The Economic Costs of Subway Deterioration

The quality of service provided by the New York City subway system has declined sharply over the past year. Riders have faced longer travel times, longer and more frequent delays, and more crowding during their daily journeys to work. These and other elements of deteriorating service impose costs that are just as real as increases in taxes or in prices. Over time, firms and their employees will seek to avoid these costs in a variety of ways. If the burden is sufficiently large, people and companies may react by moving out of the city.

This article presents estimates of the size of economic costs caused by increased subway delays. The conclusion is that the aggregate cost imposed on New York residents and firms is huge. The cost of only a five-minute increase in the average length of each ride to work may easily reach $166 million annually. Moreover, unpredictability of travel time imposes further costs. If, at random, one morning and one evening trip each week are delayed by twenty-five minutes, the time loss is the same as in the first case, but the dollar costs may be twice as large. For the typical subway rider, this may be as burdensome as a doubling of city income tax rates. Thus, time losses need not be extremely large before significant responses can be expected. In sum, even though it will take substantial infusions of capital and operating expenditures to get the system running properly, the costs of postponing improvements may be even more enormous.

Measuring the costs of lost time

The many statistics generated by the New York City Transit Authority allow no straightforward method of determining the amount of time subway riders have lost as a result of subway delays (Box 1). Nevertheless, it is possible to appreciate the magnitude of the costs by considering two representative cases. The first assumes that the length of each ride increases by five minutes; this provides a bench mark for measuring the costs of extra time on the subway. The second case assumes that two twenty-five minute delays occur at random each week, one in the morning and one in the afternoon rush hour; this allows the cost of increased uncertainty to be measured, since the time lost each week is the same as for the daily five-minute delay. If more precise information on time actually lost should become available, estimates of the costs to firms and their employees could be adjusted proportionately.

Even though five minutes per trip may not seem like very much, the immensity of the costs becomes apparent when the time losses are aggregated to a city-wide annual total. For the one million city residents who take the subway to work, the aggregate time loss each week is over 800,000 hours, or 41 million hours per year.[1]

[1] Average weekday ridership was more than 3 3 million in 1980, and there were roughly 1 8 million trips per weekend, bringing the total number of trips provided by the subway system to nearly a billion for the year The cost estimates in this article, though, focus on the estimated one million city residents who use the subway to travel to work This figure comes from the Census report that there were 1 2 million such subway travelers in 1970 and from the estimate by Tri-State Regional Planning Commission and the Regional Plan Association that there was a 15 percent drop in subway travel to the central business district by 1980

Box 1: Statistics Generated by the New York City Transit Authority

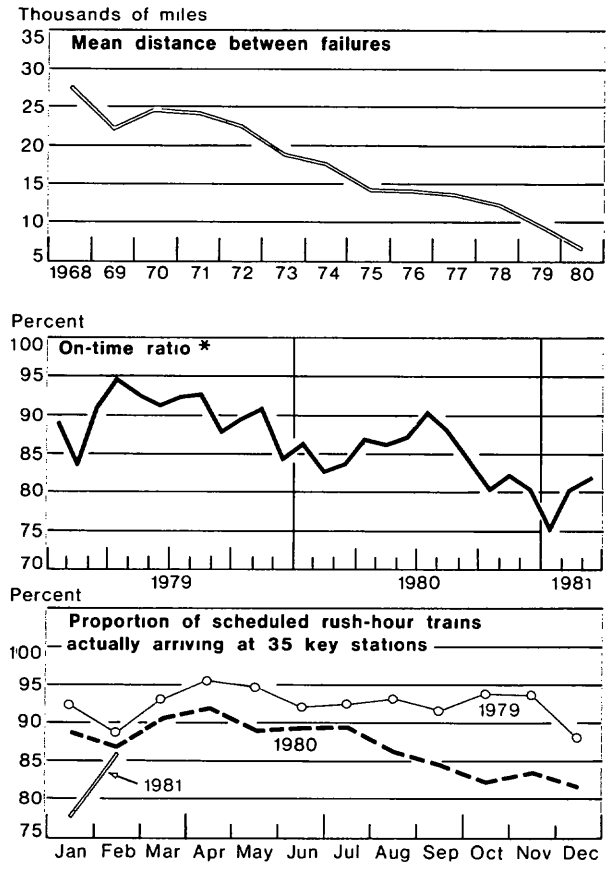
The Transit Authority does not directly measure its success in getting people to work on time Rather, it monitors adherence to schedules, counts incidents and conditions which disrupt service, and checks the status of the fleet. Disruptions affect travel times in complex ways, and there is no straightforward method of determining the impact on subway riders However, the system-oriented statistics do document the decline

