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THE EVALUATION OF BENEFITS FROM MEASURES TO INCREASE URBAN TRANSPORT EFFICIENCY

by

G. J. Roth and Y. Zahavi

Presented to

The Conference on the Economic Regulation of Urban Transportation

Annapolis

September 19-22, 1976

Abstract

The purpose of this paper is to obtain order of magnitude estimates of economic benefits likely to result from the relaxation of the economic regulation of urban transport. On the basis of a methodology which takes explicit account of tripmakers' constrained money and time travel-budgets, calculations are made in respect of an urban area with the characteristics of the Washington, D.C. Region in 1968. The transport changes examined include (a) increased car pooling (b) speeding-up of transit and (c) shifting of trips from cars to transit. The annual benefits obtainable from the measures examined are found to be within the range 16-million-dollars-plus-12-million-hours to 80-million-dollars-plus-28-million-hours.

The analysis indicates that shifts of trips from cars to transit are likely to result in a lowering of mobility unless transit-trip speeds are at least as high as car-trip speeds. It is concluded that, in an area where over 80 percent of travel is by car, and where transit speeds are lower than car speeds, increased car pooling is particularly promising as a means of increasing urban transport efficiency.

*Mr. Roth, author of "Paying for Roads", is a transport economist currently serving in the World Bank. Dr. Zahavi is a private transportation consultant. This paper reflects the personal views of the authors, and not of any organization with which they are associated.

September 14, 1976

Draft Paper for Conference on the Economic Regulation of Urban Transportation
THE EVALUATION OF BENEFITS FROM MEASURES TO INCREASE URBAN TRANSPORT EFFICIENCY

G. J. Roth and Y. Zahavi

The Problem

1. While everybody is in favor of more efficiency in urban transport, not much attention has been paid to evaluating the expected benefits in a comprehensive manner. It is not difficult to postulate a change in the urban transport system, for example a time-saving investment, and to calculate the consequent "savings" in time and money related to a given number of trips made "before" and "after" the improvement. However, this approach ignores the generated travel that invariably follows urban transport improvements and thus conceals many of their likely consequences.

2. The purpose of this paper is to obtain a deeper and more comprehensive insight into the phenomena of urban transport improvement, and to calculate order of magnitude estimates of the benefits that might reasonably be expected from the relaxation of economic regulation in the Washington, D.C. area.

Specifically, calculations are made to indicate the effects of the following:
the

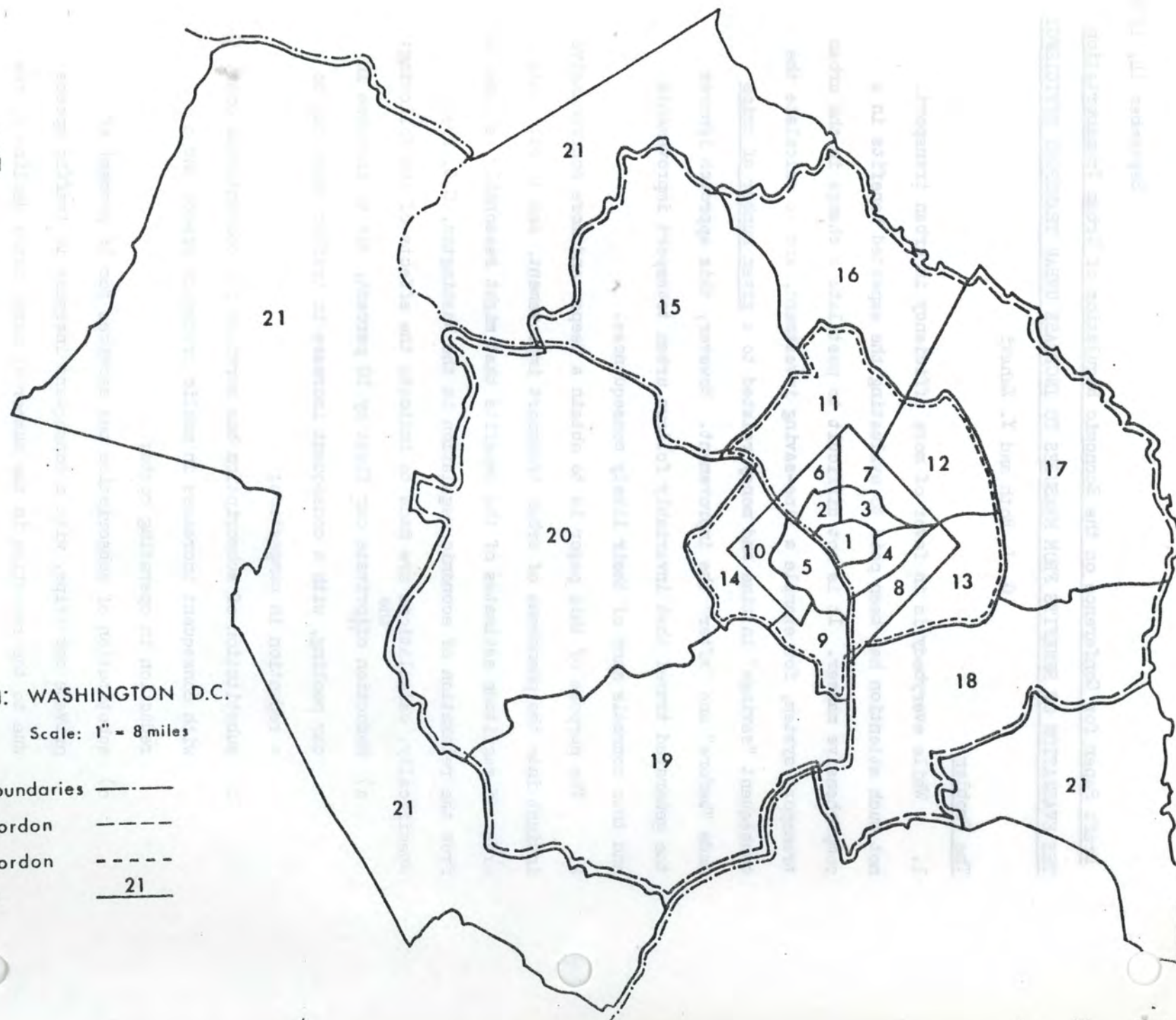
- a) Reduction of ~~the~~ private car fleet by 10 percent, due to increase in car pooling, with a consequent increase in traffic speed due to a reduction in congestion;
- b) substitution of subscription bus services for conventional ones, with consequent increases in public transport speeds and a reduction in operating costs;
- c) substitution of subscription bus services for 10 percent of private car trips, with a consequent increase in traffic speeds due to the reduction in the number of cars, but a decline in the speed of trips transferred from cars to subscription services.



