. These results are discussed in Chapter V. The relationship between transit ridership and highway vehicle miles of travel (VMT) taken from the regression analysis of 1971-74 national time series data was used to predict the effect of energy decrease futures. These results are discussed in Chapter VII.

The intent of the second study was to develop a technique for assessing the impact of changes in the times and costs of auto and transit travel on national transit ridership. This technique was applied to predict the transit ridership response to major transit incentive and auto restraint actions. These results are discussed in Chapters VIII and IX.

The reader is warned at the outset of the rough nature of these studies. They were carried out to inform policy analysts at a level where the availability of tested models is limited and the relationships to be modeled are complex. Recognizing this, special emphasis was placed on assessing the reasonableness of findings in the context of whatever empirical evidence was available.

Time Series Analyses of the Effect of Economic and Energy Conditions on Transit Ridership

Two time series analyses were carried out to assess the relationship between transit ridership and energy and economic conditions. The first used national quarterly data from 1952 to 1974 and the second used national monthly data from 1971 to 1974. The intent of these analyses was to determine which energy and economic variables are most closely related to transit ridership and to develop equations using these variables to predict transit ridership under various assumed future conditions.

The need for two different time series was based on the assumption that energy conditions have exerted a significant influence on transit ridership only in the recent past, particularly during and after the oil embargo, while the effects of economic conditions could be better estimated over a longer time period which included the several postwar recessions. This assumption was verified by the results discussed below.

Long Run (Quarterly from 1952 to 1974) Input data

Quarterly data from 1952 to 1974 was collected for the variables shown in Table 39. Additional long run time series variables were generated as indicated in Table 40.

Short Run (Monthly from 1971-74) Input Data

Monthly data from 1971 to 1974 was collected for the variables shown in Table 41. The variable "Revenue Passengers" was adjusted by the application of a factor which reflects the number of weekdays, Saturdays, Sundays, and holidays in each month from 1971 to 1974, i.e.:

$$\text{Adjusted Revenue Passengers} = \frac{(\text{Revenue Passengers})}{(1.00 \times \text{WEEKDAYS} + .675 \times \text{SATURDAYS} + .425 \times \text{SUNDAYS} + .425 \times \text{HOLIDAYS})}$$

Data Transformation

All of the above variables prefixed by the letter "B" were transformed by (1) calculating their ratio with respect to the same month or quarter of the previous year (we will refer to this as the annual change ratio) and (2) taking the natural log of this ratio:

$$L(i) = \ln \frac{B(i)}{B(i-4)}$$

for quarterly data, and

$$L(i) = \ln \frac{B(i)}{B(i-12)}$$

for monthly data.

TABLE 39

Quarterly Time Series Input

Name	Description	Sources
BGNP	GNP (billions of 1958 dollars)	*Business Conditions Digest*
BUR	Seasonally adjusted unemployment rate (% of civilian workers)	Bureau of Labor Statistics
BUCW	Seasonally adjusted unemployed civilian workers (thousands)	Bureau of Labor Statistics
BDPI	Disposable personal income (billions of 1958 dollars)	*Business Conditions Digest*
BHUF	Highway use of motor Fuel (millions of gallons)	*FHWA Highway Statistics*
POP	U.S. Population (thousands)	*1973 Business Statistics* and *Survey of Current Business*
BRP	Transit Revenue Passengers (thousands)	APTA *Monthly Transit Traffic Bulletin*
BAFRP	Average fare per revenue passenger (undefeated)	System Design Concepts computation from APTA *Transit Fact Book*
TMPG	All highway vehicles miles per gallon	FHWA *Highway Statistics*

TABLE 40

Quarterly Time Series Data Generated

Name	Generation	Description
BPHUF	(BHUF/POP X 1000)	Per capita highway use of motor fuel (gallons)
BPRP	(BRP/POP)	Per capita transit revenue passengers
BTHM	(BHUF X TMPG)	All highway vehicle miles of travel (millions)
BPTHM	(BPHUF X TMPG)	Per capita all highway vehicle miles of travel
BPGNP	(BGNP + POP X 1,000,-000)	Per capita GNP (1 958 dollars)
BPDPI	(BDPI / POP X 1,000,-000)	Per capita disposable personal income (1 958 dollars)

TABLE 41

Monthly Time Series Input

Name	Description	Sources
BPCEZ	Personal Consumption Expenditures (billions of 1958 dollars)	*Business Conditions Digest* and *Business Statistics*
BGNPZ	GNP (billions of 1958 dollars)	*Business Conditions Digest* and *Business Statistics*
BURZ	Seasonally adjusted unemployment rate (% of civilian workers)	Bureau of Labor Statistics
BUCWZ	Seasonally adjusted unemployed civilian workers (thousands)	Bureau of Labor Statistics
BUVMTZ	All urban highway vehicle miles of travel	FHWA Program Management Division
BTVMTZ	All highway vehicle miles of travel	FHWA Program Management Division
BAFRPZ	Average fare per revenue passenger	System Design Concepts Computation from APTA *Transit Fact Book*
BGSZ	Gasoline sales	FHWA *Highway Statistics*
WKY) SAT) SUN) HOL)	The number of weekdays, Saturdays, Sundays and holidays in a given month.	APTA Monthly Transit Traffic Bulletin
RPZ	Transit revenue passengers (thousands)	APTA Monthly Transit Traffic Bulletin

Analytic Procedure

The analytic procedure employed a computer-based stepwise regression analysis. The computer tested equations of the form

$$\ln (Y) = ai \ln Xi$$

where Y represents the annual change factor for transit ridership and the Xi represents the annual change factors of other variables.

In each step of the computation procedure, the computer could enter or remove a single variable. An F-ratio was calculated to determine which variable would be entered or removed.

The computation procedure enforced a zero regression intercept. This meant that annual changes in transit ridership would be related only to annual changes in variables measuring energy and economic conditions, If there is a strong up or down trend in transit ridership unrelated to the economic and energy variables tested, it would not show up in the results. To circumvent this problem, an artificial variable with a constant annual change factor was generated and included with the other economic and energy variables which might be entered in a particular step.

Results of the Long Run Regression Analysis of Transit Revenue Passengers

The regression coefficients, their standard errors and the R2 values (calculated about zero, not about the mean) of the first three steps of the long run regression analysis of transit revenue passengers are shown in Table 42. The variables entered were: were:

1. average fare per revenue passenger (LAFRP)
2. seasonally adjusted unemployment rate (LUR) and
3. highway vehicle miles of travel (LTHM).

Subsequent steps entered variables which were highly colinear and produced minimal increases in R2.

From 1952 to 1974, the variable most strongly related to transit ridership was average fare. The negative coefficient indicates that increases in average fare are associated with decreases in ridership, as would be expected. However, the magnitude of the coefficient is larger than expected. It suggests that the price elasticity of transit ridership is -.64 while other studies have indicated a price elasticity of about —.3 or slightly higher. A likely reason for this discrepancy is that the computer procedure does not distinguish ridership declines due to fare increases from fare increases by transit agencies to compensate for declining revenues. Thus, the decline in ridership actually caused by a 1 percent fare increase should be less than the .64 percent indicated in the above equation.

After average fare, the unemployment rate proved to be the variable most strongly related to transit ridership. The finding that the unemployment rate is the national economic indicator most closely correlated with transit ridership suggests that the primary impact of worsening economic conditions on transit ridership is a reduction in transit work trips associated with increased unemployment, rather than a general reduction in more discretionary transit travel associated with decreased personal income. However, despite the (statistical) significance of the relationship between unemployment and transit ridership, the actual decrease in ridership which would be predicted from an increase in unemployment is relatively small. Assuming that the fare remains constant, an increase in the unemployment rate from 5.0 percent to 7,5 percent would cause a decline in transit ridership of about 2 percent.

The relationship used to estimate the effect of the recession and depression and economic futures on transit (discussed in Chapter V) was taken from the second step of the regression analysis of 1952-74 national data. To assess the validity of this relationship between transit ridership and the unemployment rate, it was applied to the increase in unemployment which occurred between October 1973 and December 1974. The resulting estimate of the associated decrease in transit ridership was compared with the decrease estimated from national data using an analysis of the impact of incremental unemployment on transit riders hip (described in Chapter V). In both cases, the decrease in transit ridership estimated to be caused by the increase in unemployment was about 2 percent.

In the third step of the long run regression analysis, the variable entered was highway vehicle miles of travel. While the size of the coefficient of this variable was roughly consistent with the results of the shorts run regression analysis described below, the entrance of this variable caused an unreasonably large reduction in the coefficient of average fare due to problems of collinearity.

Results of Ihe Short Run Regression Analysis of Transit Revenue Passengers

The regression coefficients, their standard errors and the R2 values of the first three steps of the short run regression analysis are shown in Table 43. The variables entered were:

1. highway vehicle miles of (LTVMTZ)
2. the artificial variable representing a constant annual change factor (LCONZ)
3. gross national product (LGNPZ)

As with the long run analysis, subsequent steps entered variables which were highly colinear and produced minimal increases in R2.

The variable most strongly related to transit ridership in the 1971-74 time period was total highway vehicle miles of travel. In selecting vehicle miles, the regression procedure rejected average fare and the unemployment rate, the variables

TABLE 42

Long Run (Quarterly) Regression of Transit Revenue Passengers (LRP)

- **First three steps shown**
- **Independent variables entering were LAFRP, LUR, LTHM,**
- **R2 and standard errors of coefficients calculated about zero, not about the mean.**

Step Number	Coefficients of Independent Variables (Standard Errors of Coefficients) LAFRP	LUR	LTHM	R2
1	–.7081 7 (.06772)			.5597
2	–.64044 (.06854)	–.04943 (.01 641)		.6022
3	–.1 7607 (.1 0225)	–.09545 (.01 636)	–.64858 (.1 1 668)	.7092

TABLE 43
Short Run (Monthly) Regression of Adjusted Transit Revenue Passengers (LFRPZ)

- **First three steps shown**
- **Independent variables entering were LTVMTZ, LCONZ, LGNPZ**
- ***R2 and standard errors Calculated about* zero, not about the mean**

Step Number	Coefficients of Independent Variables [Standard Errors of Coefficients] LTVMTZ	LCONZ	LGNPZ	R^2
1	-.58696 (.1 2505)			.4004
2	–.86580 (.09881)	.03196 (.00533)		.7175
3	–.48734 (.1 2670)	.04888 (.00691)	–.65668 (.1 6747)	.8111

which were most strongly related to transit rldership in 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 Iongrun 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 shortrun regression analysis did not explicity 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.

The relationsip between transit ridership and highway vehicle miles of travel taken from the second step of the shortrun regression analysis was applied to predict the impact of energy decrease futures on transit ridership (described in chapter VII). For this purpose, estimates of the decrease in highway vehicle miles of travel associated with each of the three energy decrease futures were made based on assumed improvements in passenger car fuel economy in the 1975-80 time period.

To assess the validity of the relationship between transit ridership and highway vehicle miles of travel, it was applied to the 8.5 percent decrease in highway VMT which occurred between February 1973 (prior to the fuel crisis) and February 1974 (when the fuel crisis was at its peak). These months differed little in terms of average transit fare or unemployment. The regression relationsip predicted a 7.9 percent increase in transit ridership as compared to an 8.4 percent measured increase, according to APTA Monthly Transit Traffic Bulletins.

The fact that GNP was entered on the third step with a minus sign is counter to expectation, given that highway vehicle miles of travel had been entered on the first step. The shift of travelers from transit to auto would be expected with increases in GNP. However, this effect should be accounted for by the highway vehicle miles of travel term in the equation and increases in GNP at a fixed level of highway travel would be expected to increase transit ridership.

A Technique for Forecasting the Effect of Major Transit Incentive and Auto Restraint Actions on Transit Ridership

This section describes an analysis of the impact upon transit ridership of changes in the times and costs of auto and transit travel. The analysis led to the development of an equation relating these changes (expressed in absolute terms) to percentage changes in transit ridership.

This equation was applied to predict the ridership response to major transit incentive and auto restraint actions (discussed in Chapters VIII and Ix) .

This equation was based on an extension of logit mode split models to account for the fact that improvements in the time and cost of transit travel may induce additional trips, rather than just divert travelers from other modes. As will be discussed below, this extension is important if the technique is to produce results consistent with past experience in the implementation of transit fare reductions and service improvements. Another virtue of the technique is that it provides reasonable results for large changes in the time and cost of travel by various modes. Several other techniques produce results consistent with empirical evidence for small changes in times and costs but produce unreasonable results for large changes.