For example, failure statistics indicate that the train breakdowns per mile of service were 30 percent higher in 1980 than in the previous year and 75 percent higher than in 1968 (chart). Even if one could estimate with confidence that half of the breakdowns took place during rush hour and that each train carried 1,000 passengers, the resulting estimate of the impact on riders would still ignore the effects on the following trains.

A more direct measure of lateness is given by the on-time ratio (chart). A train is considered on time unless it completes a trip more than four minutes behind schedule. From September 1980 through March 1981 the rush-hour on-time ratio averaged about 80 percent, down from the 88 percent level in mid-1980. This reflects a 70 percent increase in lateness. However, trains canceled at the terminal due to breakdowns or equipment shortages are not included in the fractions, and trains abandoned in mid-trip are considered *on time* Moreover, trains can run behind schedule within the business district and still be considered on time by making up lost time after most passengers have left the train Multiplying the number of passengers by the lateness ratio (*i.e.*, 1 minus the on-time ratio) would thus provide only an incomplete count of lateness of unspecified lengths.

Cancellations and abandonments are not counted separately for rush hour by the Transit Authority. However, a related measure, rush-hour key-point performance, may be helpful by recording the difference between scheduled and actual arrivals at thirty-five major transfer points (chart) This statistic reveals that no-shows increased from 12 percent to 18 percent of the rush-hour schedule in recent months This reflects a substantial increase in travel time for many subway riders The minimum possible delay caused passengers by an abandonment is equal to the "headway" (the interval between trains, averaging two to five minutes during rush hour). If passengers cannot fit on the next train, the delay is much longer These complications make it difficult to judge the impact on subway riders, either in number or in length of time

Finally, no single statistic can capture the effects of local trains which switch to express tracks, or the delays that are magnified as connections are missed, or the trains that are slowed as that last passenger fights the closing doors The subway trip is a complex process, and many things can go wrong Since the system-oriented statistics cannot capture the myriad of determinants of subway travel times, a sophisticated estimate of time losses must be as open to question as the naive assumption that the average subway rider faces an extra twenty-five minutes per week in morning travel time. Although the latter course has been taken, the dollar estimates can easily incorporate any new information.



* Trains either arriving at the terminal within four minutes of schedule or taken out of service in mid-trip as a percentage of train trips actually started

Source New York City Transit Authority

Initial costs of subway delays

The immediate impact of a sudden increase in travel time is that many subway riders are late for work. For a while after the delays materialize, firms and their employees may continue to view the increased crowding and longer travel times as isolated episodes which have plagued the subway system from time to time. As a result, workers may be slow to adjust their times of departure for work, and the lateness may persist for some time.

The reductions of output which result from this are substantial. Twenty-five minutes of lateness for each of one million subway riders amounts to an aggregate cost of over 400,000 person-hours each week. Multiplying this time loss by the average wage (taken to be $8 00 per hour) yields an estimate of the value of the

Box 2: Measuring the Value of Lost Personal Time

Although economists have long realized that travel time is an important cost affecting many consumer decisions, no simple rule of thumb has emerged for assigning a dollar value to the personal activities foregone while traveling to work. For many years, economists multiplied the wage rate by the number of hours traveled in order to value the time, however, Lowdon Wingo* showed that this method is inappropriate when workers cannot freely choose the number of hours worked each day. A second complication was introduced by Gary Becker,† who specified a model which allowed the journey to work to be unpleasant *per se* To determine the burden felt by an increase in subway delays, then, it is necessary to determine (1) the value of the personal and family activities foregone because of travel time and (2) the value of the unpleasantness which must be endured

A number of economists have tried empirically to ascertain the value people place on travel time by observing the time-money tradeoffs involved with travel-mode or auto-route choices. However, the information gained is to a large extent anecdotal Automobile trips cannot be compared with subway trips; even mass transit systems vary greatly from city to city. As a result, the studies do not provide a consensus on the value of time However, many estimates lay between 25 and 50 percent of the wage. While none of these studies are very recent, and none involve New York subways, they do provide a basis for valuing the time spent traveling by subway