FIGURE 1: WASHINGTON D.C.

Scale: 1" = 8 miles

State Boundaries	———
1968 Cordon	- - - - -
1955 Cordon	- · - · -
Districts	<u>21</u>



The Scenario

3. The calculations relate to the conditions obtaining in the Washington, D.C. area in 1968, the latest year for which comprehensive travel data are available. The area considered is shown on the attached map. The population considered consists of residents of districts 1-14, while their travel covers districts 1-20. The basic population and car data for each district were obtained from unpublished survey material collected for the 1968 Transportation System Findings Report by the Metropolitan Council of Governments (COG), and are summarized in Table 1. Basic travel characteristics for 1968, with corresponding figures for 1955, are given in Table 2.

TABLE 1 - BASIC DATA ON POPULATION, HOUSEHOLDS, CARS
AND TRIPMAKERS, WASHINGTON, D.C. 1968

District	Population	Households	Cars	Tripmakers per Household
1	76,803	37,133	20,613	1.37
2	17,060	8,070	5,476	1.62
3	96,519	36,143	20,890	1.60
4	82,365	27,377	18,125	1.58
5	61,005	28,772	31,714	1.59
6	46,681	20,287	21,216	1.75
7	116,054	37,770	38,258	1.84
8	184,256	58,180	42,658	1.73
9	110,760	38,270	48,349	1.90
10	98,999	36,049	48,451	1.93
11	277,901	85,981	135,468	2.18
12	190,630	64,552	90,699	1.98
13	143,599	42,688	56,679	2.13
14	<u>89,966</u>	<u>25,950</u>	<u>41,934</u>	<u>2.35</u>
Total	1,592,599	547,224	620,531	1.87

TABLE 2 - TRAVEL CHARACTERISTICS OF WASHINGTON, D.C. TRIPMAKERS
1955 AND 1968

	"Car-only"* Tripmakers		"Transit-only"* Tripmakers	
	1955	1968	1958	1968
Daily (door-to-door) Travel Time, hours	1.09	1.11	1.27	1.43
Time per trip, hours	0.35	0.35	0.55	0.67
Number of trips per weekday	3.07	3.16	2.31	2.12
Distance traveled per day, miles	12.73	16.10	8.45	8.92
Distance per trip, miles	4.15	5.10	3.66	4.21
Speed, door-to-door, mph	11.70	14.50	6.65	6.24

* "Car-only" tripmakers are those from households in which all trips are made by private car. "Transit-only" tripmakers belong to households in which all trips are made by transit. A third group, from households using mixed modes is not shown; its travel characteristics are intermediate between the first two groups. "Transit" describes all public transport trips, including those by taxi and school bus.