Key findings of this analysis cited in the main body of the report include the following:

- the predicted transit ridership response to eliminating the out-of-pocket cost of transit travel is a 40-60 percent increase in transit ridership. An additional 20 percent ridership increase would result from associated service improvements including a 40 percent increase in transit vehicle miles of operation and faster bus speeds in the peak period made possible by eliminating the time associated with fare collection. Thus, the net effect of no fare transit and related service improvements is estimated to be a 60-80 percent increase in transit ridership.

Past experience with small transit fare increases suggests that for a unit percent increase in the fare, a .33 percent decrease in ridership results (i. e., a transit price elasticity of –.33).

The equation used to estimate the effect of changes in travel times and costs produces results consistent with this experience for small fare increases or decreases. However, for large fare decreases, the equation produces larger ridership increases per unit percent reduction in the transit fare, e.g., the 40-60 percent increase in ridership noted above rather than a 33 percent increase which would be the case if the percent ridership increase per unit percent reduction in the transit fare was a constant ratio.

The finding that this ratio increases for large fare reductions is consistent with the Atlanta experience where a decrease in the transit fare from 40$ to 15C (a 62.5 percent decrease) is estimated to have caused a 28 percent increase in ridership. This increase is larger than would be anticipated by applying the transit price elasticity estimated for small fare changes.

- The effect of a 50 percent increase in the price of gasoline would be less than a 10 percent increase in transit ridership.

- A $1.50/day increase in the price of commuter parking in areas well served by transit (downtown areas of large SMSAS, containing about 25 percent of SMSA employment) has a far greater effect on transit ridership than a 50 percent gasoline price increase, causing about a 15 percent increase in transit ridership on a national basis.

As an independent check of the effect of a 50 percent increase in the price of gasoline on transit ridership, the decrease in highway VMT associated with this increase in the price of gasoline was estimated and the relationship between transit ridership and highway VMT taken from the short run (1971-74) regression analysis was applied. This led to the same conclusion—that a 50 percent increase in the price of gasoline would cause less than a 10 percent increase in transit ridership. This conclusion is also consistent with the Chicago Area Transportation Study estimate of the effect of fuel costs on transit ridership discussed in Chapter X.

The estimate that a $1.50 increase in the price of commuter parking would cause a 15 percent increase in transit ridership is roughly consistent with the findings of an independent analysis of the effect of an increase in Washington, D.C. parking costs (discussed in Appendix D). In that analysis, a $1.50 increase in the average parking cost was estimated to cause a 20 percent increase in transit trips.

Logit Modal Split Models

A logit modal split model estimates the share of travelers (or the probability of an individual traveler) using a particular mode i in making a particular trip by an equation of the form

$$MS_i = \frac{e^{+U_i}}{\sum_{\text{all modes } j} e^{+U_j}}$$

where

MSi = the fractional share of travelers using mode i in making the trip

and U_j = an index of the utility of using mode j in making the trip

Using home interview survey data for various areas and trip purposes, a number of studies have calibrated logit modal split models with utility functions specified as:

$$U_j = \beta_j \, IVTT_j + \gamma_j \, OVTT_j + \delta_j \, OPTC_j$$

Socio-economic variables.

where:

$IVTT_j$ is in-vehicle travel time in minutes by mode j

$OVTT_j$ is out-of-vehicle travel time (walking and waiting) in minutes by mode j

$OPTC_j$ is out-of-pocket travel cost (fares, tolls, vehicle operating expense) in cents by mode j

and β_j, γ_j, and δ_j are parameters which were empirically estimated.

The logit mode split equations can be used to estimate the effect of changes in travel times and costs by a particular mode upon the share of travelers using that mode, i.e.

$$MS_j' = \frac{MS_j}{MS_j + (1-MS_j) \times \exp(U_j-U_j')}$$

where

MS_j is the share of travelers using mode j before the change in travel times and costs

MSj' is the share of travelers using mode j after the change in travel times and costs

U_j is the utility of travel by mode j before the change in travel times and costs, and

Uj' is the utility of travel by mode j after the change in travel times and costs.

To estimate the term (U_j-U_j'), it is necessary to know only the changes in the time and cost variables, OVTT, IVTT and OPTC, and the appropriate coefficients for these variables in the linear utility equation.

Table 44[1] shows estimates of β_T, γ_T AND δ_T from various studies which calibrated logit modal split models using home interview survey data from

TABLE 44

Logit Modal Split Model Coefficients for Transit Travel Time and Costs

Model	Logit Coefficients for IVTT (β_T), OVTT (γ_T) and OPTC (δ_T)		
	β_T	γ_T	δ_T
Charles River Association 1967 Pittsburgh HIS[3]			
• Work Trips	-.0369	[1]-.150	-.0242
• Shopping Trips	-.0636	[1]-.398	-.0466
Cambridge Systematics Inc. 1968 Washington HIS[3]			
• White Collar Work Trips	-.0198	-.06422	-.014368
Moshe Ben-Akiva 1968 Washington HIS[3]			
• Shopping trips	-.0328	-.1266	[2]-.0252

[1] The estimates of γ_T shown were for walk time only. Wait time was not included.
[2] This coefficient was estimated as -.1514/INCODE where INCODE is a nonlinear function of household income. The value shown is for household incomes between $10,000 and $12,000.
[3] HIS means Home Interview Survey

1967-68. All these studies attempted to predict the split between only two modes—auto driver and transit passenger. The diversion of auto passengers and the inducement of new trips will be added to the equation as discussed later in this section.

For all models except the Cambridge Systematics White Collar Work Trip Model, the logit coefficients for auto times and cost were constrained to equal the corresponding logit coefficients for transit times and cost. The Cambridge Systematics logit coefficients for auto times and cost were (for one way trips):

$$\beta_A = -.0225$$

$$\gamma_A = -.05502$$

$$\delta_A = -.02946$$

Of these, only the auto out-of-pocket cost coefficient (δ) differs significantly from the corresponding transit coefficients and, in this regard it should be noted that the auto cost includes only parking, not vehicle operating cost.

To the extent that vehicle operating costs are positively correlated with parking costs, it is anticipated that the value of δ_A would have been lower had auto operating costs been included.

The ratio β_T / δ_T represents empirical evidence of the rate at which travelers trade in-vehicle travel time and money in making travel decisions. For the studies referenced in Table 44, this ratio ranges from 1.30 to 1.52, surprisingly little variation considering that different trip purposes and different cities were studied. These studies indicate that in making travel decisions in the 1967-68 time period people on the average weighted in-vehicle travel time at a rate of 1.3-1.5¢ per minute.

The ratio γ_T / β_T represents empirical evidence of the relative unpleasantness of in-vehicle travel time and out-of-vehicle (walking and waiting) travel time. For the studies referenced in Table 44, this ratio varies from 3.2 to 6.2. However, the studies used different definitions of out-of-vehicle time. Those with the higher ratios (Shop) used only walk time, while the other used both walk and wait in estimating γ_T.

For the purpose of predicting the effects of changes in the times and costs of travel in this study, the following values were selected:

- $\delta = -.01333$
- $\beta = -.03$
- $\gamma = -.09$

As indicated below, these values are consistent with recent empirical evidence.

The ratio of β to δ is 2.25. This is the result of updating the 1.5 ratio suggested from Table 44 to account for the 50 percent rate of inflation from 1968 to the present.

The ratio of γ to δ is 3.0. The lowest value of this ratio, from those in Table 44, was used since the intention is to use γ only to estimate the effect of changes in wait time, not walk time.

Extension of the Logit Modal Split Model

As noted previously, the logit modal split equation was developed to predict the split of travelers between modes—in our case auto drivers and transit passengers, i.e.:

$$\frac{MS_T'}{MS_T} \quad \frac{1}{MS_T + (1-MS_T) \times \exp(\Delta U_A - \Delta U_T)}$$

However, the percentage increase in transit ridership associated with reductions in the times and cost of transit travel will be equal to the percent increase in MS_T only if all the new transit riders would otherwise have been auto drivers. If some of the new transit riders would otherwise have been auto passengers, pedestrians, or not made the trip, then the above equation will underestimate the growth in transit ridership. This can be seen as follows:

- Let T' and A' (T and A) equal the number of transit and auto driver trips after (before) the change.
- Let MST' (MST) equal the share of auto driver and transit trips which are by transit after (before) the change, i.e.

  $$MS_T' = \frac{T'}{T' + A'}, \qquad MS_T = \frac{T}{T + A}$$

- Let q equal the share of new transit riders which would otherwise not have been auto drivers, i.e.:

  $$(T' - T) \times (1-q) = A - A'$$

- The above equations can be solved for the growth factor for transit, i.e.:

  $$\frac{T'}{T} = \frac{\frac{1}{MS_T} - q}{\frac{1}{MS_T'} - q}$$

This equation indicates that if all the new riders on transit had been diverted from other modes explicitly included in the modal split models (q=0), then the change factor for transit ridership (T'/T) is the same as the change factor for the *share* of riders using transit (MS_T'/MS_T). However, if some of the new transit riders are diverted from modes not explicitly included in the modal split models or are induced to make trips they otherwise would not make by transit fare reductions or service improvements, then the change factor for transit ridership will be greater than the change factor of the *share* of travelers using transit, i.e., if q>0, then

$$\frac{T'}{T} > \frac{MS_T'}{MS_T}$$

Substituting the equation for MS_T'/MS_T into the above equation for T/T, the result is

$$\frac{T'}{T} = \frac{1}{1 + \alpha \ (\Delta U_{AD} - \Delta U_T) + 1)}$$

where

$$\alpha = \frac{1 - MS_T}{1 - qMS_T}$$

MS_T = transit's fractional share of transit passengers plus auto drivers

and

q = the fraction of new transit riders which would *not* otherwise have been auto drivers.

This is the equation which was used to estimate the effect of transit incentive and auto restraint actions on transit ridership.

Estimates of Parameters

In applying the above equation, all transit ridership was evenly divided into two categories: peak and off-peak ridership. Based on temporal distributions of transit travel, the peak period would cover roughly 5 hours on an average weekday.

Values of α were calculated from estimates of MS_T and q for transit travel in peak and off-peak time periods. Also, in order to estimate the reduction in automobile energy consumption associated with predicted transit ridership increases, the average trip length and fuel efficiency of an auto driver trip diverted to transit in the peak and off-peak periods were estimated. These are shown in Table 45.

In estimating the values of α to use with the equation for T'T, it should be noted that a value of MS_T Typical *of transit* travel rather than of all travel should be used. This is because the T'T is a transit growth factor and using a value of MS_T typical for all travel would overestimate transit growth. Transit trips are not homogeneously distributed over all travel. Rather, they are heavily concentrated in downtown areas of large cities. For example, in all 5MSA'S with population greater than 250,000, about 12 percent of the work trips are by transit. However, residents of the central cities in SMSA'S with population greater than one million account for more than 60 percent of all transit work travel. The value of MST for these work trips is about .4.[1] As a more extreme example, transit travel into and within Manhattan constitutes about 12 percent of all transit travel in the United States. The value of MST for total daily travel into and within Manhattan is .79.[2] The value for MST of .5 for the peak period (implying a 50-50 split between auto drivers and transit passengers) presented in Table 45 is the assumed median for peak period transit travel.

The much lower value for MST of .2 in the offpeak period is a result of the fact that about 60 percent of SMSA transit travel is for the purpose of earning a living while only about 38 percent of 5MSA auto driver trips are for that purpose, [3] i.e.

$$.5 \times \frac{.4}{.6} \div \frac{.38}{.62} = .2$$

Not all peak period travel is for the purpose of earning a living and not all off-peak travel is for other purposes, so the estimated value of .2 is a rough approximation. However, with q = .7 the value of α which is used in forecasting transit ridership increases is not particularly sensitive to changes in MS_T, i.e. α =.89 for MS_T=.3 and α =.97 for MS_T=.1. Thus, any value of MS_T between .1 and .3 could be used without significantly affecting the forecasted increase in ridership.

The estimated values for q are based upon an onboard survey conducted by the Metropolitan Atlanta Rapid Transit Authority in November 1972. On March 1, 1972, the Metropolitan Atlanta Rapid Transit Authority had instituted a reduction in the base fare from 40¢ to 15¢ and, during the following year, implemented a number of service improvements. The onboard survey of transit patrons was

[1] Calculated from 1970 Census Data presented in the *Urban Transportation Factbook*, American Institute of Planners and Motor Vehicle Manufacturers, Association, March 1974.