The estimates presented in this article make the conservative assumption that people value their personal time at 25 percent of the wage, the lower end of the range (table) This applies to the time people spend at their work place before working time. On the other hand, subway travel is unpleasant, and subway riders would be willing to pay a premium to avoid the unpleasantness For that reason, the time spent on the subway is assumed to impose a cost equal to 50 percent of the wage. The "unpleasantness premium", then, is 25 percent of the wage It is reasonable to add such a premium, since there are many express-bus riders who willingly pay significantly higher fares in order to buy improved amenities (including a seat).

It would be inappropriate to use the estimates of the value of time presented here for interpersonal comparisons, since the true values may not be constant across income class or by any other demographic stratification The only assumptions used in this research with respect to income distribution are that the dollar value of time losses are higher for high-income persons and that high-income persons are more likely to respond strongly to an increase in costs

* Lowdon Wingo, Jr , *Transportation and Urban Land* (Washington Resources for the Future, Inc , 1961), pages 52-62

† Gary S Becker, "A Theory of the Allocation of Time", *Economic Journal* (September 1965), pages 493-517

Values of Time by Location and Foregone Activity

As a percentage of the wage rate

Location	Foregone activity	Value of foregone activity	Unpleasantness premium	Total cost
Subway	Work	100	25	125
Subway	Personal	25	25	50
Work place	Personal	25	—	25

Annual Direct Costs of Subway Delays
In millions of dollars

Cost	Across-the-board 5-minute delays AM	PM	Total	25-minute random delays: one morning, one afternoon per week AM	PM	Total
Leave normal time for work; arrive late						
Borne by firms	166	0	166	166	0	166
Borne by employees	42	83	125	42	83	125
Total	208	83	291	208	83	291
Leave early for work; arrive on time						
Borne by firms	0	0	0	0	0	0
Borne by employees	83	83	166	250	83	333
Total	83	83	166	250	83	333

lost output equal to $3.3 million per week, manifesting an annual rate of $166 million (table).[2] Initially, the major portion of these costs may be borne by firms, since strict lateness policies may have been unnecessary before the subway deterioration These costs are one third as large as the city corporation income tax [3]

In addition to these costs, firms may suffer further output reductions which can be particularly burdensome if the delays are of random duration and frequency. Even firms which dock the pay of latecomers bear substantial costs as a result of the increase in subway delays. Valuing lost output at the wage rate does not account for short-run disruptions such as idle machine time or teams that are understaffed. The absence of even a single employee may be costly to firms working on rigid schedules, especially if the disruptions occur at random. For instance, the lateness of a secretary may reduce the productivity of one or more executives Moreover, an employee arriving late for work after spending extra time in a crowded, motionless subway car is likely to be less productive on the job. None of these costs borne by firms are included in the estimates reported above, so that docking the wage of latecomers does not insulate firms from the costs of the subway decline. The result is that all firms have incentives to eliminate lateness, even if sanctions stricter than docking are required.

Costs faced by employees

As employees are induced to leave earlier for work, they are forced to forego personal time which otherwise would be spent with their families, doing work around the house, or enjoying leisure activities. Putting a monetary value on this cut in living standards is difficult. Economists have investigated this problem and have come up with rather diverse estimates of the value people place on foregone personal time. However, 25 percent of the hourly wage seems to be consistent with many estimates (Box 2) This means they would be prepared to pay up to that amount to hold on to an hour of personal time. Moreover, since the journey to work is inherently unpleasant, the cost of extra subway time is greater. The premium for this unpleasantness is assumed to be equal to 25 percent of the wage, indicating that subway passengers would be willing to pay that much more to avoid spending more time traveling Altogether, the costs of extra time on the subway are assumed to be equal to 50 percent of the wage