The Methodology

4. The calculation of benefits uses a methodology developed recently by Dr. Zahavi and is described by him more fully elsewhere (1).

It depends on the empirical finding in a number of cities, including Washington, D.C., that both the time and the money allocated by groups of tripmakers for urban travel tend to be stable, and therefore predictable. The basic indications, which will be discussed later, may be summarized as follows:

- a) Daily travel demand is constrained by two main travel budgets, of money and of time;
- b) the travel money budget of the individual tripmaker depends on his household income;
- c) the travel-time budget for tripmakers is stable both between cities and over time within the speed ranges normally found in U.S. cities;
- d) tripmakers strive to maximize their daily travel distance within the above constraints of money and of time.

The Travel Money Budget

5. The cost of travel is recognized to be a major constraint on travel, since people can only allocate a proportion of their disposable income to transportation. The proportion of income allocated to travel seems to be stable both over time and between countries, in developed countries. Table 3 details the average personal consumption expenditure on travel vs. the total consumption expenditure in all the U.S. during 1963-1973 (2). It becomes evident that expenditures on travel tend to be a relatively stable proportion of the total expenditure, at about 13.2 percent. Since the total

expenditure was found to be about 86 percent of income, it follows that the average expenditure on travel during 1963-1973 was about 11.4 percent of income. (Disposable incomes are more difficult to define and, therefore, all data in this section are based on total income.) The same trend is also found in other countries and cities, as detailed in Table 4 (3, 4, 5, 1).

TABLE 3 - PERSONAL CONSUMPTION EXPENDITURE ON TRAVEL VS. TOTAL CONSUMPTION EXPENDITURE, ALL U.S., 1963-1973

Year	Exp. on Travel as % of Total Exp.
1963	13.1
1964	12.9
1965	13.4
1966	13.0
1967	12.7
1968	13.4
1969	13.4
1970	12.6
1971	13.6
1972	13.7
1973	13.6

TABLE 4 - EXPENDITURE ON TRAVEL AS PERCENTAGE OF INCOME

Place	Year	Expenditure %
All U. K.	1972	11.7
Fed. Rep. of Germany	1971	12.0
" "	1972	11.3
" "	1973	11.1
" "	1974	10.7
London	1972	12.3
Washington, D. C.	1968	11.2

Hence, it may be inferred that expenditures on travel tend to be a stable proportion of income, within the range of about 11-12 percent.

6. It was further noted that households who make all their trips by car tend to allocate a stable proportion of their income to travel, at about 11-13 percent, at all income levels. However, households which make all their trips by

The Travel-Time Budget

transit tend to allocate only 3-5 percent of income to travel, again at all income levels. Since the proportion of households owning a car increases with income, it follows that the total average expenditure on travel by income groups increases from about 3 percent at low income levels to a saturation level of just over 13 percent at high income levels.

makers over a 12-13 year period, as shown in Table 5. 1.10 hours per day

The average daily travel time per car tripmaker for the whole U.S. in 1970 is 1.10

TABLE 5 - DAILY TRAVEL TIME PER TRIPMAKER VS. DOOR-TO-DOOR SPEED
WASHINGTON, D.C. AND TWIN CITIES

City	Year	Car		Transit	
		Travel Time Hours	Speed mph	Travel Time Hours	Speed mph
Washington, D.C.	1955	1.02 (1)	11.7	1.27 (3)	8.6
	1970	1.11 (2)	15.2	1.12 (1)	8.2
Twin Cities	1955	1.14 (2)	13.4	1.02 (1)	7.4
	1970	1.13 (2)	17.7	1.12 (2)	7.2
All USA	1970	1.10			

Table 5 also shows the travel time of tripmakers who used only transit in Washington, D.C. and Twin Cities. This shows the significant results that while in Twin Cities the "transit-only" tripmakers had the same travel-time budget as the "car-only" tripmakers, namely about 1.1 hours per day, the travel time of "transit-only" tripmakers in Washington, D.C., in 1955 was at 1.27 hours per day, significantly higher than the travel-time budget of "car-only"

The Travel-Time Budget

7. It has already been noted that the average daily travel time per car tends to be stable, at about 0.8 hours, in cities of developed countries (6). Recent analysis of four traffic studies in Washington, D.C. and Twin Cities showed that the same phenomenon applies to tripmakers and that the average door-to-door daily travel time remained about 1.1 hours for "car-only" trip-makers over a 12-13 year period, as shown in Table 5. 1.10 hours was also the average daily travel time per car tripmaker for the whole U.S. in 1970 (7, 8).

