Stringent Transportation Measures to Reduce Vehicular Emissions in the New York City Metropolitan Area

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ABSTRACT

The analysis performed for the revised 1982 state air quality plans for New York and New Jersey revealed that significant reductions in pollutant emissions would be achieved as newer cars that cause less pollution replaced older cars that cause more pollution. Inspection and maintenance of vehicles would sustain and further induce reductions. Modest traffic engineering and local transit improvements would produce only small additional gains. More stringent transportation measures would be required to achieve clean air. Impacts of measures such as higher bridge and tunnel tolls, parking surcharges, and major transit service improvements were analyzed by using an iterative, elasticity-based sketch-planning model (SPIZZIE). The analysis suggests that although generally not justifiable on pollution reduction merits alone, these measures when packaged together may achieve multiple regional objectives. Pricing measures and service improvements that are most effective in achieving an efficient balance among modes while providing a source of revenue for maintaining and operating the transportation system are recommended for further consideration and implementation.

Controlling air pollution from motor vehicles and stationary sources is an especially challenging task in the New York City metropolitan region (Figure 1). In spite of declining population and jobs, New York, the largest, most populated city in the United States, continues to draw more than 650,000 vehicles daily to its business district from an 8,000-mile^2 area covering significant portions of three states.

Air quality concerns have spurred a concerted effort on the part of federal, state, and local governments to increase mass transit use and decrease the excessive pollutant emissions from vehicles and stationary sources that prevail in many portions of this region. Although these efforts have provided significant contributions toward cleaner air, it is recognized that if all national air quality standards are to be met, these efforts will have to be continued and expanded because vehicles are the source of approximately 90 percent of the carbon monoxide pollution in the New York metropolitan region. In addition, vehicles and gasoline handling account for approximately half of the hydrocarbon emissions, a major cause of the ozone pollution that spreads over most of the East Coast.

Analysis performed for revised 1982 state air quality plans revealed that federal new-car standards supported by a program of inspection and maintenance of control devices would achieve significant reductions in pollutant emissions. Although further small reductions are possible through conventional traffic engineering and local transit improvements, more stringent measures are required to achieve clean air.

In this paper the evaluation of alternative stringent measures to achieve multiple transportation, fiscal, and environmental objectives in the New York City metropolitan area is summarized. Stringent measures to reduce pollutant emissions in the metropolitan area through pricing and automobile restrictions were first proposed in the 1973 air quality plan for New York City (1). Later many of these measures were considered politically infeasible and were not implemented. However, opinion surveys continue to reflect strong public support for environmental control. In 1981 more than 85 percent of those questioned favored maintaining clean air regulations at least at current levels (2). This relatively strong backing exists even with growing awareness of the cost associated with such controls (3).

A more comprehensive analysis of these measures performed for the revised 1982 state air quality plans for New York and New Jersey revealed a wide range of benefits to the public and might warrant reconsideration.

REVISED SIP REQUIREMENT

The Clean Air Act, as amended in August 1977, required the revision of air quality state implementation plans (SIPs) in areas that exceeded the National Ambient Air Quality Standards (NAAQS) for specific pollutants. Under provisions of the amended act, revised plans demonstrating attainment of ozone and carbon monoxide standards by the end of 1987 by using reasonably available measures were to be submitted to the U.S. Environmental Protection Agency (EPA) by July 1, 1982.

Most of New York City, portions of suburban New York, and the central business districts (CBDs) of several older cities in northeastern New Jersey were designated nonattainment areas for carbon monoxide (CO) (Figure 1). All of New Jersey and New York State were designated nonattainment areas for ozone.

The amended act and subsequent EPA guidelines suggested that the revised plans be based on a comprehensive technical analysis of alternative transportation strategies performed by local, regional, state, and operating agencies with the participation of local elected officials and the public. Such an analysis was performed. In this paper the evaluation is described of measures generally perceived by officials to be stringent, that is, measures not readily accepted by the public.