[2] *Ibid.* and *Subway Riders and Manhattan Autos*, Tri-State Regional Planning Commission, October 1971.

[3] *1974 National Transportation Report*, page IV-3.

conducted to assess the impact of reduced fare and service improvements on transit ridership patterns.

The MARTA report[4] defines new riders as those who responded "no" to the question "Did you ride the bus regularly before March 1 when the fare was 40 Q?" Old riders are defined as those who responded "yes" to this question. The report found no significant increase in weekday bus use by old riders due to the fare reduction and service improvements. However, on Saturdays and Sundays, old riders were found to have increased their trip making by 20 percent and 50 percent respectively due to the fare reduction and service improvements. Over the course of an entire week, 91 percent of the increase in trips was accounted for by new riders and 9 percent was accounted for by increased transit travel by old riders.

New riders were asked "How did you make this trip you're taking today before you started using this bus?" On weekdays, the time period during which "new riders" were estimated to account for virtually all of the increase in transit ridership associated with the fare reduction and service improvements, 41.8 percent of the new riders stated that they had previously been auto drivers. During the period from 6 a.m. to 9 p.m. on weekdays, 51.3 percent of the new riders stated that they had previously been auto drivers.

The average trip lengths for auto driver trips diverted to transit, shown in Table 45 were estimated as follows:

—The National Personal Transportation Survey indicated the average trip length for an auto work trip was 9.4 miles and the average trip length for a shopping trip was 4.4 miles.

— Approximating the peak period distribution of auto driver trips diverting to transit as 80 percent work trips and 20 percent shopping trips using the above trip lengths, the peak period average is 8.4 miles.

— Approximating the off-peak period distribution of auto driver trips diverting to transit as 40 percent work trips and 60 percent shopping trips, the off-peak period average is 6.4 miles.

The average fuel efficiency of urban autos is estimated to be 12 miles per gallon.[5] The peak spread between peak and off-peak fuel efficiencies shown in Table 45 was arrived at judgmentally, to reflect the more congested conditions of peak period travel.

Analysis of the Effects of Doubling Transit Vehicle Miles of Operation

It is anticipated that the predominant share of the indicated increase in transit vehicle miles of operation would be allocated to increasing the frequency of service on existing lines. While there may be some opportunities to develop new lines, their number is limited by the generally low employment and residential densities in suburban areas not currently linked by transit.

The allocation of additional transit vehicle miles to existing transit lines decreases the time riders spend waiting at transit stops. If transit riders arrive randomly at a transit stop rather than trying to meet a scheduled vehicle, the effect of doubling transit vehicle miles is to reduce waiting time by 50 percent. For riders meeting scheduled vehicles, the effect of doubling the frequency of scheduled service is to reduce by 50 percent the amount of time transit riders have to allow for the fact that the transit system will not get them to their destination at their preferred time of arrival. Also, if transit riders miss the scheduled vehicle they are attempting to catch, they will spend 50 percent less time waiting for the next vehicle.

The analysis of the effect on peak period ridership of doubling transit vehicle miles of operation is summarized as follows:

- Reduction of Transit Wait Time = 2.5 minutes
- Net Reduction of the Disutility of a Peak Period Transit Trip = 2.5 × .09 = .225
- T'/T (with α =.667) = 1.155
- Percentage Increase in Peak Period Transit Ridership = 15.5 percent

The analysis of the effect on off-peak period ridership is summarized as follows:

- Reduction of Transit Wait Time = 5.0 minutes
- Net Reduction of the Disutility of an Off-Peak Period Transit Trip = 5 × .09 = .45
- T'/T (with α =.93) = 1.50
- Percentage Increase in Off-Peak Period Transit Ridership = 50 percent

Average peak period wait time was assumed to be 5 minutes and average off-peak wait time was

4 The *Effect of* Fare *Reduction on* Transit *Ridership* in the Atlanta Region, Technical Report No, 2: Analysis of Transit Passenger Data, MARTA, November 1973.

5 Highway Users Federation Technical Study Memorandum No. 9.

assumed to be 10 minutes, both of which were assumed to be cut in half by doubling transit vehicle miles. The peak period ridership increase of 15 percent was calculated with $\alpha = .667$ as appropriate for peak period conditions. The off-peak ridership increase of 50 percent was calculated with $\alpha = .93$ as appropriate for off-peak conditions.

Table 46 summarizes the effect of doubling transit vehicle miles of operation on energy consumption by automobiles in the peak and off-peak periods. The combined result is a savings of 24,000 barrels/day.

TABLE 45

Estimated Conditions for Transit Travel in the Peak and Off-Peak Periods To Predict Transit Ridership Increases and Reductions in Automobile Energy Consumption Associated with Transit Fare Reductions and Service Improvements

	Peak Period	Off-Peak Period
MS_T	.5	.2
q	.5	.7
α	.667	.93
Average Auto Trip Length*	8.4 miles	6.4 miles
Average Auto Fuel Efficiency*	11 miles/gallon	13 miles/gallon

*Estimates pertain to those auto driver trips which would be diverted to transit by fare reductions or service improvements.

No Fare Transit With Service Improvements

Total elimination of the transit fare will promote ridership increases by:

- reducing to zero the out-of-pocket cost of transit travel
- increasing the speed of buses (particularly in the peak period) by eliminating the time associated with fare collection and allowing passengers to board through both doors.

Also, to the extent that ridership increases due to the above factors require additional transit vehicle miles of operation, the improved frequency of service will promote further ridership increases.

The peak period effect of no fare transit with service improvements was estimated as follows:

- Reduction in the out-of-pocket cost of a transit trip = 31.96¢
- Reduction of transit in-Vehicle Travel Time = 2.0 minutes
- Reduction of Transit Wait Time = 1.4 minutes
- Net Reduction in the Disutility of a Peak Period Transit Trip = $31.96 \times .0133 + 2.0 \times .03 + 1.4 \times .09 = .612$
- T'/T (with $\alpha = .667$) = 1.44
- Percentage Increase in Peak Period Transit Ridership = 44 percent.

TABLE 46

Estimates of the Effect of Doubling Transit Vehicles Miles of Operation on Energy Consumption by Automobiles

	Peak	Off-Peak	Total
(1) 1974 Annual Transit Ridership (Millions)	2803	2803	5606
(2) Estimated Increase in Transit Ridership	434 (+15.5%)	1404 (+50%)	1835 (+32.7%)
(3) Average Length of a Diverted Auto Driver Trip	8.4 miles	6.4 miles	
(4) Average Fuel Efficiency of a Diverted Auto Driver Trip	11 mpg	13 mpg	
(5) Fraction of Transit Ridership Increase Associated with the Diversion of Auto Drivers	.5	+ .3	
(6) Barrels/Day Reduction in Automobile Energy Consumption	+10809	+13498	24307

† $$(\#6) = \frac{(\#2) \times (\#3) \times (\#5)}{(\#4) \times 365 \times 42}$$

The assumed reduction in the out-of-pocket cost of a transit trip of 31.96cents was equal to the average transit fare in 1974.[5]

The reduction in in-vehicle travel time of 2 minutes was estimated as follows:

- Assume that a transit bus carries 60 passengers at its peak load point during the peak period.
- Thus, prior to reaching the peak load point, the average passenger has been on the bus while 30 other passengers boarded the bus.
- Assume that the time required for boarding the bus could be reduced by 4 seconds per passenger if no fare collection is necessary and passengers are allowed to board through both doors. The assumed 4 seconds is probably too high for suburban bus stops with fewer than three passengers boarding and too low for downtown bus stops with more than ten passengers boarding.
- Thus, on the average, the in-vehicle time spent by passengers will be reduced by 2 minutes.

The reduction in peak period wait time of 1.43 minutes was based on a 40 percent increase in the vehicle fleet to cover the peak period ridership increase, assuming that the average wait time in the peak period is 5 minutes; i.e.:

5 x ; = 1.43 minutes,

The off-peak period effect of no fare transit with service improvements was estimated as follows:

- Reduction in the Out-of-Pocket Cost of a Transit Trip = 31.96¢
- Reduction of Transit Wait Time = 2.9 minutes
- Net Reduction in the Disutility of an Off-Peak Period Transit Trip = 31.96 × .0133 + 2.9 × .09 = .687
- T′/T from Equation (with α =.93) = 1.86
- Percentage Increase in Off-Peak Period Transit Ridership = 8670

As with the peak period, the off-peak reduction in the out-of-pocket cost of transit travel was assumed to be 31.96d, the average fare in 1974.

The reduction in off-peak wait time of 2.86 minutes was estimated assuming that vehicles added to the transit fleet to cover peak period ridership increases would be used also to expand off-peak transit vehicle miles of operation by 40 percent and that the average off-peak wait time is 10 minutes. i.e.:

$$10 \times \frac{.4}{1.4} = 2.86 \text{ minutes.}$$

No reduction of in-vehicle time during the off-peak period was estimated since the time savings associated with the elimination of fare collection were not viewed as significant under the less congested conditions of off-peak travel.

Table 47 shows an analysis of the effect on energy consumption by automobiles of no fare transit and related service improvement in the peak and off-peak periods. The combined effect is a savings of 55,000 barrels/day.

A 507₀ Increase in the Price of Gasoline

Estimates of gasoline price elasticities were made by Data Resources Inc.[7] using a dynamic consumption function. The dynamic consumption function enables the short term effects of a gasoline price increase to be estimated separately from those effects which occur over a longer time period. The usefulness of this procedure is characterized as follows:

> "In the first time period after a price increase consumers can make only marginal adjustments, such as cutting the number of trips to the store, re-arranging the use of autos to save gasoline, and forming of car pools. As time passes, however, more opportunities for conservation appear. Large inefficient cars can be replaced by small, more efficient ones, families can relocate so as to minimize the mileage traveled to work and the store, more housing near modes of mass transit can be constructed, and conservation habits become more refined. "[8]

[5] '74-'75 Transit *Fact* Book

[7] *A Study of* the Quarterly Demand *for Gasoline* and impacts *Of* Alternative *Gasoline* **Taxes,** Data Resources, Inc., Lexington, Mass., Preliminary Report, December 5, 1973.

[8] *Ibid.*, page `1.22.

TABLE 47

ESTIMATES OF THE EFFECT OF NO FARE TRANSIT AND RELATED SERVICE IMPROVEMENTS ON ENERGY CONSUMPTION BY AUTOMOBILES

	Peak	Off-Peak	Total
(l) 1974 Annual Transit Ridership (Millions)	2803	2803	5606
(2) Estimated Increases in Transit Ridership	1233	2410	3643
(3) Average Length of a Diverted Auto Driver Trip	8.4 miles	6.4 miles	—
(4) Average Fuel Efficiency of a Diverted Auto Driver Trip	11 mpg	13 mpg	—
(5) Fraction of Transit Ridership Increase Associated with the Diversion of Auto Drivers	.5	.3	—
(6) Barrels/Day Reduction in Automobile Energy Consumption	• 3071 o	• 2321 8	53928

$$^{*}(\#6) = \frac{(\#2) \times (\#3) \times (\#5)}{(\#4) \times 365 \times 42}$$

This study estimated that the short term price elasticity (short term is defined as 3 months) ranges from ,07 to .14 depending on the definition of gasoline consumption and the long term price elasticity (which requires roughly ten quarters to be fully achieved) ranges from .26 to .30.

If it is assumed that the short term price elasticity is due to a reduction in vehicle miles of travel and the difference between the short and long term elasticities is due to more fuel-efficient automobiles, then a 50 percent increase in the price of gasoline would result in a **3.5-7. o** percent reduction in vehicle miles of travel (since the short term price elasticity of gasoline is **.07-.14).**

The regression analysis of the effect on transit ridership of energy and economic conditions described previously led to the following relationship between transit ridership and highway vehicle miles of travel:

$$\frac{T'}{T} \text{ is proportional } \left(\frac{VMT'}{VMT}\right)^{-.86}$$

Applying this relationship to a 5 percent reduction in highway vehicle miles associated with a 50 percent increase in the price of gasoline leads to an estimated 4.5 percent increase in transit ridership.

Alternatively, the effect of a 50 percent increase in the price of gasoline can be estimated by:

- estimating the additional cost per trip by auto associated with the gasoline price increase
- using the equation for T'/T to calculate the effect on transit ridership of a fare reduction equal to the additional cost per trip by auto
- canceling out that portion of the ridership increase which would not be diverted from autos.