TABLE 5 - DAILY TRAVEL TIME PER TRIPMAKER VS. DOOR-TO-DOOR SPEED
WASHINGTON, D.C. AND TWIN CITIES

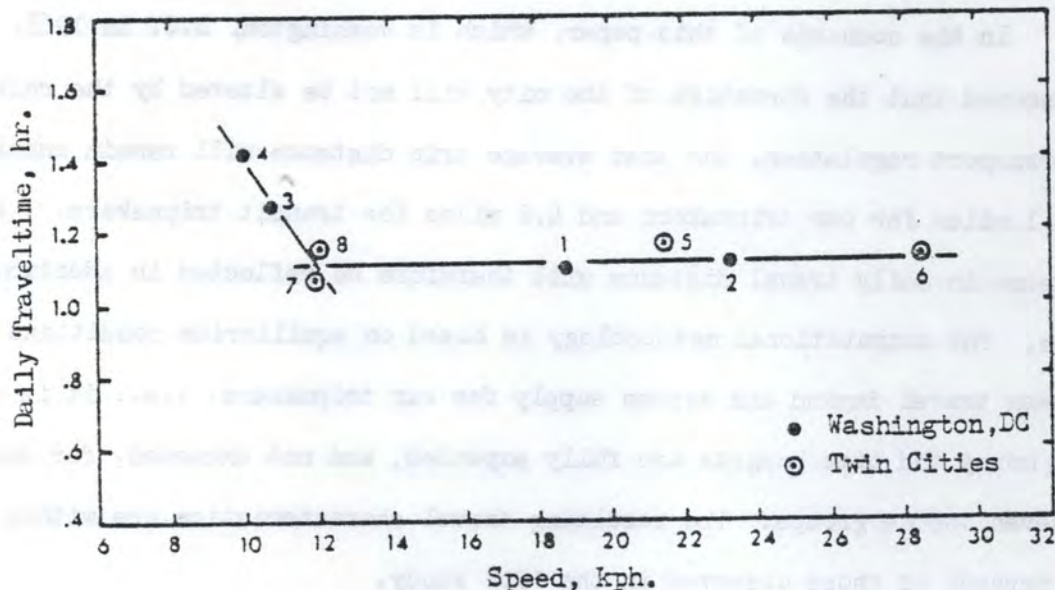
City.	Year	Car			Transit		
		Travel Time Hours	Speed		Travel Time Hours	Speed	
			mph	kph		mph	kph
Washington, D.C.	1955	1.09 (1)	11.7	18.8	1.27 (3)	6.6	10.7
	1968	1.11 (2)	14.5	23.3	1.42 (4)	6.2	10.0
Twin Cities	1958	1.14 (5)	13.4	21.5	1.05 (7)	7.4	11.9
	1970	1.13 (6)	17.7	28.5	1.15 (8)	7.5	12.1
All USA	1970	1.10					

8. Table 5 also shows the travel time of tripmakers who used only transit in Washington, D.C. and Twin Cities. This shows the significant result that while in Twin Cities the "transit-only" tripmakers had the same travel-time budget as the "car-only" tripmakers, namely about 1.1 hours per day, the travel time of "transit-only" tripmakers in Washington, D.C., in 1955 was at 1.27 hours per day, significantly higher than the travel-time budget of "car-only"

tripmakers, and by 1968 the travel time of "transit-only" tripmakers in Washington, D.C. increased even more, to 1.42 hours, while the travel time of "car-only" tripmakers remained virtually the same.

9. The daily travel times of "car-only" and "transit-only" tripmakers shown in Table 5 are plotted in Figure 2 against average door-to-door travel speed, and it will be seen that the daily travel time rises when travel speeds fall below about 7.5 mph. (11 kph)

FIGURE 2. Daily Travel Time Per Tripmaker vs. Door-to-Door Speed
Washington, D.C. and Twin Cities



10. It should be noted that while the trip rates of "car-only" tripmakers in Washington increased from 3.07 to 3.16 between 1955 and 1968, the trip rate of the "transit-only" tripmakers decreased from 2.31 to 2.12, and came close to the minimum trip rate of 2.0 per day.* The increase in the travel time of this group was therefore not accompanied by an increase in trip rate but

* 2.0 trips per tripmaker is the minimum rate because virtually all urban trips involve outward and return journeys on the same day.

reflected the fact that "transit-only" tripmakers had no other way of carrying out the minimum number of trips that they considered necessary.

11. For the purpose of predicting travel behavior, it will therefore be assumed that in all cases where tripmakers travel more than the preferred daily travel time of 1.1 hours, an increase in speed will result in a reduction in daily travel time to the preferred figure of 1.1 hours, as long as the base-year trip rate is not reduced. However, for tripmakers already traveling within this limit, it will be assumed that increases in speed will result in more travel: either more trips or longer trips, or a combination of both.