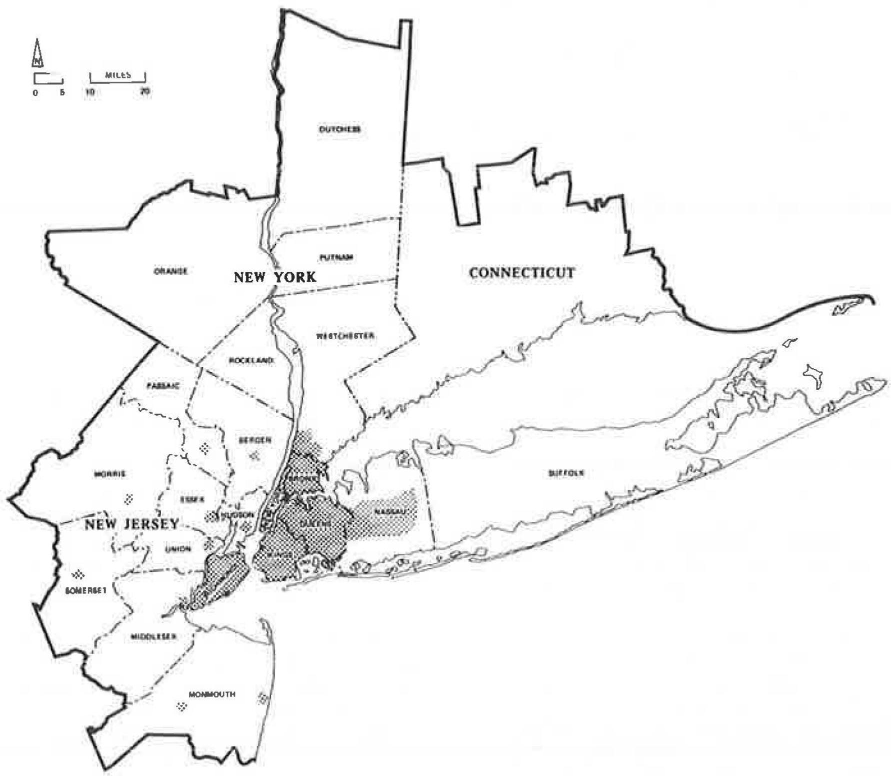


FIGURE 1 Nonattainment areas for carbon monoxide: New York City metropolitan area.

GROWING TRAFFIC VOLUMES

Population in the three-state metropolitan area peaked in 1971 and has declined each year since then to about 18 million in 1980. The major loss took place in New York City and other older urban centers and was partially offset by minor growth in the outer suburban areas (4). Automobile ownership continued to grow faster than population; 20 percent more cars were registered in the suburbs in 1981 than in 1971 (5). Personal travel increased 11 percent regionwide between 1970 and 1980, but the bulk of this was inter- and intrasuburban travel by automobile, which increased 19 percent during this period; small increases registered on certain facilities following the gasoline shortages of 1974 and 1979 (5). Slightly more than three-quarters of all daily trips in the region are now by automobile.

This increasing reliance on the automobile strains the available capacity of the street system, particularly as daily work and business trips converge on older employment centers. About 36 percent of the urban highway system experiences severe congestion during both peak work-travel periods (6). This mismatch of demand and capacity appears to contribute to two distinct pollution problems: high levels of CO caused by accumulations of slow-moving vehicles in congested business districts and high levels of ozone recorded late in the day in Long Island and Connecticut caused partially by hydrocarbon and nitrogen oxide emissions from large volumes of congested morning peak traffic.

CARBON MONOXIDE, A CBD PROBLEM

CO monitors continue to show a steady decline in background levels of this traffic-generated pollutant in the densely developed business districts of both New Jersey and New York. Reduction in CO is particularly noticeable in New Jersey where the federal motor vehicle control program has been made more effective through an inspection and maintenance program initiated in 1974. In Manhattan, however, the 8-hr CO standard continues to be exceeded several times daily and there are insufficient valid data to establish a trend. It is estimated that although the federal new-car program and annual inspection and maintenance may bring CO to healthy levels by 1987 in most areas, the Manhattan business district and other locations of chronic traffic congestion may be exceptions.

Although jobs in Manhattan have decreased over the past 20 years, it continues to be an area of intense economic and cultural activity. Of the almost 3 million who enter the business district below 60th Street daily, 2 million enter by public transport and 930,000 by motor vehicle.

Automobile trips into the CBD have continued to increase since systematic traffic counts became available in the 1920s (5). More than 650,000 motor vehicles entered the 9-mile^2 area on a typical workday in 1980. It is estimated that up to 400,000 vehicle miles of travel per square mile occur in the most active portions of Manhattan; about half are generated by taxis and a quarter each by trucks and private automobiles. The large volume of trucks and buses compounds the problem by slowing traffic so that vehicles pollute at even higher rates. The risk to health is particularly severe for thousands of pedestrians and outdoor workers who are directly exposed daily to the pollutants present in vehicular exhaust.

Several traffic engineering measures have been implemented during the past few years to improve traffic flow in the CBD. These include stricter enforcement of traffic regulations, fewer on-street parking slots, introduction of exclusive bus lanes, and channelization. Although these measures produce local improvements and begin to address the problem of allocation of scarce street space, they might be more effective if integrated with available mechanisms to control travel demand and produce revenue for transportation system improvements. Some of these mechanisms were explored through an analysis of alternatives performed as a basis for actions in the revised 1982 state air quality plans of New York (7) and New Jersey (8).