Carrying out these steps for the peak period:

- Increase in the Out-of-Pocket Cost of a Peak Period Auto Trip = 22.9¢
- Net Reduction in the Disutility of Transit Travel Relative to Auto Travel = .0133 × 22.9 = .305
- T'/T (with α = .667) = 1.212
- Fraction of Transit Ridership Increase Associated with Diversion of Auto Drivers = .5
- Percentage Increase in Peak Period Transit Ridership = .5 × 21.2 percent = 10.6 percent

and for the off-peak period:

- Net Increase in the Out-of-Pocket Cost of an Off-Peak Auto Trip = 14.7¢
- Net Reduction in the Disutility of Transit Travel Relative to Auto Travel = .01333 × 14.7 = .196
- T'/T (with α = .93) = 1.20
- Fraction of Transit Ridership Increase Associated with Diversion of Auto Drivers = .3
- Percentage Increase in Off-Peak Period Transit Ridership = .3 × 20 percent = 6 percent

The 22.9¢ increase in the price of a peak period auto trip assumes an average trip length of 8.4 miles, an average fuel efficiency of 11 miles/gallon and a price increase of 30¢/gallon. The 14.7¢ increase in the price of an off-peak period auto trip assumes an average trip length of 6.4 miles and an average fuel efficiency of 13 miles/gallon.

Combining the peak and off-peak increases, the net effect of a 50 percent increase in the price of gasoline using the above steps is an 8.3 percent increase in transit ridership. This is close to twice the 4.5 percent increase estimated using the results of the regression analysis. However, both are quite small, indicating the limited effect of gasoline price increases on transit ridership. Further, had the cost of the peak and off-peak auto trips been estimated with average fuel efficiencies of 17 and 19 mpg, such

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as might be the case in 1980 if the gasoline price increase is implemented, then the two methods would have produced a most identical results.

$1.50/Day Increase in the Price of Downtown Commuter Parking

This action is designed to provide a disincentive to auto use in the travel market best served by transit: travel to or from work places in downtown areas of SMSA'S with population greater than 250,000. Twelve percent of all work travel in these SMSA'S is by transit.[9] However, given the heavy downtown orientation of transit systems, it is estimated that about 90 percent of transit work travel is to a downtown area containing 25 percent of SMSA employment. It is in these areas, to which transit carries about half of the work trips, where the parking price increase would be implemented, About 93 percent of all transit travel occurs in SMSA'S with populations greater than 25,000,[10] Thus, noting that 60 percent of all transit travel is work travel, about half of all transit travel in the United States is work travel to the area affected by the parking price increase.

The analysis of the net effect on transit work trips of a $1.50/day increase in the price of commuter parking in downtown areas of large cities takes into account the following separate effects:

- the increased out-of-pocket cost of an automobile work trip
- the reduction in travel time by automobile resulting from lower levels of congestion as fewer people drive to work
- the reduction in time spent waiting for transit resulting from increases in the size of the transit fleet.

In order to calculate the transit ridership increase associated with these effects, it was assumed that the primary result would be the diversion of auto drivers (i.e., q = 0) to transit and that typical value of MS_T for transit work trips to the affected areas is .6. It should be recalled that in selecting a value of α for use in calculating T'/T, a typical value for *transit* travel, not for *all* travel, should be used. Thus, a value of α = .4 was used. The net effect was calculated as follows:

.

- Increase in the Out-of-Pocket Cost of a One-Way Auto Trip = 75cents
- Reduction in Auto In-Vehicle Travel Time = 10 minutes
- Reduction in Transit Wait Time = 1 minute
- Net Reduction in the Disutility of Transit Travel Relative to Auto Travel =(75) X (.01333) + (1) x (.09)+ (–10) X ~~~(.03) = .79.
- T'/T (with ~ = .4) = 1,28
- Percentage Increase in Transit Work Trips = 28 percent.

The increase in the out-of-pocket cost of an auto work trip is shown above as 75cents since the estimating equation pertains to one-way work trips, against which only half of the parking charge should be applied.

The 10 minute reduction in auto in-vehicle travel time is a result of the roughly 30 percent decrease in the volume of auto work trips to the area affected by the parking price increase. It corresponds to an increase in speed from 20 to 30 miles per hour for the 9.4 miles of an average work trip.

The 1 minute reduction in transit wait time is the result of a 25 percent increase in the transit fleet necessary to cover the 30 percent increase in transit work trips, since about 80 percent of peak period transit ridership is work travel.

Table 48 shows an analysis of the effect of the parking price increase and energy consumption by automobiles.

TABLE 48

ESTIMATE OF THE EFFECT OF A $1.50/DAY INCREASE IN THE PRICE OF DOWNTOWN COMMUTER PARKING ON TRANSIT WORK TRIPS TO THE AFFECTED AREA

1974 Transit Work Trips to the Affected Area	2803
Estimated Increase	784
Average Fuel Efficiency of a Diverted Auto Driver Trip	10 miles per gallon*
Average Trip Length of a Diverted Auto Driver Work Trip	9.4 miles
Barrels/Day Reduction in Automobile Energy Consumption	48073

● 1O mpg was used for the affected work trip because it was assumed that these work trips would be through the most congested parts of the urban areas, and thus have slightly less auto efficiency than the average auto work trip.

Appendix B

Questionnaire

rhe following questionnaire was sent to transit operators in the nine metropolitan areas examined In Energy, the Economy ond Mass Transit's companion study, "Assessment of Community Planning for Mass Transit." Nearly complete responses plus supplemental material were received from Atlanta, Minneapolis/St. Paul and Seattle. Partial responses and/or supplemental material were received from Chicago, Denver, San Francisco, and Washington, D.C. Boston and Los Angeles did not reply.

A complete discussion of the results of the survey is contained in Chapter X.

QUESTIONS REGARDING THE CAPABILITY OF METROPOLITAN AREAS
TO RESPOND TO CHANGING NATIONAL ENERGY AND ECONOMIC CONDITIONS

Part of a Study Being Conducted for
the Office of Technology Assessment
U.S. Congress

I. Please provide estimates of total revenue passengers by month from January 1973 through February 1975.

(a) To the extent that information is available, does the recent trend hold for all types of operations? How do each of the following compare with overall trends?

Express bus ______________________

Local bus ______________________

Rapid transit ______________________

Peak periods ______________________

Off peak ______________________

Other notable differences, if any (special services, etc.)

____

(b) Please indicate the extent to which any of the recent changes in ridership are due to each of the following, insofar as is known:

Major improvements in service: ______________________ date(s) ____________

Major reductions in service: ______________________ date(s) ____________

Changes in fares: ______________________ date(s) ____________

Oil embargo: ______________________

Recession and unemployment: ______________________
(Please attempt to estimate what proportion of recent ridership losses, if any, is due to the recession and what proportion is due to an end to the gasoline shortage. Our analysis indicates a national readership loss of about I percent for every 2 percent increase in the unemployment rate.)

2. Please provide your most recent forecasts of total revenue passengers:

Date forecast made ____________________

1974 actual ____________________

1975 ____________________

1976 ____________________

1977 ____________________

1978 ____________________

1979 ____________________

1980 ____________________

Are all forecasts for calendar year?

____

Fiscal years?

(dates) ____________________

3. How would transit operations be affected if there were substantial reductions in gasoline consumption over the next 2 to 5 years of the following amounts (due either to shortages or major price increases or tax increases):

(i) Decrease by January 1976 equal to experience of 1973-74 winter (1 million barrels per day reduction in rate of oil consumption nationally)

(ii) Decrease by January 1977 of three times as much (3 million barrels per day)

(iii) Decrease by January 1980 of six times as much (6 million barrels per day)

(Our analysis indicates that these three levels of gasoline shortages would result in national transit ridership increases of about (i) 5 percent in 1975 and 3 percent more by 1976, **(ii) 7 percent** ***per year*** from 1975 through 1977, and (iii) 7 percent per year through 1980.)

(a) How would these increases affect peak-to-base ratios?

(i) ____________ (ii) ____________ (iii) ____________

(b) How would these increases affect the financial picture of transit operations over the years?

(i) ____________ (ii) ____________ (iii) ____________

(c) About how much and what type of additional transit equipment and manpower (over and above present expansion plans) would be required to adequately accommodate these three possible conditions and would you expect difficulties in achieving the necessary rates of increase ?

- buses (i) ____________ (ii) ____________ (iii) ____________
- drivers (i) ____________ (ii) ____________ (iii) ____________
- mechanics (i) ____________ (ii) ____________ (iii) ____________
- rail cars (i) ____________ (ii) ____________ ____________

- low capital improvements to existing facilities (reserved lanes on existing streets, etc.)

(i) ______ (ii) ______ (iii) ______

(d) Do you anticipate that any of these increases in capital facilities and operating levels would require substantial increases in existing Federal program commitments? ______

Could additional local matching funds be raised? ______

(e) Are emergency plans available which would respond to short term energy reductions of the levels

m d ______

If so, how long would it take to build the staff and equipment levels that would be needed?

(i) ______ (ii) ______ (iii) ______

4. If there were a substantial increase in UMTA capital grant funds available in your metropolitan area during the next 5 fiscal years as part of a program to stimulate employment, how much of an increase in actual obligations could realistically be made, above that Jevel already programed for capital improvements, regonizing the time needed for additional studies and approvals?

$ ______ of Federal funds, matched by $ ______ of local funds.

How would that increase (over and above presently programed improvements) likely be broken down among the following categories and in what years could the money be spent?

		%	Years obligated
(a)	planning and design of capital improvements	______	______
(b)	right-of-way acquisition	______	______
(c)	new buses	______	______
(d)	new rail rolling stock (light or heavy?)	______	______
(e)	construction of maintenance or storage facilities	______	______
(f)	construction of new rail routes or extensions	______	______
(g)	modernization of old transit facilities	______	______
(h)	construction of new technology systems	______	______
(i)	construction of new busways	______	______

5. To what extent would the ability to accelerate the capital program during the next 3 fiscal years *be* constrained by each of the following factors:

(a) lack of State or local matching funds ______

(b) need togetvoter approval for additional funds ______

(c) need to get official approval of plans ______

(d) Lack of detailed plans ______

(e) environmental impact statement approvals ______

(f) inability to pay for additional operating subsidy that would likely be required ______

(g) lack of staffing/resources to plan and implement new programs ______

6. (a) Is there any additional Federal level action that would be of substantial assistance (beyond provision of more funds) in accelerating capital improvements? ______

______

(b) Is there any additional Federal level action that would be of substantial assistance (beyond provision of more funds) in accelerating the provision of improved transit services to respond to potential future deteriorating energy and economic conditions? ______

______

(c) Are there any substantial legal problems at the State and local level which would delay an accelerated Federal transit program, e.g., contractual commitments to localities and State agencies; required planning and review time periods; legislative limitations on annual public expenditures in one sector; legally binding master plans including growth schedules or moratoriums? ______

______

7. What percentage of the money from the 1974 Act which can go to either operating or capital costs will be used for operating subsidies?

1975 ______ **1978** ______

1976 ______ **1979** ______

1977 ______ **1980** ______

Appendix C

Interindustry Analysis

INTRODUCTION

This Appendix presents the computational procedure used in the calculation of the employment generated per $1 million of production in four industries (Public Transit, Bus Manufacturing, Rail Car Manufacturing, and Rapid Transit Construction) as reported in chapter VI.

Basically the procedure involved the calculation of the total employment generated by the production of goods and services by the industries. Total employment includes not only the employment in the industry itself but also the multiplier effect, which includes jobs in industries directly supplying the main industry plus the suppliers of the suppliers, as well as jobs created by the expenditure of wages and salaries. This analysis separately calculated the employment generated in the main industry, the direct supplying industries and the indirect supplying industries.

No published data is available which would show the employment multiplier generated by the four main industries of interest here:

1. The Public Transit Industry
2. The Bus Manufacturing Industry
3. The Rail Car Manufacturing Industry
4. The Rapid Transit Construction Industry

However, the Input-Output Structure of the U.S. Economy: 1967[1] presents information on the multiplier in terms of value of production rather than employees. The basic task of this analysis has been the conversion of the dollar values of production attributable to the four industries into employees.

The Input-Output (1/0) Tables divide the whole U.S. economy into 367 industries. The industries most closely resembling the four industries investigated here are:

11,03 New Construction, Public Utilities approximating Rapid Transit Construction.