12. In the scenario of this paper, which is Washington, D.C. in 1968, it is assumed that the structure of the city will not be altered by the relaxation of transport regulation, and that average trip distance will remain unchanged at 5.1 miles for car tripmakers and 4.2 miles for transit tripmakers. Any increase in daily travel distance will therefore be reflected in additional trips. The computational methodology is based on equilibrium conditions between travel demand and system supply for car tripmakers, i.e., it is assumed that money and time budgets are fully expended, and not exceeded, for each of seven income groups. The resulting travel characteristics are within a few percent of those observed in the 1968 study.

Putting the Methodology to Work

13. The methodology described above was used to examine four alternatives to the "Base case," which is the Washington, D.C. travel situation in 1968. These alternatives were as follows:

Case 1. Shift from Cars to Carpools: In this case it is assumed that, as a result of car users being allowed to give each other trips for money, there would be an increase in car pooling which would bring about a 10 percent reduction in car traffic, with a resulting increase in speed, of both cars and transit.

Case 2. Replacement of Peak Period Stage Bus Services by Subscription Bus Services: It is assumed that the stage bus services provided by the 1,000 conventional stage buses that in 1968 were used only in the peak periods, were replaced by subscription bus services of the kind used in the Peoria-Decatur demonstration project in 1966-1970 (9). On the basis of the results obtained in Peoria, it is assumed that average transit ("in-vehicle") speeds would rise from the 1968 level of 55 percent of car speeds to 75 percent of car speeds, with fares remaining at 6¢ per mile.

Case 3 (1+2 Combined): In this case it is assumed that car traffic is reduced by 10 percent, and simultaneously bus speeds are increased so that transit speeds are 75 percent of car speeds.

Case 4. Shift from Cars to Subscription Buses. It is assumed that, as a result of the introduction of subscription bus services,

10 percent of car tripmakers (drivers and passengers) would shift to the speeded-up bus services, and that the consequent reduction of 10 percent in car traffic would result in a further reduction in car and transit travel times, as in Case 1.

14. On the basis of the data from the CCG Study, of known speed-flow relationships, and of the 1968 money and time travel budgets established for the Washington, D.C. area, the Summary Table 6 was prepared showing, for the base case and the four alternatives, for car and transit separately, the following characteristics:

Distance: The total daily "in-vehicle" miles of travel carried out by car and transit tripmakers;

Trips: The total number of daily trips by car and transit tripmakers;

Hours: The total daily hours ("in-vehicle" time) of travel by car and by transit;

Speed: The average network speed, separately for car and transit, calculated as the sum of "in-vehicle" person miles divided by the sum of "in-vehicle" person hours.

Expenditure: Daily expenditure by tripmakers on car and on transit.

Increases in travel speed allow tripmakers to increase their daily travel distance within their daily travel time budgets. Since the unit cost of car-travel decreases with increase in speed (within the speed range found in cities), the end result is that the car tripmakers can increase their daily travel distance considerably for comparatively slight additional expenditures.

TABLE 6-- AVERAGE WEEKDAY TRAVEL IN THE WASHINGTON, D.C. AREA 1968
CONSEQUENCES OF HYPOTHETICAL MODAL CHANGES

		Base Case	Case (1) 10% Reduction In Car Traffic Due To Increased Car Pooling	Case (2) Transit Speeds Rise To 75% Of Car Speeds	Case (3) Cases (1)&(2) Combined	Case (4) 10% Reduction In Car Traffic Due to Shift To Speeded-Up Transit
<u>Distance:</u>	car drivers	8,927,255	8,460,360	8,927,255	8,460,360	8,460,360
(miles)	car tripmakers	12,229,117	12,886,881	12,229,117	12,886,881	11,579,853
	transit tripmakers	2,284,119	2,284,119	2,324,660	2,447,867	3,439,915
	Total	14,513,236	15,171,000	14,553,777	15,334,748	15,019,768
Modal Split by Distance (%)		15.7	15.1	16.0	16.0	22.9
<u>Trips:</u>	car drivers	1,750,442	1,658,894	1,750,442	1,658,897	1,658,894
(No.)	car tripmakers	2,397,866	2,526,840	2,397,866	2,526,840	2,270,559
	transit tripmakers	543,838	543,838	553,490	582,825	819,027
	Total	2,941,704	3,070,678	2,951,356	3,109,665	3,089,586
Modal Split by Trip No. (%)		18.5	17.7	18.7	18.7	26.5
<u>Travel Time:</u>	car tripmakers	528,460	528,460	528,460	528,460	474,885
(hours)	transit tripmakers	197,660	187,684	147,687	147,687	201,986
	Total	726,120	716,144	676,147	676,147	676,871
Modal Split by Time (%)		27.2	26.2	21.8	21.8	29.8
<u>Vehicle Speed:</u>	car	23.14	24.39	23.14	24.39	24.39
(mph.)	transit	11.56	12.17	15.74	16.57	17.03
Weighted Average		19.99	21.18	21.52	22.68	22.19
<u>Expenditure:</u>	car tripmakers	1,422,000	1,296,317	1,422,000	1,296,317	1,296,317
(US\$)	transit tripmakers	137,047	137,047	139,480	146,872	206,395
	Total	1,559,047	1,433,364	1,561,480	1,443,189	1,502,712
<u>Mobility:</u>	car (%)	150.6	158.7	150.6	158.7	142.6
(trips per	transit (%)	34.1	34.1	34.8	36.6	51.4
100 pop.)	Total	184.7	192.8	185.4	195.3	194.0
<u>Cost per Trip:</u>	car tripmaker	0.59	0.51	0.59	0.51	0.57
(US\$)	transit tripmaker	0.25	0.25	0.25	0.25	0.25
Weighted Average		0.53	0.47	0.53	0.46	0.49
Average Exp. per HH on Travel (US\$)		2.85	2.62	2.85	2.64	2.75
Average HH Income (US\$) per day		27.24	27.24	27.24	27.24	17.24
Travel Exp. as % of Income		10.5	9.6	10.5	9.7	10.1
Daily Distance per Tripmaker (miles)		14.00	14.64	14.04	14.80	14.49
Daily Exp. per Tripmaker (US\$)		1.50	1.38	1.51	1.39	1.45