OZONE, A REGIONWIDE PROBLEM

Pollutants emitted by motor vehicles and industry in Pennsylvania, New Jersey, and New York appear to contribute to high ozone readings in eastern Long Island and New England. As the phenomenon of long-range transport of pollutants in the northeastern United States becomes better understood and more accurately defined, more efficient and cost-effective strategies to alleviate the problem will emerge. Continuous monitoring during the 1979-1981 base period showed that all state measurement sites but one exceeded the federal ozone standard and there was no discernible downward trend. Based on a crude simulation, it is estimated that a regionwide reduction of nonmethane hydrocarbon emissions in excess of 60 percent will be necessary if the national ozone standard is to be met by 1987. A reduction of this magnitude requires measures of major scope and impact on travel, commerce, and industry.

In the New York metropolitan area automobiles, taxis, and trucks generated about half of the nonmethane hydrocarbons emitted in 1980. The remainder came from industrial and other stationary sources. It is estimated that existing controls will reduce emissions from stationary sources 13 percent by 1987.

Federal emissions standards for new cars, if reinforced with a program of annual inspection and maintenance of pollution control devices, could reduce reactive hydrocarbon emissions from mobile sources 58 percent by 1987, far short of the amount required for attainment of the standard. The states are reluctant to impose more stringent technically feasible controls on industry for fear of the economic consequences. More stringent measures affecting personal travel are also viewed by state and local agencies as politically and economically unacceptable.

Further investigation of these stringent transportation measures revealed that they may contribute to more efficient personal mobility, lower fuel consumption, and also lower emissions. Although generally not economically justifiable because of pollution reduction alone, their apparent contribution to the achievement of multiple regional objectives makes them worthy of consideration, evaluation, and implementation, where feasible.

REGIONAL TRANSPORTATION SOLUTIONS FOR CLEANER AIR

In a time of scarce resources, it is imperative to preserve the existing transportation system and develop a permanent source of funds for maintaining the system and operating it efficiently. Efficient operation implies maximum use of public transit wherever feasible and better management of street space in more automobile-dependent parts of the region. By moving more persons per vehicle at a faster rate, such improvements lower emission levels and conserve fuel.

In particular, the demand for transportation facilities can be managed through varying the cost of using the system. Pricing, skillfully applied, is a potentially powerful tool for achieving

1. A more efficient transportation system in which the demand for a facility is adjusted to match available capacity or service,
2. A source of revenue that can be dedicated for maintenance and operation of the transportation system, and
3. A more equitable means for financing the system.

Pricing is particularly applicable in the New York metropolitan area because the physical and administrative mechanism for charging fees for the use of the transportation system is already in place. Manhattan-bound trips can be controlled by varying the tolls on the river crossings, altering parking charges, and changing the transit fare. More widespread management of travel can be achieved through imposing additional gasoline taxes and tolls on suburban facilities and at selected cordons.

More than 1.4 million vehicles enter and leave Manhattan daily via 18 bridges and 4 tunnels (Figure 2). Drivers from New Jersey pay a uniform toll on all crossings into New York City, whereas drivers from New York City, Long Island, and the northern suburbs have a choice of paying a toll or entering free. It is estimated that half of all drivers park free and the others pay a substantial amount to park in garages and lots.

The 3.37 million daily subway riders currently pay a flat fare of 75 cents, whereas 586,000 daily commuters from the suburbs of New Jersey and New York pay a fare based roughly on distance traveled. Revenue generated at the fare-box pays for about 60 percent of the cost of operating the subway system and about 40 percent of the daily expenses of the various commuter lines.

TRANSPORTATION PRICING MEASURES

Several regional schemes to manage travel demand more efficiently through pricing measures were analyzed. Travel, environmental, energy, and economic impacts of alternative travel cost and service levels were quantified by using models that simulate the regional transportation system and the travel characteristics of its users.