59.03 Motor Vehicles and Parts approximating Bus Manufacturing

61.04 Railroad and Street Cars approximating Rapid Transit Cars

79,01 Local Government Passenger Transit approximating Public Transit

[1] U.S. Department of Commerce, BEA, 1975

Although the industries as defined for the Input/Output Tables do not correspond exactly to the transit industry and its major capital goods suppliers, the distribution of material purchases of these industries is approximately the same. For example, the Input/Output industry “Railroad and Street Cars” uses approximately the same proportion of steel, iron, plastics, wages, salaries, etc. as the rapid transit car manufacturers, such as Rohr and Pullman. Thus, both industries will purchase from the same industries and generate the same amount of employment per dollar of production.

The 1/0 Tables are printed in three volumes; the first and third volumes were used in this analysis. The first volume, “Transactions Data for Detailed Industries” records the purchases and sales of every industry to every other industry in 1967. The total of all purchases by an industry (inputs) plus the value added in production (labor, profit, interest, etc.) equals the production or total output of the industry. For example, the Public Transit Industry (79.01) made purchases of $1.4 million from the Industrial Controls Industry (53.05) in 1967. The transit industry’s direct purchases from other industries, totaled $333.7 million. These purchases combined with a value added (wages, salaries, taxes, profit, etc.) of $640.5 million equals a total output of $974.2 million for the Local Government Passenger Transit Industry in 1967. The purchases by the transit industry create employment in the direct supplier industries which is part of the employment generated as a result of the existence of the transit industry, The calculation of the amount of employment which can be credited to the transit industry and the other three industries is explained in detail in the following section entitled “Direct Employment Generated.”

The third volume of the 1/0 Tables "Total Requirements for Detailed Industries" lists the amount of output required both directly and indirectly from each industry for a dollar of final output by each other industry. Thus every dollar of final output by the Railroad and Street Car Industry (61.04) is responsible for direct and indirect purchases from the Blast Furnaces and Basic Steel Products Industry (37.01) of 31.662$. Since these values in Volume III include both direct and indirect purchases, the summation of the requirements (direct and indirect purchases from each industry) will equal the multiplier. The summation of the direct and indirect requirements (from Volume 111) for the four industries is listed below,

Industry		Multiplier
11.03	New Construction, Public Utilities	2,36
59.03	Motor Vehicles and Parts	2.61
61,04	Railroad and Street Cars	2.60
79,01	Local Government Passenger Transit	1.67

Thus, one dollar of final output in the Motor Vehicle Industry requires total output of $2.61 from the total of all industries when direct and indirect purchases are summed. It should be cautioned that the multiplier shown here is expressed in dollars, not jobs. The number of jobs generated per dollar of output varies greatly from industry to industry, and thus employment and dollar value of output cannot be assumed to be closely related.

By multiplying the multiplier by the final industry output, the total requirements (both direct and indirect) can be calculated for each industry, Thus, for Public Transit the total requirements equal: 1,67 X $974.2 million = $1,624,8 million. If the final output of the transit industry itself and the direct requirements are subtracted from total requirements, only the indirect requirements remain. The calculation of the employment generated by the indirect requirements of each of the four industries is contained in a section below entitled "Indirect Employment Generated. "

The employment calculations for main industry itself in the production of its final output is contained below in "Main Industry Employ merit."

The summation of the indirect, direct, and main industry employment equals the total employment generated by each industry. This employment and the calculation of the total employment generated per $1 million of production is in the last section of this appendix.

Direct Employment Generated

This section explains the procedure used to ~alculate the employment generated by the direct purchases of the four industries examined here. Four steps were required: 1) calculation of percent of the direct supplying industry's output generated by the four industries; 2) determination of the total employment in the direct supplying industries; 3) calculation of the employment generated in the direct supplying industries by the four industries; and 4) summation of the direct employment generated.

Step 1:

It was assumed that the proportion of purchases by the four industries to total output of direct supplying industries would be equal to the proportion of employment attributable to these purchases to total employment in the direct supplying industries. Thus, according to Volume I of the 1/0 Tables the Railroad and Street Cars Industry (61.04) directly purchased $312.8 million of the total output of $25,155.9 million of the Blast Furnaces and Basic Steel Product Industry (37.01), or 1,243 percent. Thus, 1.243 percent of the employment in the Blast Furnaces and Basic Steel Products Industry is generated by the purchases of the Railroad and Street Car Industry. These percentages were calculated for every direct purchase made by the four industries investigated in this study.

Step 2:

The next step was to calculate the total employment for each of the direct supplying industries, so that the percentages (described in the previous paragraph) could be applied. Application of the percentages was the final step in calculating the direct employment generated by the four industries.

The Bureau of Economic Analysis (BEA), the same group which produces the 1/0 Tables, also produced employment figures which are internally consistent with 1/0 data. Unfortunately these employment figures are for 2-digit Standard Industrial Classification (SIC) industries, and most of the 1/0 industries correspond to 4-digit SIC's,

Four-digit SIC industries employment data for 1967 is available from the Census of Manufacturers prepared by the Bureau of the Census. These data contain the number of employees in each of the 4-digit and 2-digit SIC industries in 1967.

In order to maintain internal consistency it was necessary to use the 2-digit BEA employment figures as control totals, These totals were divided among the 4-digit SIC's by using the relationships of the Census of Manufacturers (CM) 4-digit employment to 2-digit employment,

$$\frac{\text{CM 4-digit SIC Employment}}{\text{CM 2-digit SIC Employment}} = \frac{\text{BEA 4-digit SIC Employment}}{\text{BEA 2-digit SIC Employment}}$$

Thus, the **1967 total** employment in SIC *33* (Primary Metal Industries) is 1,281,000 according to the Census of Manufacturing (CM) and 1,326,000 according to the BEA. 1/0 industry 37.01 "Blast Furnaces and Basic Steel Products" is made up of SIC's **3312, 33l3, 3315, 3316,** and 3317 with a combined employment of 617,300 according to the CM. This employment is 48.19 percent of the Census of Manufacturing 2-digit total (1,281,000). 48.19 percent of BEA's 2-digit SIC employment is 638,999 which is the total employment used for 1/0 industry 37.01 "Blast Furnaces and Basic Steel Products" in this analysis.

Total employment for most of the direct supplier industries was calculated in this manner. In some industries for which 4-digit employment was not available, it was necessary to calculate employment by using the value added of the 1/0 industry. This procedure is described below in the calculation of main industry employment.

Thus, total employment in each of the direct supplying industries was calculated in a manner internally consistent with the 1/0 data.

Step *3:*

The number of employees generated in each of the direct supplying industries by purchases made by the four industries was calculated by multiplying the percentage developed in Step One by the employment developed in Step Two. For example, the Railroad and Street Car Industry (61.04) purchases 1.243 percent of the output of the Blast Furnaces and Basic Steel Products Industry (37.01). Thus, of the 638,999 total employees in the Blast Furnaces Basic Steel Products Industry, 7,943 or 1.243 percent are employed due to Railroad and Street Car direct purchases.

The number of employees in each of the direct supplier industries attributable to purchases made *by each* of the four industries was calculated in this manner.

Step 4:

Employees generated by direct purchases of the four industries was totaled, resulting in the following direct employment estimates:

Industry	Direct Supplier Employment 'Generated
New Construction, Public Utilities	243,046
Motor Vehicles and Parts	944,116
Railroad and Street Cars	41,736
Local Government Passenger Transit	11,798

Because the four industries vary greatly in size, and thus in employment generated it is necessary to reduce the industries to a common unit for valid comparisons, Therefore, by dividing the employment figures by the output of their generating industry, the following number of direct employees per $1 million of output is calculated:

Industry	Direct Supplier Employment Generated per $1 million output in **1967**
New Construction, Public Utilities	22.3
Motor Vehicles and Parts	23.5
Railroad and Street Cars	23.4
Local Government Public Transit	12.1

Indirect Employment Generated

The calculation of the indirect employment generated was a simple process requiring only three steps: 1) calculate total requirements for the four industries; 2) calculate indirect requirements by subtracting direct requirements and total output from total requirements; and 3) calculate indirect employment generated using national averages for employee compensation, etc.

Step 1:

As described in the introduction, the summation of the total requirements for each industry (as contained in Volume III of the 1/0 Tables) produced a multiplier. This multiplier indicates the number of dollars of total production required to produce one dollar of output in each industry. The total requirements for an industry equal the multiplier times the total output (in dollars) of the industry. The calculation of total requirements for the four industries is shown in columns 1, 2, and 3 in Table 49.

Step **2:**

The total indirect requirements for the four industries is calculated by subtracting the direct requirements and total output for each industry from the total requirements, as shown in columns 3, 4, 5, 6, and 7 of Table 49. Total output and the direct requirements are taken from Volume I of the 1/0 Tables.

Step **3:**

The indirect requirements for each of the four industries come from a wide range of supplier industries, with no one industry or group of industries dominating the indirect inputs. Rather than calculate the employment generated in each of the indirect supplying industries, it was felt that employment generated in the indirect supplying industries as a whole should be calculated.

It is felt that the indirect suppliers as a whole closely resemble the national economy, thus justifying the use of national figures to calculate employment.

In 1967, 59.23 percent of the GNP (or national output) was in the form of employee compensation, Of employee compensation, 90,55 percent is wages and salaries. By assuming that these same percentages apply to the total indirect requirements of the four industries, the amount of wages and salaries can be calculated. Then by dividing the wages and salaries by the 1967 average wage and salary ($6,230) the number of employees is computed. This is shown in Table 50.

The amount of indirect employment generated per million dollars of output for the four industries is shown below:

Industry	Indirect Employment generated by $1 million output in **1967**
New Construction, Public Utilities	**63.7**
Motor Vehicles and Parts	**78.7**
Railroad and Street Cars	**75.3**
Local Government Passenger Transit	**28.0**

Main Industry Employment

The final component of the employment generated by the four industries is in the industry itself. Since the employment in the main industry is a large proportion of total employment, it is very important to calculate the employment in the same manner for each industry, or to use the same source for the employment estimates, thereby retaining the comparability of the employment estimates between industries,

The Census of Manufacturers (CM) 4-digit SIC employment estimates did not include either the Local Government Passenger Transit or New Construction, Public Utilities Industries. Other employment estimates from groups such as trade organizations were not generated in the same manner as the CM estimates. In addition, many of the trade groups

TABLE 49
CALCULATION OF INDIRECT REQUIREMENTS
($million 1967)

	Final output (1)	x	Multlpller (2)	=	Total reqmts (3)	less	Total output (4)	–	Direct and in-direct reqmts. (5)	less	Direct reqmts (6)	·	Indirect reqmta. (7)
New Construction Public Utilities	10,919.0	x	2.36179	=	25,768.4	-	10,919.0	=	14,669.4	–	6,790.9	·	S8,0785
Motor Vehicles and Parts	42,316.5	x	260912	=	110,4088	-	42,316.5	–	68,0923	-	29,3932	·	$38,705.2
Railroad and Street Cars	1,786.6	x	259748	=	4,640.6	-	1,7666		2,854.0	-	1,2924		$1,5616
Local Government Public Transit	9742	x	1.66779	=	1,624.8	-	974.2		650.6	-	3337		$3169

SOURCE System Design Concepts, Inc , using *Input/Output Structure of the* U. S Ecorromy 1967

TABLE 50

COMPUTATION OF INDIRECT EMPLOYMENT

	Indirect Requirements ($millions) (1)	Employee Compensation 59.230/o of (1) (2)	Wages and Salaries 90.550/0 of (2) (3)	1967 Average Wage and Salary (4)	Indirect Employment (3) / (4) (5)
New Construction, Public Utilities	$8,078.57	$4,784.9	$4,332.7	$6,230	695,464
Motor Vehicles and Parts	38,705.2	22,925.1	20,758.7	6,230	3,332,050
Railroad and Street Cars	1,561.6	924.9	837.5	6,230	134,435
Local Government Public Transit	316.9	187.7	169.9	6,230	27,278

SOURCE: System Design Concepts, Inc.

did not define the industries in the same manner as the 1/0 Tables did. For example, the American Public Transit Association compiles employment estimates for the entire public transit industry, but does not list separately the employees in local government-owned public transit systems to conform with the 1/0 definition.