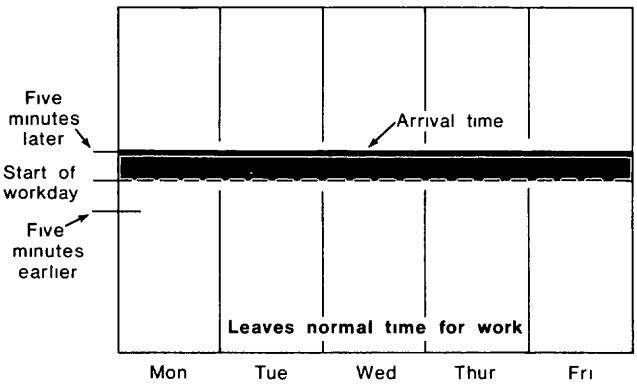
The amount of personal time which workers must give up to avoid lateness depends on the uncertainty of transit performance. If the twenty-five minutes of morning delays were distributed uniformly and predictably each week, any lateness could be avoided by leaving for work five minutes early every day (Figure 1) This

[2] In 1978, the average payroll per employee (excluding those workers who were self-employed or in the public sector) was $14,356, according to data in *County Business Patterns* Dividing by 2,080 hours and inflating by 20 percent to cover the increase in wages between 1978 and 1980 yields $8 28 In 1970, the average family income of workers who traveled by subway was 96 percent of that of all employees Assuming that the same relationships held in 1980, the average hourly earnings of subway riders would then have amounted to $7 95 Alternatively, average weekly earnings for covered employment in 1979 were $303 17 in New York City Dividing by forty hours and inflating to 1980 by 10 percent yields $8 34 The 4 percent subway correction yields $8 00

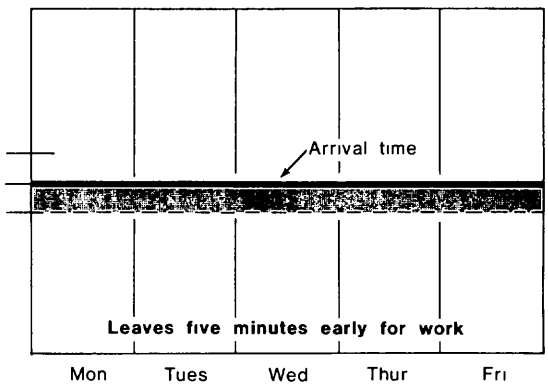
[3] The annual city corporation tax revenue is $502 million, compared with an annualized cost of delays of $166 million Of course, not all the burden of subway deterioration is borne by corporations

Figure 1

Time Losses Caused by a Five-Minute Increase Per Day in Morning Commuting Time



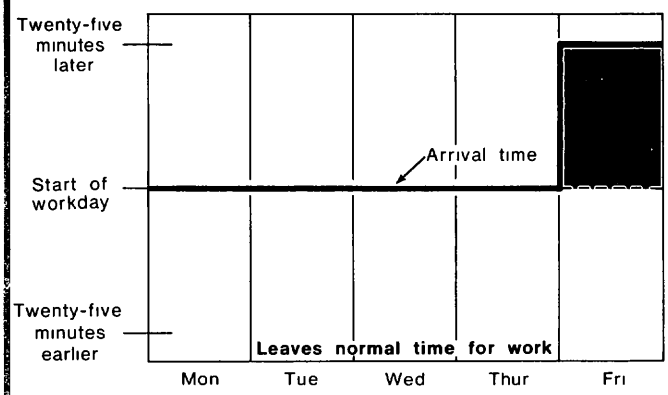
Location	Foregone activity	Time lost	Value
Subway	Work	25 minutes	$3 33
Subway	Personal	——	——
Work place	Personal	——	——
	Total	25 minutes	$3 33



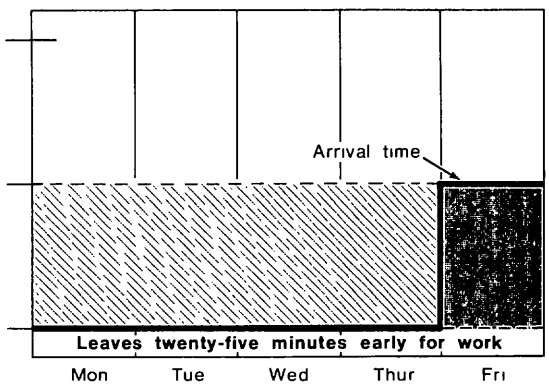
Location	Foregone activity	Time lost	Value
Subway	Work	——	——
Subway	Personal	25 minutes	$1 67
Work place	Personal	——	——
	Total	25 minutes	$1 67