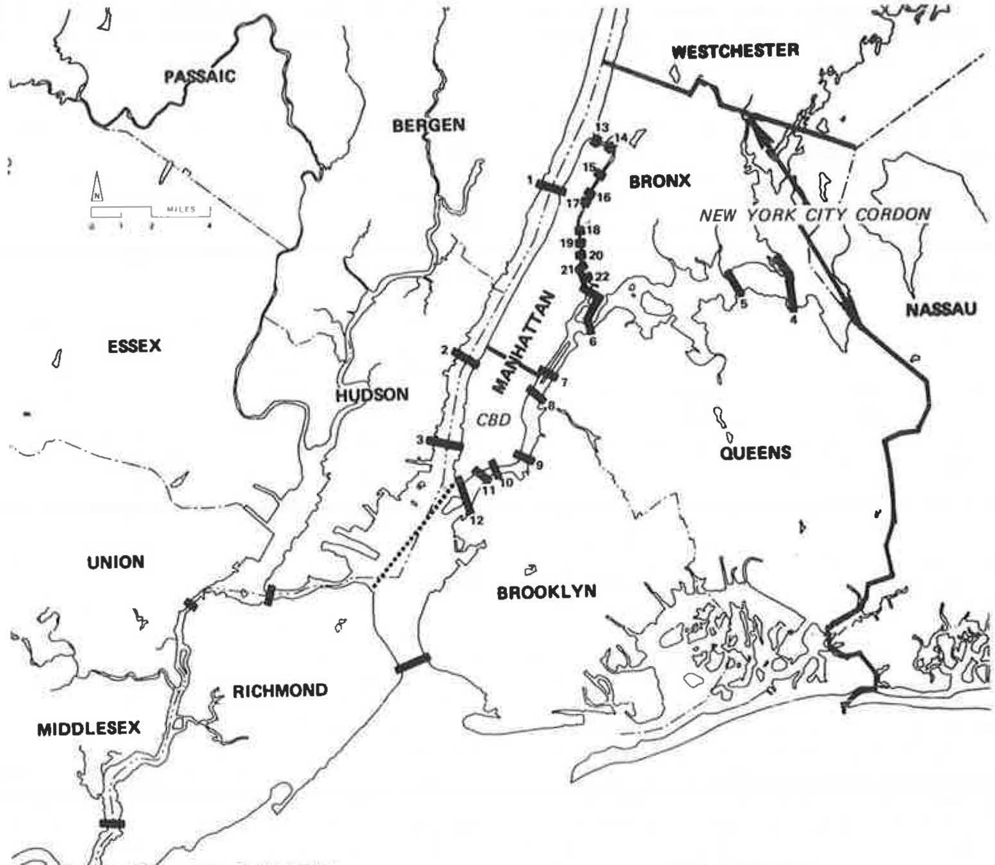
Specifically the following strategies were explored singly and in combination:

1. Controlling automobiles entering Manhattan through river-crossing tolls and parking fees,
2. Controlling automobiles entering New York City through tolls at the city line,
3. Controlling automobile use regionwide through a gasoline tax,
4. Raising the transit fare to increase revenue,
5. Improving transit service, and
6. Allowing the transit system to continue to deteriorate.

Each of these measures would affect vehicular pollutant emissions in varying degrees depending on the pricing level and the geography affected. Thus the first measure would primarily affect CO in Manhattan, whereas the third could produce areawide ozone reductions.

MEASURES OF EFFECTIVENESS

The policy packages were evaluated on the basis of five measures, expressed as changes from the base case:



TOLL FACILITIES

Port Authority of New York and New Jersey (PANYNJ)

George Washington Bridge (1)
Lincoln Tunnel (2)
Holland Tunnel (3)

Triborough Bridge and Tunnel Authority (TBTA)

Throgs Neck Bridge (4)
Bronx-Whitestone Bridge (5)
Triborough Bridge (6)
Queens Midtown Tunnel (8)
Brooklyn Battery Tunnel (12)

Henry Hudson Bridge (13)

FREE FACILITIES

New York City Department of Transportation (East and Harlem Rivers)

Queensboro Bridge (7)
Williamsburg Bridge (9)
Manhattan Bridge (10)
Brooklyn Bridge (11)
Broadway Bridge (14)
University Heights Bridge (15)
Washington Bridge (181st. St.)(16)
Alexander Hamilton Bridge (17)
Macombs Dam Bridge (18)
145th St. Bridge (19)
Madison Ave. Bridge (20)
Third Ave. Bridge (21)
Willis Ave. Bridge (22)

FIGURE 2 River crossing locations.

1. The effect on economic activity in the CBD as expressed by the change in travel to that area,
2. The effect on CO emissions in the Manhattan CBD (this is also an indication of the amount and speed of traffic in the CBD),
3. The effect on regionwide highway travel and hydrocarbon emissions as expressed by changes in vehicle miles of travel (VMT), and
4. Savings to tripmakers in travel costs expressed as the dollar value of changes in travel time and fuel consumed.

A sketch-planning travel demand model was used to simulate stringent measures and to derive the measure of effectiveness.

SPIZZIE: AN EVALUATION TOOL

The Sketch-Planning Iterative Zone-to-Zone Impedance Elasticity Model (SPIZZIE) is a program that estimates changes in automobile and transit trips caused by policies affecting travel costs or times in the New York metropolitan area (9). The model does this by applying empirically derived elasticities to a model of travel demand and highway supply consisting of a zone-to-zone modal trip table the automobile component of which is loaded onto a spider network that determines zonal and interzonal mileages, speeds, and costs. Highway level of service varies with vehicular volumes, so equilibrium of demand and supply is approximated through iteration. The program is written in FORTRAN and stored in disk packs.