Thus any increase in travel speeds provides a strong incentive to increase spatial opportunities in cities, and it is clear from the evidence that people do in fact take advantage of these opportunities.

Mobility: The number of weekday trips per hundred people. As trip length is assumed to remain unchanged, any change in the daily distance traveled is reflected pro rata in a change in the number of trips, and hence in mobility.

Cost per Trip: These costs relate to expenditures by the tripmakers.

In the case of transit, this was 25¢ (6¢ per mile) in 1968.

In the case of car trips, costs fall as traffic is speeded, in accordance with the formula

$$c = 1.683 v^{-0.75}$$

where c represent travel costs in \$ per mile, and v car speed in mph.*

Expenditure per Household: The figures given for illustrative purposes are for the income group \$8,500 per year which represents the weighted average of the population in the study area in 1968. Annual income is converted to daily income on the basis of 312 days per year, and the daily expenditure on travel is shown as a percentage of this.

Daily Distance Traveled per Tripmaker: The total distance traveled per day divided by the number of tripmakers.

Daily Travel Cost per Tripmaker: The total cost expended by tripmakers in the area, divided by their number.

The expected travel statistics for the four cases are shown in Table 6.

*Within a stable car travel-time budget, both standing and operating costs vary with speed.

15. Case 1. A reduction of the private car fleet by 10 percent, due to an increase in car pooling, would increase the travel speeds, and reduce the costs, of both car and transit trips. Car tripmakers would be able to travel additional miles within their travel time budget, and would increase their daily travel miles from 12.2 to 12.9 million miles. Their costs per trip (due to higher speeds and higher vehicle utilization) would fall from 59¢ to 51¢. As a group, their expenditure on travel would fall, although the payments for car pooling would bring about money transfers within the group, the effects of which have been ignored. Transit tripmakers would save time, but not sufficient time to bring them within the "preferred" daily travel-time budget of 1.1 hours. They would therefore not increase their travel mileage. Transit modal split would decline from 15.7 percent to 15.1 percent by distance, and from 18.5 percent to 17.7 percent by trips. However, the increased speed of transit would benefit the operators \$3 million a year by reducing their capital and operating costs, as is shown in Table 7 below.

16. Case 2. The rise in transit speeds would make no difference to car tripmakers, and the vital statistics of their trips would remain the same as in the base case. Transit tripmakers would enjoy a large saving in travel time, so that their original trips would take less than the preferred daily travel time of 1.1 hours. They would therefore increase their daily trip distance to 2.32 million miles, from 2.28 million miles in the base case. The savings to the transit operators would be \$16 million per year, as against \$3 million in Case 1. The increased transit mileage would raise the transit modal split from 15.7 percent to 16.0 percent by distance and from 18.5 percent to 18.7 percent by trips.

17. Case 3 (1+2 combined). As is to be expected, this combination includes the most favorable features of cases (1) and (2). It results in the highest

mobility of all the cases tested: 195.3 trips per 100 persons per day, compared to 184.7 in the base case.