Figure 2

Time Losses Caused by a Single Random Twenty-Five Minute Increase Per Week in Morning Commuting Time



Location	Foregone activity	Time lost	Value
Subway	Work	25 minutes	$3 33
Subway	Personal	——	——
Work place	Personal	——	——
	Total	25 minutes	$3 33



Location	Foregone activity	Time lost	Value
Subway	Work	——	——
Subway	Personal	25 minutes	$1 67
Work place	Personal	100 minutes	$3 33
	Total	125 minutes	$5 00

loss of twenty-five minutes per week, valued at 50 percent of the average wage, is a cost which is equivalent to $1.67 per week, or $83.00 per year The aggregate cost of the morning delays in the predictable five-minute delay case, then, is $83 million

Alternatively, if there were only one random twenty-five-minute morning delay per week, and firms were able to eliminate lateness, then workers would have to leave twenty-five minutes early for work every day (Figure 2). In this case, subway riders lose 125 minutes of their own time each week, of which only twenty-five minutes are spent on the subways. The other 100 minutes are spent at or near the work place on the four days out of five that there is no delay. Valuing the subway time at 50 percent of the wage and the rest at 25 percent of the wage, the total weekly cost to the typical city resident who travels to work by subway is $5.00 per week, or $250 per year. The aggregate cost to the one million riders, then, is $250 million [4]

These estimates of the costs imposed by morning delays tell only part of the story. In addition, subway riders lose twenty-five minutes each week of personal time in the afternoon due to the delays This amounts to over twenty hours per year and to over 20 million hours for the entire city. This extra time on the subway is valued at 50 percent of the wage and represents an aggregate cost of $83 million, bringing the estimate of total costs to $333 million This is almost 40 percent of the size of city income tax revenues and is borne only by subway riders, who comprise 40 percent of city employment.[5]

Another aspect of subway deterioration is the increase in the unpleasantness of the journey to work As more trains lose lights, as crowding increases in cars and on platforms, and as subway service becomes more unreliable, each minute spent on the subway becomes a greater burden than before. This would be reflected in an increase in the "unpleasantness premium" above the currently assumed 25 percent of the wage. This increase applies to the entire trip, not just the extra time and may be a significant addition to the estimates presented above.

[4] Here the assumptions interact in a critical way Subway riders must give up five minutes of personal time to save one minute of lateness, but the five minutes are valued at 25 percent of the wage In this case, leaving earlier actually increases the cost to employees (thereby making necessary sanctions more severe than docking), but this result depends on the specific assumptions In general, docking is a sufficient incentive for employees to get to work on time if the proportion of trips delayed exceeds the value of personal time expressed as a fraction of the wage

[5] The taxable income (and, by implication, the tax rate) of the typical subway rider is lower than that of the average city taxpayer Further, city taxes are deductible against Federal tax liability, while commuting costs are not Thus, the subway delays may impose costs substantially greater than a doubling of city tax rates for many riders

Economic responses

It is clear, then, that travel times need not increase by very much for substantial costs to be imposed. The responses of firms and residents depend on the costs actually being faced, as well as the extent of the delays expected in the future. When subway riders perceive the higher travel costs as permanent or increasing, they inevitably will reevaluate many of the critical choices which affect their standard of living. For example, automobile travel may begin to be more attractive, home locations nearer employment centers may become more desirable, and the benefits of moving to another city may appear more compelling. The extent to which residents make these changes depends on the costs of switching to automobile use or of relocating, compared with the magnitude of the costs of subway delays. If the latter are large enough, it would not be surprising to observe all these responses.

The least expensive change may be to switch to off-peak travel Although this may not be an option for many people due to rigid family or business schedules, some employees who can alter the length and timing of the workday can cut travel costs considerably Subway cars and platforms are less crowded off peak, so that in addition to the improved amenities people do not have to let trains pass for lack of space. Further, travel times may be shorter as crowding-related delays are reduced. The lower frequency of service has offsetting effects, since the average waiting time is longer, but trains are less likely to be delayed by trouble further down the line.

