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Evaluation, prioritization and selection of transportation investment projects in New York City

JOSEPH BERECHMAN[1] & ROBERT E. PAASWELL[2,*]
[1]*CN Chair Professor, Sauder School of Business, University of British Columbia, 2053 Main Mall, University of British Columbia, Vancouver, BC V6T 1Z2, Canada & The University Transportation Research Center, Y-220, The City College of New York, New York, NY 10031;* [2]*Professor and Director, University Transportation Research Center, Y-220, The City College of New York, New York, NY 10031*
*(*Author for correspondence, E-mail: paaswell@utrc2.org)*

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Abstract. Over the last decade, a large number of high capital cost transportation projects have been proposed for the New York City Region. Many have resulted from addressing evolving capacity needs, changes in regional demographics and economics, meeting the improvements necessitated by operating century old subway systems and recognizing the impact of moving freight in a dense region. But the catalyst for bringing all of these projects to the attention of the public and all regional agencies was the tragedy of September 11, 2001. While these projects entail massive investments ($50–$60 billion), little analytical work has been carried out to measure the transportation and economic costs and benefits they entail and to categorize them accordingly. Competition among agencies to secure adequate resources to implement any of the desired projects makes such analysis necessary; yet there still remain political, vested economic interests and agency rivalry barriers to achieving this important planning objective. This paper reports the methodological approach taken by these authors for consistent and transparent project evaluation and then presents results from the ranking and prioritizing methodology. The policy underpinnings and implications of the analysis are discussed in a subsequent paper and thus only briefly touched upon here in the concluding section.

1. Introduction

A large number of significant transportation capital investment projects are currently (2004) being proposed for New York City by many public agencies. These agencies, which include the Metropolitan Transportation Authority, the Port Authority of New York and New Jersey, New Jersey Transit, the New York State Department of Transportation and the city and state economic development corporations have each defined and distinct areas of influence within the Metropolitan region. Each has a mission, for whom its defined project(s) meet specific organizational as well as regional goals; each has differing calls on capital, which could be used to implement their projects. While most belong to the Regional Metropolitan Planning Organization, all act as though their missions are first at the decision making table.

Building all of the proposed projects would require well over $50–60 billion over the next two decades, far more than will be available through the traditional sources of funding and subsidies. As a result, the city and the region must make important choices about how to prioritize these investments.

The authors were asked to develop a methodological framework to assist prominent local stakeholders, The Partnership of the City of NY, in the understanding of these projects and to provide a means to discriminate among them. The major objective of this work was to inform a group of stakeholders how to make rational and systematic choices based on economic and transportation grounds, in an environment where pertinent data is lacking, no comprehensive regional transportation plan and objectives are defined, and the decision-making environment is highly fragmented. While the evaluation methodology developed incorporates acceptable transportation-economic methods, the discussions surrounding the methods could not be divorced from key underlying institutional and political factors. Thus, the main objectives of this paper are to define the investment decision problem that the stakeholders face, to describe the methodology used to evaluate and prioritize the projects and, subsequently, to show the results from the analysis. In this paper we will only briefly address the political and policy issues raised by the technical analysis. Mainly for reasons of space and focus, such a discussion is found in a companion paper (Paaswell & Berechman 2004).

The paper is organized as follows. Following the problem definition section, the next several sections provide details of the analysis, starting with the methodology used, the data sources and the cost-benefit models. Subsequently, the Goals Achievement Matrix approach for the selection and prioritization of projects is introduced. The paper's final sections discuss key results and some specific and general policy implications.

2. The investment decision problem

A large number of transportation mega-projects, each entailing substantial capital investment have been proposed for New York City by many public agencies and private interest groups. To provide common grounds for the assessment of the relative transportation and economic merits of these projects, and to help focus the public debate on the subject, the Partnership of the City of NY proposed a subset of projects for which they wanted answers to seemingly simple questions. Are these projects worth doing? Are any "better" than the others? The authors then defined a structured response to those questions and, in doing so, changed somewhat their tenor. Our response was that projects can be evaluated and that these evaluations should be conducted through careful definition of the variables used to measure costs and benefits and through an appropriate assessment methodology.

A textbook transportation-economic evaluation of the proposed projects posed a considerable difficulty. The projects, in general, are at an early stage of planning and much of the detail ordinarily necessary for a full evaluation has not been done by the proposing agencies. In addition, the projects are diverse in purpose, directed to a wide range of different transportation and urban goals. As we note below, the raison d'être of these projects did not emerge from a comprehensive analysis of regional needs; rather they have been posed by various stakeholders putting forth agency-sponsored projects some of which are over a decade old. The question then was to how to measure the benefits and costs of these projects using a common yardstick so that ranking and prioritization can be carried out subsequently.