18. Case 4. It is assumed that the effect of raising transit "in-vehicle" speeds to 75 percent of car speeds would be to transfer 10 percent of car trip-makers to transit. This would reduce by 1.3 million the 12.9 million person-miles per day that would have been traveled by car tripmakers in the absence of the transfer. However, as transit speed remains below car speed, and because of the constraint of the travel time budget, only 1.1 million would shift to transit: 0.2 million person-miles would be lost. The person-miles transferring to transit would save about \$55,000 a day, and lose about 19,000 hours a day, so that the transfer would only take place if this exchange seemed attractive to a sufficient number of tripmakers. No evidence is available as to the substitutability of money for travel time in Washington, D.C. in 1968, and therefore the methodology used here is unable to predict how many trips, if any, would shift from car to transit under the assumed conditions.* Case (4) results in the most favorable modal split for transit--22.9 percent by distance and 26.5 percent by trips--but in terms of both "output" and cost savings it is inferior to Cases (1) and (3).

*In the Peoria demonstration project, 72 percent of subscription service trips were attracted from cars, but in that case the subscription services were reported to have enabled 67 percent of users to travel as fast as, or faster than, before (9). In the Washington, D.C. case, it is assumed that door-to-door transit-trip speeds would remain well below car-trip speeds.

Economic Evaluation of Benefits

19. The evaluation of benefits is based on conventional consumer surplus analysis. Benefits to tripmakers result from (a) savings in vehicle operating costs (VOC) and in time, on the mileage traveled before the improvement, and (b) benefits from the additional mileage traveled as a result of the improvements. The average benefits per additional mile traveled are assumed to equal half the difference between the costs of travel before and after the assumed improvement. Benefits consist of gains in money and in time, and these are shown separately in US\$ and in person-hours.

20. Benefits to the providers of public transport--mainly bus operators--are calculated on the basis of savings in capital and operating costs to be expected from the speeding up of 1,500 buses. The figures relate to 1968 conditions and may no longer be relevant. A bus is assumed to cost \$60,000, and to have a life of 10 years. At 10 percent interest, the annual capital cost of a bus approximates \$9,000. Operating costs that vary in proportion to time (mainly wages) are assumed to be \$100 per bus per day or \$31,200 a year. Benefits to transit providers resulting from newly generated traffic would be small and have been ignored. Extra revenues resulting from additional passenger mileage do not constitute an economic benefit, as they are offset by the extra fares paid, which were not debited as a cost to the tripmakers.

21. On the basis of these considerations, and of the travel characteristics given in Table 6, the following economic benefits were calculated and shown in Table 7, separately in \$\$ and hours, for car tripmakers, transit tripmakers and transit providers, for cases (1), (2) and (3) and (4).

- a) Savings in tripmakers' time on the mileage traveled before the change;

TABLE 7 - SUMMARY OF BENEFITS

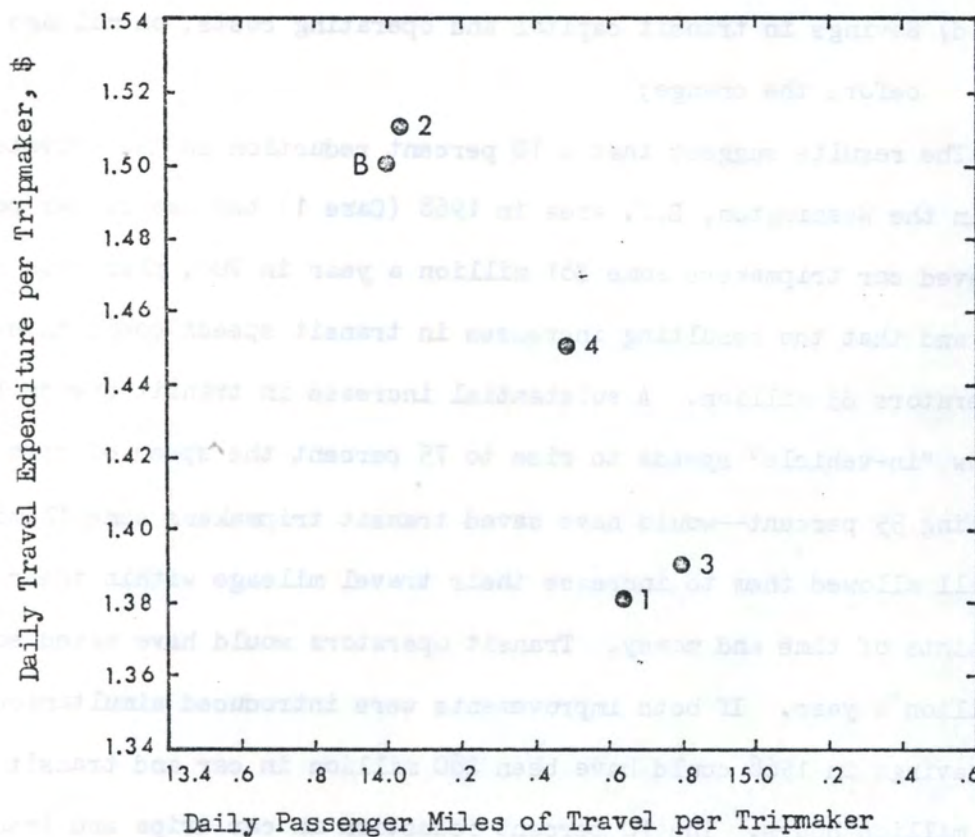
	Vehicle Costs				Time			
	Millions per year				Millions of hours per year			
	Case 1	Case 2	Case 3	Case 4	Case 1	Case 2	Case 3	Case 4
<u>Benefits to Car Tripmakers</u>								
Savings on original car-miles	59.9	-	59.9	33.6	8.4	-	8.4	2.6 ^{1/}
Benefits from new car-miles	1.6	-	1.6	2.3	0.2	-	0.2	-0.4
Total for car tripmakers	61.5	-	61.5	35.9	8.6	-	8.6	2.2
<u>Benefits to Transit Tripmakers</u>								
Savings on original transit-miles	-	-	-	-	3.1	16.4	18.7	19.8
Benefits from new transit-miles	-	-	-	-	-	0.2	0.7	0.4
Total for transit tripmakers	-	-	-	-	3.1	16.6	19.4	20.2
<u>Benefits to Transit Providers</u>								
Savings on transit capital costs	0.7	3.6	4.1	4.3	-	-	-	-
Savings on transit operating costs	2.3	12.4	14.1	15.0	-	-	-	-
Total for transit providers	3.0	16.0	18.2	19.3	-	-	-	-
<u>Total Benefits (millions)</u>	64.5	16.0	79.7	55.2	11.7	16.6	28.0	22.4