SPIZZIE's 38 zones are whole or subdivided counties, depending on intracounty variance in structure and density. Paths are simulated in the model as a series of zones traversed in the current minimum friction path between each zonal pair. The paths are fixed, are the same for work and nonwork trips, and are used to calculate origin-destination automobile mileages, times, costs, and VMT. Trips among the 38 zones are disaggregated by mode (automobile driver, automobile passenger, transit) and by purpose (work and nonwork). Travel times can be entered as an externally estimated matrix for all modes or can be calculated by SPIZZIE by using its paths of through zones for automobiles. Zonal congestion values vary by time period (peak, off peak) and class of facility (expressway, other). Access times are added at the origin and destination and vary by time of day, type of trip end (origin or destination), and zone. Travel costs either are entered exogenously or are calculated for automobiles by SPIZZIE based on mileage-related costs modified at the zone level by congestion and road type, to which are added applicable tolls and parking costs. Direct elasticities vary with mode (automobile, transit), transit-mode-share category, type of friction (time, money), and purpose (work, nonwork). The share of each direct trip change going to or coming from competing trip categories is varied according to purpose (work, nonwork), by transit-mode-share category, by mode of original trip change (automobile, transit), by type of friction (time, money), and according to whether the original trip change was an increase or decrease.

SPIZZIE starts out with base-year zone-to-zone trips, times, and costs. Next it either accepts as input or calculates a new set of interzonal impedances based on the policy to be modeled. It then estimates the change in the affected mode's zone-to-zone trips by applying the relevant elasticity to each friction change. Some of this trip change is allocated to or from other modes and destinations by using cross-elasticities. When all new zone-to-zone trips are sorted out, the model converts the new automobile driver trips into zonal VMT, which alters highway level of service by changing congestion levels. The new values are used to calculate new interzonal automobile costs and times, and the entire process converges toward equilibrium through a series of iterations. Finally, changes in VMT and speed provide changes in pollutant emissions and fuel consumption through a modified version of MOBILE 2 (10).

ALTERNATIVE SCENARIOS

Fifteen pricing and service-level policy alternatives were simulated and compared through SPIZZIE. Each simulation is described along with the underlying rationale in Table 1.

Table 2 gives a summary of the 15 sets of policies simulated and analyzed. In Table 3 travel, emission, and fuel-use impacts of each set of policies are given, and in Table 4 the resulting economic and financial consequences are quantified. A detailed discussion of the evaluation of the alternative policies follows.

Transit Fare Increase

Simulation 1 demonstrated a 3 percent increase in CO emissions in the Manhattan CBD caused by the 25 percent transit fare increase that went into effect July 1, 1981. There is a net loss in trips to the CBD of 1.7 percent with an associated decline in economic activity. Regionwide, the impact of the fare increase is a 0.2 percent increase in VMT, a 0.7 percent increase in vehicular hydrocarbon emissions, and almost $100,000 per day lost in additional travel-time and fuel costs.

Transit Fare Increase with River Crossing Tolls

When the fare increase is accompanied by a round-trip toll of $2.00 on all East and Harlem River crossings, the net loss in trips to the CBD is slightly higher (1.8 percent), but CO emissions in the CBD drop by 0.3 percent and there is virtually no change in regionwide motor vehicle travel (simulation 3). When the round-trip toll on the currently free river crossings is raised to $3.00 and TBTA tolls are raised by 50 percent, there is still a net loss in trips to the CBD with a resulting 2.3 percent decrease in CO emissions in the CBD. Regionwide, there is a small decrease in VMT with a savings of $27 million in travel time, partially offset by $12 million more spent on gasoline. These tolls would net more then $600 million a year in revenue (simulation 4).

Tolls

If a part of the revenue generated through the toll increases described earlier was allocated to operation of the transit system without the 25 percent fare increase, considerable travel and environmental benefits would result (simulation 5). There would be a 4.6 percent reduction in CBD CO emissions and a 0.3 percent vehicular hydrocarbon emission reduction regionwide. Trips to the CBD would decrease by only 0.1 percent, and travelers would save $87 million in travel time and fuel costs annually.

Doubling Transit Fare

If the transit fare were doubled to cover system operating expenses, as in simulation 6, there would be a 5 percent loss in CBD trips and a 9 percent increase in CO in the business district. Vehicular hydrocarbon emissions regionwide would increase by 1.4 percent, and users of the transportation system would pay $251 million more annually in extra travel time and fuel costs.

Tolls on All River Crossings

Doubling all PANYNJ river crossing tolls, increasing all TBTA tolls by 50 percent, and placing a $3.00 round-trip toll on all East and Harlem River crossings would produce a 5.5 percent reduction in CO in the CBD and a 0.4 percent reduction in regionwide vehicular hydrocarbon emissions (simulation 7). Additional annual revenue of $875 million would result, with a $134 million savings in annual travel-related costs.

Gasoline Tax Increase

A statewide tax of $0.15 per gallon of gasoline produces major areawide impacts on highway travel (simulation 8). Both regional VMT and vehicular hydrocarbon emissions decrease by more than 3 percent when the $0.15 fuel tax is superimposed on the toll structure of simulation 7. Total travel to the CBD decreases by 0.2 percent with a 6.3 percent drop in CO emissions. There are major annual savings in travel time and fuel costs of $444 million along with more than $900 million generated yearly by the gasoline tax surcharge.