The evidence does show some shift to earlier travel. The number of people entering the subways between 7 and 8 a.m increased by 4 8 percent between March and October 1980, while subway use fell during each of the next two hours by 2.1 percent and 9.5 percent, respectively. This indicates a general tendency to leave earlier.

Another possible short-run response to the increased subway costs is to switch to automobile use It is expensive to own and operate a car in New York, and it is inconceivable that many people would buy cars for the sole purpose of abandoning the subways However, if automobile use increases by even a small amount, the congestion costs may be significant During 1980, when subway use fell by about 2 percent, automobile traffic into Manhattan rose by 3 percent. Since many facilities were already operating at capacity, speeds declined dramatically. For example, the average speed on Fifth Avenue fell by 19 percent in 1980 to 5 8 miles per hour Further, parking facilities are limited in Manhattan, and it is unlikely that many more parked cars could be accommodated. Even so, if more subway riders switch, higher

congestion and time costs will be imposed on existing drivers and bus riders. This means that many of the more affluent residents, who in the past were able to escape the costs of subway deterioration by paying the higher outlays for automobile travel, will begin to share the burden of the decline.

Long-term responses

It is unlikely that the actions described so far could succeed in avoiding the bulk of the costs imposed by subway delays. Thus, city residents and firms can be expected to take a variety of stronger measures to avoid the increased costs. To some extent, these actions merely shift costs from one group to another. However, firms and residents may leave the area, perhaps leading to a reduction of the size of the city.

The effects of subway decline on the labor market, for example, may be substantial. Workers who have some choice might prefer to work for firms which are located near their homes. Similarly, firms which depend on tight schedules might prefer that their employees live near the work place. Advertisements in the *New York Times* specifying Manhattan residence as a requirement for employment have already begun to appear.

Where job changes are not possible, employees will attempt to restore their standard of living by increasing their wage demands. Since employees with high-level skills are relatively scarce, mobile, and in demand everywhere, they may decide to relocate to other cities if a significantly higher standard of living is available. Thus, firms in New York City must meet these wage demands if they want to keep skilled employees. At the same time, however, low-wage earners may not receive comparable wage hikes, since their lesser mobility lowers their bargaining position. Thus, the net benefits of working are likely to remain lower than before the subway decline.

Firms would not be equally affected by the increased wage demands. As most service-oriented industries and high-technology firms depend on high-skilled labor, it is especially important to retain these employees. Firms must therefore pay wages sufficient to provide the standard of living available elsewhere, the size of the required increase being proportional to the extent of subway delays.

In many industries, therefore, the increase in the cost of labor could put New York firms at a competitive disadvantage with respect to the rest of the country. The result might be that some firms and corporate headquarters would leave the city. Residents who did not receive their wage demands, and those whose employers moved away, also might relocate to another region. As mentioned, residents with scarce job skills have greater means and opportunities to move than lower income persons, and their departure tends to make the city worse off for those who cannot.[6] The loss of economic activity and of higher income residents lowers the tax base, bringing about a need for tax increases and/or service cutbacks.

Subway maintenance has been one of the prime candidates for budget cutbacks. Such reductions, however, have not been limited to times of financial difficulty; maintenance has been curtailed in varying extents for many years to limit fare and tax increases. Deferred maintenance is an appealing tactic since there may be no immediate reduction of service

The analysis presented here has shown, though, that this appealing tactic gives rise to substantial long-run costs. Indeed, the governments of New York State and New York City have adopted a policy of encouraging business activity in the region If the subway deterioration is allowed to continue, these efforts stand to be seriously undermined.

Summary

This study has shown that:

- Subway deterioration can impose huge costs to individuals in the form of lost time and to firms in the form of reduced productivity.
- The cost of only a five-minute increase in the average morning and afternoon ride may easily reach $166 million per year.
- Unpredictability of service imposes further costs. If delays are randomly distributed but still average five minutes per trip, the costs may be twice as large.
- Firms and their employees face other costs not included in these estimates.
- Individuals and businesses will try to avoid these costs in a variety of ways. If many people and firms relocate outside the region, New York's economic position will suffer.

[6] A less drastic response would be to move closer to the employment centers Since high-income persons value time savings more highly than the lower income persons, they will provide the highest bids for housing in and near Manhattan A result would be an increase in conversion of properties to high-income residential use, displacing many current residents

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