^{1/} This figure represents the difference between a gain of 8.4 millions hours to tripmakers who remain in cars, and a loss of 5.8 million hours to those shifting to transit.

- b) Savings in expenditure on cars, on mileage traveled before the change;
- c) Benefits to car and transit tripmakers due to additional miles traveled after the change;
- d) Savings in transit capital and operating costs, on mileage traveled before the change;

22. The results suggest that a 10 percent reduction in the private vehicle fleet in the Washington, D.C. area in 1968 (Case 1) because of car pooling could have saved car tripmakers some \$61 million a year in VOC, plus over 9 million hours, and that the resulting increases in transit speeds could have saved the bus operators \$3 million. A substantial increase in transit speeds (Case 2)-- to allow "in-vehicle" speeds to rise to 75 percent the speed of cars instead of the prevailing 55 percent--would have saved transit tripmakers some 17 million hours and still allowed them to increase their travel mileage within their budgetary constraints of time and money. Transit operators would have saved some \$16 million a year. If both improvements were introduced simultaneously (Case 3), total savings in 1968 could have been \$80 million in car and transit costs, and 28 million hours. The 10 percent reduction in car trips and transfer to speeded-up transit (Case 4) would have resulted in money and time savings to the remaining car trips, as in Case (3). The trips transferring to transit would have saved \$17 million a year in travel costs, but would have lost 6 million hours. Total annual benefits come out to be \$55 millions in money and 22 million hours.

FIGURE 3-THE ALTERNATIVES COMPARED



Discussion of the Results

23. It should be emphasized that the changes assumed were necessarily arbitrary, and designed to indicate the benefits obtainable from substantial--but not implausible--changes in travel conditions. The method can of course be used to evaluate likely savings from other postulated changes in any transport system, given the information about the travel habits, and the budgetary and time constraints, of different population groups.

24. The most striking of the conclusions appears to be the indication that, in an area where over 80 percent of travel is by car, increased car pooling appears to offer greater promise for improving urban transport conditions than inducing shifts from cars to transit. The first reason for this is that, under the conditions prevailing in Washington, D.C. in 1968, car pooling involves a smaller sacrifice of time to a car driver than a shift to public transport. The second reason is that car pooling involves the more intensive use of existing equipment, while substantial shifts to public transport, particularly in the peak periods, would necessitate the use of additional equipment.

25. The exercise also illustrates the difficulty of inducing shifts from private to public transport, as any substantial shift would speed up car trips, and increase the attractiveness of that mode. The analysis suggests that car tripmakers are most likely to shift to transit if they can gain time--as they can do on the Shirley Highway express bus lanes--or if they are subject to a financial penalty, such as payment of economic charges for parking or road use.

26. Some of the main differences between the cases tested are brought out in Figure 3, on which are plotted the daily travel expenditure per tripmaker against his daily miles of travel. Cases (1) and (3) are seen to have advantages

over the others, the former minimising expenditures and the latter maximising travel. Compared with the base case, all the cases tested result in increased travel, and all except Case (2) result in reduced expenditure by tripmakers.

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