CBD Parking Surcharge

A sizable decrease in CBD pollutant emissions is achieved with a $1.45 surcharge on those who park in the CBD. The parking fee, when added to the toll structure and gasoline tax of simulation 8, produces a 9 percent reduction in CO in the Manhattan busi-

TABLE 1 Pricing and Service-Level Policy Alternatives

Simulated Scenario	Rationale
1. Citywide 25 percent transit fare increase	The fare was raised 25 percent in July 1, 1981, to offset transit system operating expenses
2. Citywide 25 percent transit fare increase and $1.00 East and Harlem River round-trip tolls	Increasing tolls on currently free crossings into Manhattan to offset the negative effects of the transit fare increase
3. Citywide 25 percent transit fare increase and $2.00 East and Harlem River round-trip tolls	
4. Citywide 25 percent transit fare increase, $3.00 East and Harlem River round-trip tolls, and 50 percent increase in TBTA tolls (to Manhattan)	
5. 50 percent increase in TBTA tolls (to Manhattan) and $3.00 East and Harlem River round-trip tolls	Tolls on free crossings (without a fare increase) to manage demand and raise revenue for transit operating expenses
6. Citywide 100 percent transit fare increase	Doubling the transit fare to generate funds to operate the system
7. 50 percent increase on all TBTA facilities, 100 percent PANYNJ toll increase, and $3.00 East and Harlem River tound-trip tolls	
8. 50 percent increase on all TBTA facilities, 100 percent PANYNJ toll increase $3.00 East and Harlem River round-trip tolls, and gasoline tax increase of $0.15 per gallon	
9. 50 percent increase on all TBTA facilities, 100 percent PANYNJ toll increase, $3.00 East and Harlem River round-trip tolls, gasoline tax increase of $0.15 per gallon, and $1.45 CBD parking surcharge	Major increases in tolls on all entry facilities, a gasoline surcharge, and a parking surcharge to manage demand and generate revenue to maintain and operate the transportation system
10. 10 percent decrease in transit service	To quantify the impacts of a deteriorating transit system
11. 5 percent increase in transit service	To quantify the impacts of an improved transit system
12. 25 percent increase on all TBTA facilities and 25 percent PANYNJ toll increase	Modest increase in tolls on currently tolled facilities
13. 100 percent increase on all TBTA facilities and 100 percent PANYNJ toll increase	Doubling tolls on currently tolled facilities
14. 50 percent increase on all TBTA facilities, 100 percent PANYNJ toll increase, $3.00 East and Harlem River round-trip tolls, and $1.50 city-line round trip tolls	Disincentives to automobiles entering New York City in addition to tolls into Manhattan
15. 50 percent increase on all TBTA facilities, 100 percent PANYNJ toll increase, $6.00 East and Harlem River round-trip tolls, and $3.00 city-line round-trip tolls	

TABLE 2 Scenario Characteristics

Scenario	Fare Increase (%)	TBTA Toll Increase (%)		PANYNJ Toll Increase (%)		East and Harlem River Round-Trip Toll ($)	Gasoline Tax Increase per Gallon ($)	CBD Parking Surcharge ($)	Transit Service Change (%)	City-Line Round-Trip Toll ($)
		Manhattan	Other	Manhattan	Other					
1	25	-	-	-	-	-	-	-	-	-
2	25	-	-	-	-	1.00	-	-	-	-
3	25	-	-	-	-	2.00	-	-	-	-
4	25	50	-	-	-	3.00	-	-	-	-
5	-	50	-	-	-	3.00	-	-	-	-
6	100	-	-	-	-	-	-	-	-	-
7	-	50	50	100	100	3.00	-	-	-	-
8	-	50	50	100	100	3.00	0.15	-	-	-
9	-	50	50	100	100	3.00	0.15	1.45	-	-
10	-	-	-	-	-	-	-	-	-10	-
11	-	-	-	-	-	-	-	-	+5	-
12	-	25	25	25	25	-	-	-	-	-
13	-	100	100	100	100	-	-	-	-	-
14	-	50	50	100	100	3.00	-	-	-	1.50
15	-	50	50	100	100	6.00	-	-	-	3.00

Note: Dashes indicate category not applicable.