The only source of employment data which would include the four industries is the BEA, which publishes employment estimates in the July issues of the ***Survey of*** Current Business. Unfortunately these estimates are for 2-digit 1/0 Industries or combinations of 2-digit 1/0 Industries. Two-digit' 1/0 Industries are made up of several 4-digit 1/0 Industries. In order to use this data it was necessary to break down these employment figures into the 4-digit industries examined in this study. It was assumed that the 4-digit industry's employment was the same percentage of 2-digit employment as the 4-digit industry's percentage of 2-digit Value Added. This is the same procedure used in "Direct Employment Generated" for those industries not listed in the CM. The calculation is explained below for three of the four industries: 1) New Construction, Public Utilities (11.03), 2) Motor Vehicles and Parts (59.03), and 3) Railroad and Street Cars (61.04). Local Government Passenger Transit **(79.01)** required additional calculations, as explained in that section below,

New Construction, Public Utilities **(11.03)**

This 4-digit 1/0 Industry is included in the BEA employment calculation of the Contract Construction Industry, which includes two 2-digit 1/0 Industries: "New Construction" (11) and "Maintenance and Repair Construction" (12). In 1967, the Contract Construction Industry had 3,268,000 employedl and a Value Added of $45,475.3 million.[2]

New Construction, Public Utilities (11.03) had a 1967 Value Added of $4,128,1 million,[3] or 9.0 percent of the total Value Added of the whole Contract Construction Industry. If we assume the employment share is the same, the New Construction, Public Utilities Industry had 328,617 employees in 1967. This is the employment figure used in this analysis. For each $1 million of output 30.1 jobs are created in the main industry alone.

Motor Vehicles and Parts (59.03)

This 4-digit 1/0 Industry is included in the BEA employment estimate for Motor Vehicles and Equipment (59), which (according to the same sources noted above) had a 1967 employment of

[1] *Survey of Current Business*, July 1969.
[2] *BEA, Input-Output Structure of the U.S. Economy*, Vol. 1.
[3] *Ibid*.

832,000 and a Value Added of $13,397.5 million. Of this Value Added $12,923.3 million or 96.5 percent was from the Motor Vehicles and Parts (59.03). The same percentage employment equals 802,547 jobs or 19.0 per $1 million of output.

Railroad and Street Cars (61.04)

This 4-digit 1/0 Industry is included in the BEA employment estimate for Transportation Equipment and Ordnance, except Motor Vehicles which is made up of three 2-digit 1/0 Industries: I) Ordnance and Accessories (13), 2) Aircraft and Parts (60) and, 3) Other Transportation Equipment ***(61),*** In 1967, these 2-digit 1/0 industries combined had 1,458,000 employees and generated $17,219,7 million in Value Added.

The Railroad and Street Car Industry (61.04) had a Value Added of $94.2 million or 2.24 percent of total. The same percentage of employees equals 32,634 or 18.3 per $1 million of output in 1967.

Local Government Passenger Transit

This 4-digit 1/0 Industry is included in State and Local Government Enterprises (79) for which BEA has estimated employment. This 2-digit 1/0 Industry (State and Local Government Enterprises) is made up of three 4-digit 1/0 industries: 1) Local Government Passenger Transit (79.01), 2) State and Local Electric Utilities **(79.02),** and **3)** Other State and Local Government Enterprises (79.03), Other State and Local Government Enterprises which dominate the 2-digit industry include such things as water and sewer works and stadium management, etc.

Unlike the construction, motor vehicle and railroad car industries (discussed above) which are included in 2-digit industry made up of similar industries, Passenger Transit is combined with very different 4-digit 1/0 industries. The existence of these dissimilar industries in the 2-digit 1/0 industry BEA **employment** estimate diminish the probability that these estimates would accurately reflect the passenger transit industry which had only 10.1 percent of the total output of the 2-digit industry,

It was thus necessary to use another source for employment in the Local Government Passenger Transit Industry, The American Public Transit Association's (APTA) Transit Fact Book contains financial and employment information for the whole transit industry, but does not list the public and private operations separately.

In spite of this inconsistency with 1/0 data, it was decided that the APTA data was compatible with the 1/0 data for two reasons, First, the BEA relied upon APTA data in preparing their 1/0 Tables. Second, employee compensation as a percentage of total output were very similar for APTA and 1/0 data,

It was assumed that the value added share of total output in the Local Government Passenger Transit Industry was nearly all employee compensation. The 1/0 Tables indicate that Value Added is **65.7** percent of total output of the industry. APTA figures indicate an amazingly similar percent. According to the Transit Fact Book, in 1967 employee compensation was equal to 65.0 percent of operating revenues plus deficit (assumed to equal total output). The similarity of these percentages tend to indicate that APTA and 1/0 data are compatible, and for the purposes of this analysis, were assumed to be interchangeable.

In order to calculate the number of employees in the Local Government Passenger Transit Industry the average employee compensation ($7,222/year from APTA) was divided into total industry employee compensation. The total Local Government Passenger Transit Industry's employee compensation was assumed to equal the entire Value Added (from the 1/0 Tables) less the 1967 industry deficit (from APTA) or $573.9 million. By this procedure it was estimated that 79,470 employees were in the industry or 81.6 per $1 million of total output.

Total Employment Generated Per $1 Million Output

The total employment for each industry in 1967 is below:

Industry	Total employment generated per $ million output in 1967
New Construction, Public Utilities	116.0
Motor Vehicle and Parts	121.2
Railroad and Street Cars	116.9
Local Government Passenger Transit	121.7

In order to express the employment in terms of 1974's dollars, the GNP Deflator was used, The employment per $1 million in 1974 is listed in table 51.

TABLE 51

EMPLOYMENT GENERATED PER MILLION 1974 DOLLARS

Industry	Employment Generated Per $1 Million in 1974			
	Main Industry	Direct	Indirect	Total
New Construction, Public Utilities	20.6	15.2	43.5	79.4
Motor Vehicles and Parts	13.0	16.1	53.8	82.9
Railroad and Street Cars	12.5	16.0	51.4	79.9
Local Government Passenger Transit	55.8	8.3	19.1	83.2

Source: System Design Concepts, Inc.

Appendix D

Survey of Effectiveness of Possible Actions To Improve Transit Ridership

This Appendix consists of a compendium of references, tables, and text based on recently published sources which describe and summarize existing experience relevant to each of the transit improvement/auto restraint actions outlined in chapter Viii.

NO FARE AND REDUCED FARE

Only one city in the United States has a systemwide, free fare public transit program, the small industrial town of Commerce, Calif. Approximately 15 other cities are experimenting with variations of the systemwide concept offering no fares during peak periods, within defined zones, and for special user groups, primarily students and the elderly. Most of these programs are small and few have produced comparable ridership and diversion data, [l]* At least 10 major cities are experimenting with systemwide reduced fares, including special programs for off peak hours and weekends. .The most notable example is Atlanta where a reduction of fare from 40cents to 15cents resulted in a 28 percent increase in ridership, of which about half were previous auto users. [2] A sample of no fare and reduced fare programs for which ridership and diversion data available is presented in Table 52.

Most of these no fare and reduced fare experiments have reported promising increases in ridership, especially when accompanied by corridor or systemwide service improvements. "In general, increased ridership has not offset lower fares in terms of revenue generation, resulting in a net revenue loss. Thus, fare reductions as well as service improvements generally require some type of public subsidy. Some studies indicate that if the cost needed for a fare-reduction program were applied to service improvements, a greater diversion from auto use would occur. The combination of a fare reduction with service improvements, however, seems to be a promising tool.[3]

Unlike most innovations, transit unions have fully supported subsidized transit and are actively lobbying for it within Congress and the Executive Branch. Therefore, little transit in-house resistance is expected. [4] Some opposition might be anticipated from those public agencies which are charged with the responsibility for finding the funds to support transit subsidies in lieu of direct Federal operating monies. If local tax levies are proposed, political support for public transit from the so-called non-user groups may be jeopardized, especially in the case of free-fare subsidies.

Additional reduced fare programs for special groups (elderly, and handicapped) have been initiated in Chicago, Milwaukee, Pittsburgh, and other cities with reported ridership increases ranging from 15 percent to 62 percent. Weekend reduced fare and no fare programs in Los Angeles, Chicago. Pittsburgh, and New York have also resulted in ridership increases from 25 percent to 200 percent.

TAX INCENTIVES

The effect of tax incentives such as transit fare deductions from Federal, State, and local income taxes, and transit fare rebates, would be to reduce the cost of using transit, and thus stimulate ridership. It is argued that since tax refunds would lag considerably behind the payment of transit fares and only apply to those who file income tax returns or itemize deductions, it is likely that their effect would be considerably less than a direct fare reduction. [s] On the other hand, public support for tax deductions and rebates might be stronger among non-user groups, than for fare reductions which require local tax increases. The net impact of either fare reductions or tax incentives on transit ridership may ultimately depend on the extent to which these actions are accompanied by service improvements and auto restraint measures.

*See References at end of chapter, on p. 147.

Table 52

SUMMARY OF NO-FARE AND REDUCED FARE IMPACTS ON TRANSIT RIDERSHIP AND DIVERSION

City	Type of Program	Results
Rome	Systemwide no fare during rush hour. 43- day experiment in May-July 1972; financed from general City revenues.	5 percent increase in total transit ridership. Ridership increase exceeded available excess capacity during peak hour resulting in chaos.
Seattle	CBD no fare zone. 105 square blocks, subsidized by City: September 1973.	Ridership increased on some lines in the area by 56 percent.
Dayton	CBD no fare zone. 66 block area; 1973.	14 percent increase in total transit ridership. 28 percent of this increase diverted from autos. Reported shift to long-term parking in peripheral areas.
Rockford	Senior citizens no fare program during off-peak hours. Subsidized 50 percent by State DOT and 50 percent by local revenue sharing funds; 1974.	100 percent increase in monthly senior citizen transit ridership.
Atlanta	Systemwide reduced fare from 40cents to 15cents. Funded by 1 percent sales tax. April 1973.	30 percent increase in total transit ridership, 50 percent of this increase diverted from autos.
San Diego	Systemwide reduced fare from 35cents to 25cents. Funded from State gasoline tax; 1973.	22 percent in total transit ridership.
Los Angeles	Systemwide reduced fare from zone system fares as high as $1.45 to a flat 25cents rate.	22 percent increase reported in weekday transit ridership.

PRIMARY SOURCE: "No Fare and Low Fare Transit", prepared for the California Legislature by the Metropolitan Transportation Commission, June 1973.

TRANSIT AND TRAFFIC MANAGEMENT

Priority Lanes and Control Devices

It has been estimated that in most cities buses carry a high proportion (85 percent) of peak-hour travelers on city streets and arterials. [6] Thus the most prevalent bus priority treatments to date have been designed to separate buses from mixed traffic on CBD arterial access routes by reserving one lane of street capacity for high occupancy vehicles. This is usually accomplished by eliminating curb side parking and utilizing this lane for buses and taxis (Table 53). Contra-flow or reversed-flow bus lanes on arterials are less common because of the obvious safety and traffic control measures required. In general, most priority bus lanes on arterials are implemented to improve traffic flow, reduce congestion, and increase the efficiency of transit. Almost all demonstrations to date have reported modest savings in transit travel times and some reduction in congestion. Impacts on ridership are difficult to assess because arterial treatments usually cannot be isolated from other service improvements and often constitute only one portion of a priority lane system extending between the CBD and peripheral areas.

Bus priority lanes on freeways are less common than arterial treatments and represent a fairly recent policy emphasis aimed at increasing the carrying capacity of existing highways and providing an attractive, efficient alternative to auto travel. Two approaches are commonly advanced. [4]

1. Reservation of a lane in the most heavily traveled side of the freeway. In this approach all or part of a lane of traffic is reserved for high occupancy vehicles, usually at the critical "bottleneck" portion of the freeway during the peak period. It may be sufficient to reserve lanes through very short bottleneck areas such as tollbooths or sections of the freeway where demand exceeds design capacity.