TABLE 3 Scenario Results

Scenario	Change in CBD Trips (%)			Change in CBD Street Use (%)			Change Regionwide (%)		Regionwide Avg Weekday Measures			Change Screen Line (%)	
	Transit	Driver	Total	VMT	Avg Speed	CO Emissions	VMT	HC Emissions	Mileage Savings (miles)	Fuel Savings (gal)	Transit Time Savings (hr)	Manhattan	City Line
1	-2.44	+1.35	-1.72	+1.42	-2.66	+3.10	+0.21	+0.65	-16,800	-81,000	-	-	-
2	-2.42	+0.84	-1.80	+0.47	-0.90	+1.32	+0.12	+0.49	-8,800	-65,500	-	-	-
3	-2.35	+0.30	-1.83	-0.45	+0.80	-0.29	+0.02	+0.33	-1,200	-47,800	-	-	-
4	-2.23	-0.49	-1.88	-1.67	+3.04	-2.33	-0.10	+0.16	+7,600	-28,600	-	-	-
5	+0.23	-1.80	-0.14	-3.01	+5.54	-4.62	-0.32	-0.18	+23,400	+12,700	-	-	-
6	-7.35	+4.19	-5.16	+4.30	-8.00	+8.74	+0.66	+1.40	-51,100	-170,900	-	-	-
7	+0.25	-2.05	-0.16	-3.52	+6.48	-5.50	-0.63	-0.43	+32,200	+51,100	-	-	-
8	+0.29	-2.36	-0.19	-4.02	+7.38	-6.28	-3.41	-3.10	+66,700	+502,300	-	-	-
9	+0.58	-4.95	-0.46	-4.71	+10.51	-8.96	-3.47	-3.22	+72,900	+515,700	-	-	-
10	-4.38	+2.00	-3.19	+1.86	-3.55	+3.96	+0.25	+0.74	-23,500	-90,900	-170,500	-	
11	+2.47	-2.17	+1.63	-1.96	+3.88	-3.14	-0.23	-0.12	+25,100	+8,300	+85,200	-	-
12	+0.03	-0.27	-0.03	-0.41	+0.76	-0.36	-0.12	-0.18	+5,400	+22,300	-	-	-
13	+0.11	-1.01	-0.10	-1.48	+2.73	-2.16	-0.44	-0.15	+19,100	+21,400	-	-	-
14	+0.26	-2.09	-0.16	-3.82	+3.04	-5.86	-0.87	-1.05	+46,700	+136,300	-	-2.00	-7.00
15	+0.51	-4.39	-0.45	-7.37	+6.10	-10.48	-1.56	-1.84	+81,100	+241,700	-	-4.00	-14.00

TABLE 4 Financial and Economic Impacts

Scenario	Annual Savings ($000,000s) Automobile Time	Annual Savings ($000,000s) Transit Time	Annual Savings ($000,000s) Fuel	Annual Revenue Change ($000,000s) TBTA	Annual Revenue Change ($000,000s) PANYNJ	Annual Revenue Change ($000,000s) East and Harlem Rivers	Annual Revenue Change ($000,000s) Transit	Annual Revenue Change ($000,000s) Gasoline Tax Surcharge	Annual Revenue Change ($000,000s) CBD Parking Surcharge	Transit Operating Cost Increase ($000,000s)	City-Line Toll Revenue ($000,000s)
1	-59	-	-34	+3	+1	-	+351	-	-	-	-
2	-31	-	-28	+2	+1	+202	+351	-	-	-	-
3	-4	-	-20	+1	-	+401	+351	-	-	-	-
4	+27	-	-12	+48	-1	+597	+351	-	-	-	-
5	+82	-	+5	+48	-3	+589	+4	-	-	-	-
6	-179	-	-72	+11	+6	-	+1,332	-	-	-	-
7	+113	-	+21	+134	+149	+588	+4	-	-	-	-
8	+233	-	+211	+134	+149	+586	+4	+903	-	-	-
9	+255	-	+217	+134	+149	+570	+8	+902	+114	-	-
10	-82	-256	-38	+5	+3	-	-63	-	-	-	-
11	+88	+128	+3	-6	-3	-	+36	-	-	+45	-
12	+19	-	+9	+69	+37	-	-	-	-	-	-
13	+67	-	+9	+265	+146	-	+2	-	-	-	-
14	+163	-	+57	+134	+149	+588	+4	-	-	-	260
15	+284	-	+102	+134	+149	+570	+8	-	-	-	480

ness district (simulation 9). The parking surcharge produces an annual revenue of $114 million.

Transit Service Changes

Deterioration of the transit system would depress the economy of the metropolitan area and the CBD. If trips by public transportation took 10 percent longer because of service costs, travel to the CBD would decrease by more than 3 percent, and there would be 4 percent more CO emissions (simulation 10). Regionwide VMT would increase 0.25 percent and $376 million more would be expended annually in travel and fuel costs.

Improvements to public transportation service resulting in a 5 percent shorter journey time would bring 1.6 percent more trips to the CBD and would lower CO emissions by more than 3 percent (simulation 11). Regionwide VMT would decrease by 0.2 percent, and travelers would save $219 million annually in travel and fuel costs.

Increased Tolls on Currently Tolled Facilities

A modest 25 percent increase in tolls on all TBTA and PANYNJ toll facilities would produce small but generally positive changes: stable trips to the CBD, small decreases in emissions, $28 million saved annually in travel and fuel costs, and $106 million generated in additional revenue (simulation 12).

Doubling tolls on the TBTA and Port Authority crossings produces more substantial changes with positive impacts. There would be a 2 percent decrease in CO emissions in the CBD, a 0.4 percent reduction in regionwide VMT, $76 million saved annually in travel and fuel costs, and more than $400 million in annual revenue generated (simulation 13).

Controlling Automobiles Entering New York City

Automobile entries into New York City could be controlled through a charge on all cars crossing the city line. A $1.50 city-line cordon charge in addition to increased Manhattan entry charges would reduce areawide vehicular hydrocarbon emissions by 1 percent and CBD CO emissions by almost 6 percent (simulation 14). In addition, this policy would generate $220 million in travel-time and fuel cost savings and more than $1.1 billion in revenue.

A $3.00 city-line charge in addition to a $6.00 round-trip toll on the East and Harlem Rivers, doubled Port Authority facility tolls, and 50 percent TBTA toll increases would lower regionwide vehicular hydrocarbons by almost 2 percent and central area CO emissions by more than 10 percent (simulation 15). There would be $386 million saved in travel-time and fuel costs with more than $1.3 billion generated in added revenue.

SUMMARY OF RESULTS

Impacts of six of the simulated pricing policy proposals are highlighted in Table 5. The relative effectiveness of various road-pricing measures, transit service improvements, and transit fare increases in achieving certain key objectives related to travel, the environment, the economy, and generated revenue is shown. The conclusions and recommendations that follow are based on the policy impacts shown in Tables 2-4 and highlighted in Table 5.

Fuel taxes and cordon charges are effective in reducing areawide VMT and vehicular hydrocarbon emissions. Substantial user savings and revenue accrue (simulations 8, 14, 15, and particularly simulation 9). CO emissions in the CBD can be lowered substantially by restructuring the price of automobile entry into Manhattan and New York City and through better management of parking controls. Substantial savings to travelers and revenues are also generated (simulations 5, 7, 9, 14, and especially simulation 15). Improved public transit service to the business district produces increased economic activity and less pollution in the CBD (simulation 11). A sharp increase in the public transit fare produces a substantial increase in pollutant emissions and a decline in economic activity in the CBD (simulation 6). Negative impacts of smaller increases in the transit fare can be partially offset with automobile-entry controls and transit service improvements (simulation 4). Deterioration of the public transit system and substandard service produce a less efficient transportation system, more pollutant emissions, increased fuel use, and losses in travel time, revenue, and economic activity (simulation 10).

Based on these findings, a number of strategies are recommended for more detailed study and implementation. To obtain areawide vehicular nonmethane hydrocarbon emission reductions, the following combination of policies is recommended:

1. A restructured system of tolls on all New York City river crossings;
2. A statewide gasoline tax surcharge;

TABLE 5 Impacts of Selected Policies

Simulation	Change from Base (%) CO in CBD	CDD Activity	Regionwide VMT	Change from Base ($000,000s/year) Savings in Travel Cost	Revenue Generated
9. Toll increases, gasoline tax, and parking surcharge (50 percent increase on all TBRA facilities, 100 percent PANYNJ toll increase, $3.00 East and Harlem River round-trip toll, gasoline tax increase of $0.15 per gallon, and $1.45 CBD parking surcharge)	-9.0	-0.5	-3.5	472	1,877
15. Toll increases and city-line tolls (50 percent increase on all TBTA facilities, 100 percent PANYNJ toll increase, $6.00 East and Harlem River round-trip tolls, and $3.00 city-line round-trip tolls)	-10.5	-0.5	-1.6	386	1,341
5. Tolls on free crossings [50 percent increase in TBTA tolls (to Manhattan) and $3.00 East and Harlem River round-trip tolls]	-4.6	-0.1	-0.3	87	638
13. Doubled tolls on currently tolled facilities (100 percent increase on all TBTA facilities and 100 percent PANYNJ toll increase)	-2.2	-0.1	-0.4	76	403
11. Improved transit service (5 percent increase in transit service)	-3.1	+1.6	-0.2	219	(-18)
6. Doubled transit fare (citywide 100 percent transit fare increase)	+8.7	-5.2	+0.7	(-251)	1,349

Note: Adverse impacts are underlined.

3. A transit fare level that rises no faster than the cost of living;
4. Improved transit service financed with a portion of the revenue generated from tolls, the gasoline tax, and fare-box proceeds; and
5. Maintenance of the highway network with a portion of the revenue generated from tolls and the gasoline tax.

In addition, policies recommended to lower CO levels in the CBD are

6. Better management of parking in the CBD through restrictions and charges, and
7. Pedestrian and transit malls along with other amenities to make the CBD more attractive.

Future studies should further examine these policies:

1. Variation of the transit fare by time of day to optimize the use of available off-peak system capacity (11),
2. Variation of the transit fare according to trip length,
3. Variation of highway facility tolls and parking charges (according to available street capacity) by time of day, and
4. A network of automobile-free zones in Manhattan (12).

Although commitments to implement stringent measures were not obtained, the analysis and recommendations described in the foregoing were included in the 1982 New York SIP (7). A similar analysis was included in the 1982 New Jersey SIP (8).

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