Table 53

SUMMARY OF PRIORITY LANE TREATMENT IMPACTS ON TRANSIT RIDERSHIP AND DIVERSION

Type of Treatment	Example	Description	Results
ARTERIAL RELATED			
Bus Streets	Nicollet Mall, Minneapolis	8-block "transit mall" for pedestrians and buses.	Traffic congest ion reduced and bus ridership in mall area increased by 18,000 per day.
CBD Curb Bus Lanes, Normal Flow	Baltimore	11 bus only curb lanes covering 5 miles.	No reported changes in ridership; transit speeds increased by 2104 in a.m. peak and 17% in p.m. peak.
Arterial Curb Bus Lanes, Normal Flow	New York City	15 miles of curb bus lanes on 11 streets mostly in midtown Manhattan.	No significant changes in ridership; time savings for buses increased from 22% to 42%.
	Vancouver	6-block p.m. peak hour curb bus lane on George Street.	Bus travel time reduced by 30%; 12% ridership increase reported.
CBD Median Bus Lanes, Contra-Flow	Chicago	.6 mile median busway on Washington Street.	
CBD Curb Bus Lanes, Contra-Flow	San Antonio		
Arterial Curb Bus Lanes, Contra-Flow	Louisville	Two contra-flow lanes on parallel streets during peak hours.	25 % time savings reported.
FREEWAY RELATED			
Bus Lanes on Freeways, Normal Flow	Washington, D.C.	9th Street Expressway.	
	Seattle	Reversible freeway lanes with exclusive bus ramps, service improvements and park-and-ride lots.	Ridership increased by 1/3; new riders were equally divided between those diverted from autos and those who did not previously make the trip.
	1-495, New Jersey	21 /2-mile contra-flow bus lane which operates in morning peak connecting the New Jersey Turnpike and the Lincoln Tunnel.	6% increase in morning peak period ridership and time savings of over 10 minutes per trip.
	Long Island Expressway, New York	2.2-mile contra-flow bus lane operated during morning peak.	Time savings of 12 minutes per trip for transit riders, 16 to 23 minutes for auto users.
	Boston	8.4-mile contra-flow bus lane operated during morning peak.	Bus riders save 14 minutes per trip; auto users save from 17 to 22 minutes per trip.

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Table 53-Continued

SUMMARY OF PRIORITY LANE TREATMENT IMPACTS ON TRANSIT RIDERSHIP AND DIVERSION Cent'd.

Type of Treatment	Example	Description	Results
Bus Lane Bypass of Toll Plaza	San Francisco	System of priority lanes for buses and carpools at the Bay Bridge toll plaza.	Bus and car travel times reduced by 5 minutes; 8 to 10% increase in ridership.

PRIMARY SOURCE: "Bus Use of Highways: State of the Art," National Cooperative Highway Research Program, Report 143, Washington, D.C., 1975

2. Use of an opposing lane. In this approach a lane on the least heavily traveled side of the urban freeway is reserved for high occupancy vehicles. For example, in the a.m. peak, a lane on the outbound portion of the freeway usually next to the median strip, is reserved for high occupancy vehicles to travel inbound against the traffic flow on the outbound lane. In this way, the exclusive use lane does not subtract from the total previously existing capacity on the congested portion of the freeway.

It should be noted that priority lanes need not run the entire length of a freeway, but might be appropriate for only close in, relatively short sections where congestion severely retards transit travel times. [4] Such treatments are generally inexpensive to implement requiring only signing, striping, lane delineators or cones, etc., but often are difficult to enforce and may have "adverse impacts on adjacent auto drivers. As indicated in Table 53, ridership, diversion, and time savings data thus far reported by a sample of existing freeway priority experiments is promising. The most successful demonstrations have been operated during peak periods and in combination with peripheral parking, exclusive access ramps and priority lane CBD distribution systems.

Bus priority signal systems such as metered bus ramps, signal preemption, special signalization, and special turn permission are being tested throughout the country. These systems vary in effectiveness based on their application in each situation,

The implementation and successful operation of priority bus lanes on arterial streets, highways, and access ramps is primarily dependent on well defined traffic management policies and a high level of intermodal cooperation. Designation of priority lanes usually does not require legislative action other than local approval, and few significant obstacles are apparent at the State and Federal levels. [3] Opposition can be expected where priority treatments exclude private carriers or present a competitive threat to para-transit modes such as taxi cabs, An example of this opposition was evidenced by a recent protest in New York City as reported in The New York Times, April 16, 1975:

> "QUEENS BLVD. BUS LANE POSTPONED" The city's Traffic Department postponed plans to establish an experimental two-and-a-half-mile express bus lane along Queens Boulevard after 100 Medallion cab drivers blocked the lane Monday night to protest their exclusion from it, A departmental spokesman said the project had "been postponed until further notice" so that meetings could be held with the Community Planning Board, the Chamber of Commerce, the tax industry, and local organizations. Under the planned 2-week experiment, express buses would have been allowed to travel east along a normally westbound lane, away from the Queens-bound rush-hour crush, beginning at 5 p.m. each weekday,

TRANSIT SERVICE IMPROVEMENTS

Fleet Expansion

In a recent EPA publication it was concluded that the improvement and expansion of mass transit facilities, especially bus fleet expansion, is one of the key elements necessary to attract auto drivers to transit and reduce VMT, [7] While no data on po~ tential transit ridership increases are available, EPA estimates that in order to achieve a 10 to 20 percent reduction in auto use by diversion of work trips to transit, existing bus fleets would have to be expanded by 50 percent, and in some cases over 500 percent. [7] Current EPA and DOT estimates of the amount of fleet expansion required to comply with transportation control plans are presenied in Table 54. EPA estimates are higher because:

1, In some cities EPA projects that transportation controls will achieve a greater reduction in automobile usage than DOT projects.

2. EPA has assumed that increased carpooling will achieve 25 percent of the needed reductions in auto use, whereas DOT assumes that carpools will carry 75 percent of the diverted auto travelers. [7]

EPA has specifically approved transit plans as part of transportation control plans in Washington, D. C., Baltimore, and Seattle, where firm commitments for fleet expansion have been made.

Express Bus Systems

Express bus systems in Seattle, Milwaukee, Washington, D. C., Portland, Oreg. and other United States cities have demonstrated that express bus service can attract significant transit ridership, especially in corridors not served by rail transit lines. The following is a summary of key ridership- and diversion-related experience thus far recorded by existing systems:

1. Express bus ridership, particularly those riders diverted from automobiles, appears to be very sensitive to cost and service variables such as parking costs and fares, time savings, and rider comfort.
2. Ridership increases may vary significantly among express bus routes, especially in areas where the service is aimed primarily at the suburban -to-CBD commuter market. As a result, successful express bus lines may not always increase total system ridership. For example, bus ridership on the Seattle Blue Streak route increased over 30 percent while total system ridership has decreased. [8]
3. In some cases, ridership increases may reflect a diversion from other transit lines, as well as the automobile. It has been estimated that over 38 percent of total ridership on the Shirley Highway route was diverted from other transit routes, while approximately 10 percent were former carpoolers. [8]
4. Most existing express bus systems provide free or inexpensive fringe parking either at regional shopping areas or on publicly owned land adjacent to major CBD access routes. The potential for feeder bus services instead of peripheral parking facilities has not yet been fully investigated.
5. The most successful express bus services have usually been implemented in conjunction with other transit service improvements or ridership inducements, Priority lane treatments, special fare, and accessible, inexpensive parking facilities are common examples.
6. Express bus service to particular employment concentrations, such as the Swan Island prepeak express in Portland, may have a high potential for attracting new transit riders.

Special Services

The national experience with special transit services consists of approximately 75 demand-responsive systems and a wide variety of small-scale, privately operated variations, usually consisting of only one or two vehicles. The most frequently cited demonstration projects have taken place in Haddonfield, N. J.; Ann Arbor, Mich.; Batavia, N. Y.; Bay Ridges, Ontario; and Regina. Saskatchewan. All of these demonstrations serve population concentrations of under 50,000 distributed over a limited area, operate on a subsidy and have attracted sufficient ridership to warrant fleet and service expansions after an initial operating period. In demonstrations where demand-actuated special services were coordinated with existing

Table 54

BUS FLEET EXPANSIONS NEEDED TO ACHIEVE PROJECTED REDUCTIONS IN AUTO USE

City	EPA Estimate		DOT Estimate	
	VMT Reduction Percent	Buses	VMT Reduction Percent	Buses
Los Angeles	17	12,913	7	2.533
San Francisco	14	3,310	7	787
Baltimore	4	377	tl 3	267
N.. New Jersey	18	8,684	8	1,840
Sacramento	9	501	7	186
San Diego	10	1,709	7	307
Phoenix/Tucson	8	802	8	386
Houston/Galveston	5	730	6	386
Denver	14	1,175	10	400
San Joaquin Valley	7	569	7	266
Boston	13	2,882	8	520
Washington, D.C. area	5	1,058	tl 2	467
Springfield, Mass.	● 9	58	● 22	40
New York City	● 5	502	● 40	213
Pittsburgh	6	663	1	26
Philadelphia	5	700	1	67
San Antonio	1	49	2	53
Salt Lake City	● 17	116	● 19	53
Seattle	● lo	174	● lo	80
Spokane	● 5	174	● 7	13
Portland, Oreg.	● lo	116	● lo	53
Minneapolis	2	267	● 2	27
TOTAL		37,529		8,970

● CBD only +Peak Period

SOURCE: **Transportation Controls To Reduce Auto Use and Improve Air Quality in Cities**, EPA, November 1974.

transit services, some increases in systemwide ridership have been recorded.

In most instances special services have acted as a catalyst for new transit operating and marketing techniques, They have also demonstrated that a variety of different transit markets exist, and the necessity to provide different services for each market. {10} The dimensions of the special service market, and the potential ridership which such services could attract in combination with other existing and proposed transit improvements was estimated in a recent study of the Cleveland Metropolitan Area. If implemented as part of a metropolitanwide program of transit improvements including fare reductions, modernization, service coordination, and new rapid transit lines, special services might increase total system ridership by as much as 15 percent. [20]

TRANSIT CAPITAL IMPROVEMENTS

Light Rail Systems [11]

The role of light rail technology in future United States transport systems appears to involve two types of situations. In one of them an inexpensive right-of-way would be available for which light rail would be the least expensive medium-capacity grade-separated system. This would of course require adequate distribution in the CBD. The other situation would reflect the European view that light rail has a higher amenity coefficient than buses and is worth installing even if the long run total costs are higher than bus systems which would move the same capacities, The maximum capacities of light rail systems are influenced by the same factors as rail rapid transit—number of cars per hour and standee ratios. The typical single car operation with a 2-minute headway (30 cars per hour) can move 6,000 to 9,000 one-way riders. The largest practical trains are three cars, due to movements in mixed traffic on some portions of the route. This provides an upper capacity range of *10,000* to 27,000 per hour. The capacities assume either 200 or 300 riders in either a 75-foot straight car or a 90–100 foot articulated car. The standee ratios would be 2.2 to 2.5. These capacities are all based on observation of actual operations.

Automated Guideway Transit (AGT) [21]

AGT may be divided into three categories:

1) Shuttle-Loop Transit SLT)
2) Group Rapid Transit (GRT)
3) Personal Rapid Transit (PRT)

All of these systems operate unmanned vehicles on exclusive guideways.

Several SLT systems are currently in operation at airports, recreational centers, and private commercial developments. These systems provide low to medium capacity service usually on closed circuits requiring no switching. In specialized urban environments where loop service (such as in a CBD) or shuttle service (such as between two large activity centers) is needed. SLT systems could improve transit service and ridership. However, the SLT systems are not suited for service to large metropolitan areas.

GRT systems are in partial operation at the Dallas/Ft. Worth Airport (AIRTRANS) and under construction at Morgan town, W.Va. Both have experienced technical difficulties; however, within the next few years systems of this type should be capable of serving light to medium density corridors in urban areas. A GRT system is planned for Denver which would greatly improve transit service and ridership in the area.

PRT systems are invisioned to consist of small vehicles which carry a passenger or a small group of passengers to their destination with few, if any intermediate stops. No PRT systems are in operation at this time, and it is not likely that such systems will have any impact on urban transportation in the short term.

Exclusive Busways

Exclusive busways involve the construction of a special facility of some type, usually permanent, exclusive lanes for buses similar in cost and design to freeway construction, or separate access ramp facilities. In some cases, part of an existing highway is converted to a busway utilizing one or more existing lanes or the median strip. Operationally, busways are similar to temporary reserved or priority lanes, but their capacity can be significantly higher depending on access restrictions and control devices. The busway capacities presented in table 55 assume conventional headways and traffic safety devices, and exclusive lanes on expressways or high class arterials with restricted access and few controlled intersections. [11] It now appears that "platooning" [13] could further increase these capacities to an upper range of 1,100 to 1,400 buses per hour.

Existing experience with busways is limited to the three demonstrations listed in table 56, These busways ranged in cost from $1.9 million (Seattle,

Table 55

HOURLY ONE WAY EXPRESS BUS CAPACITIES ON BUSWAYS

Busway Operation	Buses per Hour per Lane	Riders per Hour at Average Occupancies 45	60
Medium Speed Operation 30-35 mph	[b]750	33,750	[a]45,000
High Speed Operation 50-60 mph	500	22,500	([a])

[a]No standees on high speed services due to passenger safety. There are serious safety arguments against the practice for medium speed services with very short headways implied here—5 seconds. The above figure may surrogate for double-deck or articulated buses. It will not be used in any of the subsequent tables.

[b]To obtain 700 to 800 buses per hour all loading and unloading must be done *off* the roadway and traffic segregation and flow controls must be sophisticated. These volumes are actually attained by the Port of New York-New Jersey Authority using Lincoln Tunnel (6 lanes with 2 reversible, bus-only lanes in peak hours) and the Port Authority Bus Terminal which has a *four-lane* throughout capacity. During rail service strikes almost 900 buses per hour have used this system but the speed drops by 5-10 mph, i.e., to 20-25 mph.

SOURCE: Reference 11.

Table 56

SUMMARY OF BUSWAY IMPACTS ON TRANSIT RIDERSHIP AND DIVERSION

Example	Description	Results
Blue Streak, Seattle	9 miles of reversible bus lanes, exclusive *bus* ramp, fringe parking.	Ridership increases by 1/3; new riders were equally divided between those diverted from autos and those who did not previously make the trip. Bus speeds increased 5-7 mph and average transit travel time improvements were 11 minutes in the a.m. and 9 minutes in the p.m. peak periods. Total daily passenger volume of 10,000.
San Bernadino, Los Angeles	11 -mile busway downtown Los Angeles and El Monte located within the median and adjacent to the San Bernadino Freeway.	Average patronage increases of up to 200 percent have been reported. Total daily passenger volume is expected to reach 17,000 upon completion.
Shirley Highway, Washington, D.C.	9-mile busway between Northern Virginia and Washington, D. C., *special bus* access *ramps at interchanges,* fringe parking, and bus shelters.	Bus ridership increased from 27 percent in 1968 to approximately 37 percent in 1972. Some of this increase was diverted from other bus lines as well as autos. Total daily passenger volume has exceeded 16,000 utilizing 300 buses with time savings of 10 to 15 minutes over autos.

PRIMARY SOURCES: References 6,8, and 9

exclusive bus ramps) to $53 million (San Bernadine, 11-mile busway). All of these facilities reported ridership and diversion increases that are interrelated with express bus service improvements and other fare and fringe parking inducements.

AUTO RESTRAINT

Road User Charges

Despite an ever increasing number of potential road pricing mechanisms such as metering, automatic scanning, differential license plates, etc., the only road pricing practices currently in use are charges applied through gasoline taxes and tolls on bridges, tunnels, and other roadways. These practices have traditionally been implemented to raise revenues (not to control traffic) in order to pay for highway construction costs (fuel taxes) and the construction of high cost bridges, tunnels, and freeways (tolls).

The toll collection approach is in wide use at present and may be an effective means of increasing transit ridership. Applied by public authorities (and occasionally local governments) operating river crossings or high capacity highways, tolls are levied to recover the costs of these particular facilities from the motorists actually using them. In contrast to fuel taxation, whereby motorists pay "averaged" prices for road use, toll collection imposes differing charges which can be varied according to the cost of the specific facility and how many times it is used. [14] Furthermore, tolls are widely levied in high density urban locations where maximum auto restraint and diversion to transit could be expected, assuming alternative transit service is available. Among the large cities with toll facilities on major entry points for high capacity highway links in the city are Boston, New York City, Philadelphia, Baltimore, Chicago, Kansas City, Jacksonville, and Miami.

Comparisons of the impact of toll increases on traffic volume on existing bridges has revealed that increases of up to 87 percent may reduce traffic by only 6 percent, However, where reasonably good bus service exists as an alternative mode during the peak hour, it has been estimated that a 25-cent toll would result in an 11 percent reduction in CBD work trips. [15]

In summary, relatively light congestion toll increases may be effective in diverting auto drivers to transit in situations where an alternative transit mode is available which can provide a competitive level of service for large numbers of travelers with negligible congestion effects. @51 Examples are the Lindenwald corridor in Philadelphia, where high speed rail service is available as an alternative to auto travel, and the Shirley Highway in Washington, D. C., where high quality express bus service is operating.

Parking Taxes

Parking taxes resulting in parking rate increases have been implemented in London, New York, Pittsburgh, San Francisco, and other major cities, but efforts to isolate the impacts of these increases on transit ridership and auto diversion have yielded few definitive conclusions. In general, parking taxes can be applied for the entire day (flat rate per hour) or for peak periods only, depending on what portion of the parking market the tax is aimed at; long term parking (commuters) or short term parking (primarily shopping, business, and deliveries),

Assuming that parking taxes would be implemented to discourage commuters from driving their private cars into the CBD and use alternative transit services, what are the potential effects on transit ridership? Using a mode split model fitted to Washington CBD-bound work trips, one researcher [16] estimated changes in travel behavior as shown in Table 57. Using an average current parking charge of $2, the data in Table 57 lead to a price elasticity estimate of –.41 for auto driver trips and a "cross-elasticity" of ,38 for bus passenger trips. [17] This data is consistent with experiences reported in other cities indicating that the price elasticity of parking demand is fairly low (–.3 to –.4).

Since parking taxes could possibly affect only 40 percent of all CBD trips in most areas (assuming 60 percent pass through without stopping), parking taxes alone may not be a very effective means of reducing total CBD-oriented traffic volumes. However, at a demand elasticity of –.3 and a tax increase of $2, peak hour transit usage might be expected to rise from 20 to 30 percent, making the parking tax one of the most effective auto restraint/transit improvement actions in terms of transit ridership and energy conservation. This increase would depend on the scale at which the tax is applied, how much of the market it includes, and the availability of quality transit alternatives, Seven United States cities have included parking surcharges as part of AQIP Plans; Washington, D. C., Boston, and five metropolitan areas in California. [7]

Table 57

PROJECTED CHANGES IN TRAVEL BEHAVIOR RESULTING FROM A PARKING TAX IN WASHINGTON, D.C.

Increase in Average Parking Cost	Auto Driver Trips	Transit Trips
$ .25	–4	+3
.50	–8	+6
.75	–12	+1 o
1.00	–15	+13
1.50	–20	+20
2.00	–23	+26
2.50	-26	+33
3.00	-29	+38
3.50	–31	+42
4.00	–34	+47
4.50	–36	+51
5.00	–37	+55

SOURCE: Ted Erlich, "Transportation Pricing and Parking Charges," paper presented at the 'meeting of the Highway Research Board's Committee on Taxation, Finance, and Pricing, Washington, D. C., January 1973.

Parking Regulations

Parking regulations are ways to control the location, amount, and use of parking without resorting to a pricing mechanism. In most metropolitan areas administrative action has been taken to prohibit on-street parking whenever and wherever it obstructs traffic movement, typically along major arterials during commuting hours. This has been particularly effective in New York City where strict enforcement prevails and iIlegally parked motorists are towed away, resulting in a $75 fine. However, such measures usually improve traffic flow characteristics to the benefit of the auto commuter, rather than encourage transit ridership. Other cities have moved to limit existing on-street parking **at certain** hours to residents only, in an attempt to discourage parking on city streets by residents of outlying districts. Boston, for example, now limits all nighttime street parking to city residents who display a special sticker on their windshield. [14]

Since most commuters use long term off-street parking, regulations which attempt to influence their mode of travel to the CBD must focus on these spaces. Studies show that in most metropolitan areas with a population over 100,000, commercial, off-street parking may account for as much as 80 percent of all parking in the city. [17] This preponderance of commercial facilities and the lack of any precise data on the effects of reducing off-street parking supply, greatly complicates the use of parking regulations to achieve change-of-mode objectives. For example, simple reductions in the total quantity of available parking in an area may not affect commuters at all, Since CBD parking space is frequently allocated on a first-come-first-served basis or through monthly contracts, commuters are likely to consume whatever space remains after a parking supply cutback, eliminating all non-work travelers from the parking market. [7]

While many cities such as London and Washington, D. C., have already reduced the total number of available on-street parking spaces, regulations to limit the supply of off-street parking have only recently been initiated, primarily because of their controversial effects on private and commercial operations and unknown impacts on peak-hour commuters. Moratoriums on new parking facilities both public and private, restrictions governing the location of new off-street spaces, and limitations on the number of spaces permitted in new office and residential structures are some of the regulations currently being tested. Several areas such as San Diego, Los Angeles, Portland, and Seattle have developed parking regulatory programs as part of AQIP transportation control plans. These programs regulate the location, operation and increase in parking related facilities, consistent with air quality needs, [7] Another approach has been to provide free or reduced-cost municipal parking as an inducement for commuters to switch modes. Boston, Chicago, and Cleveland all have peripheral parking programs which have dramatically increased peak hour ridership on specific transit lines.

Auto-Free Zones

"Vehicle-free zones generally refer to closing off a limited area in a heavily trafficked commercial district to autos and trucks. There are over 100 cities in the world which have banned traffic from portions of their central cities, Most of these cities are in Europe where population densities are higher and people are more accustomed to using bicycle, pedestrian, and transit modes. The impetus behind most of these zones is to eliminate an ever-increasing level of traffic congestion which leads to high air pollution, noise, accident rates, and unpleasantness levels. There were questions as to whether the pedestrian malls would result in less sales and therefore offset the economic viability of the area. Experience indicates that the economic viability has not been threatened and has in fact improved in many locations. [3]

"Gothenburg, Sweden, is an example of an area where an attempt was made to restrict unnecessary traffic. In this case, autos were not banned, but the city was divided into sectors, and vehicles were not allowed to cross sector lines. Through traffic was rerouted. This resulted in: elimination of traffic congestion, less travel in the area, more distance traveled by through traffic at higher, speeds, and better performance by transit vehicles in the CBD. However, it is significant that Gothenburg is a relatively small city which is well served by transit." [3]

In the United States the major examples of such zones have been shopping malls and street closings. The 8-block Nicollet Avenue transit mall in Minneapolis is one of the few cases where transit considerations were included as a major component. In this treatment a pedestrian street also functions as a local transit distribution system and a terminal for buses entering the CBD. Bus ridership in the mall area increased by 17,500 per day.

LAND USE CONTROLS

See Chapter XI for long-range land use considerations.

MARKETING

Many transit systems across the country have initiated extensive advertising and promotional campaigns in order to counteract declining ridership. Others have used marketing techniques to dispel transit's poor image during the conversion from private to public ownership, and to promote new services and disseminate information concerning system operations. The impact of these marketing programs varies widely, from no effect to slight reductions in the rate of ridership decline, to I0-15 percent ridership increases on particular transit lines. No conclusive evidence exists to support the position that marketing techniques alone will influence transit ridership in the short run. [18] However, some transit systems such as those in Seattle, Pittsburgh, and Cleveland have credited marketing techniques as partially responsible for meeting limited ridership objectives. The most successful marketing programs have placed heavy emphasis on customer information services, methods to increase transit visibility, and close coordination with new service improvements.

STAGGERED WORK HOURS

Staggered work hours may be achieved by varying starting and release times in major employment centers or by allowing "flexible" work periods for individual employees on a companywide basis. The general effect of such measures would be to reduce peak-hour pressure on existing transportation facilities (highways, bridges, tunnels, transit systems), reduce congestion and consequently, reduce the need for new facilities and services. Staggered work hours might be beneficial to transit in at least two ways:

1! By reducing the peak-period demand and spreading it to times when transit vehicles are operating at lower capacity, transit service can be improved, thus attracting increased ridership. A recent variable work hours program in Ottawa reported that ridership, expressed as a percentage of seating capacity, had a "flatter distribution" during peak periods and that transit ridership increased slightly. [19]

2. Because an effective staggered work hours program is likely to reduce congestion and create some excess capacity in the highway network during peak hours, it could make travel by automobile more attractive. However, if this excess highway capacity is utilized for new transit services such as priority or exclusive bus lanes, transit ridership and auto/transit mode shifts might be increased.

Experience also indicates that staggered work hours can have negative impacts on carpooling programs and may present transit scheduling problems which could jeopardize transit patronage. [4]

NEW TECHNOLOGY

"Current manual bus scheduling procedures are extremely slow and inefficient. As a result of this archaic technology, it is almost impossible to make major route and schedule changes in the medium-sized and larger bus systems. Assignment of men and vehicles is accomplished in an inefficient manner and route patterns are not easily changed in response to changes in the patterns or origins and destination. It is thought that automation of this procedure, chiefly through computerization, would improve the frequency and thoroughness of schedule revision." [4]

Selective computerization of key portions of the transit industry could be implemented in the short term resulting in near term service improvements and cost saving benefits. Gradual automation of the entire industry promises many long-term benefits which are essential to the reorganization of existing services and the creation of new services competitive with the automobile. Implementation of these measures is dependent on careful application to each transit system and could face resistance from unions.

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