3. The range of projects proposed for evaluation

From a normative standpoint, the process of project evaluation should be part of an overall process of regional transportation planning and design. A major component of this process is the project generation phase, where projects are first proposed and subsequently become part of the set of alternatives to be evaluated. In theory, we can distinguish between several approaches to project generation and evaluation, based on the underlying transportation planning perspective or perception of what urban planning is about.[1] It is beyond our scope here to examine this issue with any degree of rigor. Suffice it to say that in this study the set of projects put forward for analysis represents a mixed bag of planning objectives and perceived needs. Whereas some were proposed to solve transportation problems, others are meant to mainly boost real-estate development and economic growth in specific locations. Still others have resulted primarily from political aims.

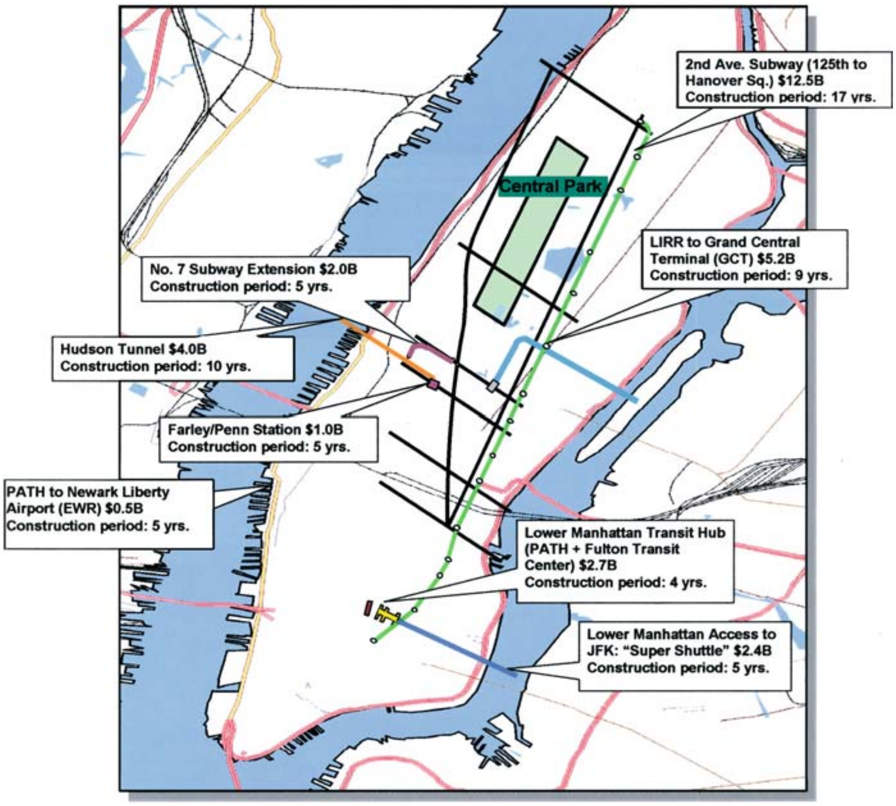
From a large set of projects, eight were selected for closer evaluation. While at face value these projects were presumed to meet basic transportation and economic needs and thus stand the best chance to be considered for implementation, there had been no comprehensive regional analyses to either test these needs or to set a project priority list.[2] From a transportation perspective, each project had a unique objective, ranging from subway congestion reduction, to creating transportation hubs, to enhancing the accessibility of Manhattan's downtown area. This list represents projects that were either set off by the tragic events of September 11, 2001 (e.g., the Fulton transit center and permanent PATH Station), those that were already on the drawing boards of public agencies (e.g., the Second Avenue subway), or were proposed by a mix of political and private interests (e.g., JFK access to Lower Manhattan).

It should be noted that the list of projects selected consisted of those most visible and important to the group, The Partnership of the City of NY, which initiated this study. The projects to be evaluated were essentially Manhattan oriented – passenger transportation type projects. A major proposal for a freight rail tunnel was not incorporated; neither was a substantial suburban bridge reconstruction nor a West Side highway (project B, which was removed from list). Table 1 presents the list of projects considered in this study, assembled by geographic area of impact.

Table 1. List of projects[a].

Symbol	Project title
Rebuild lower Manhattan	
A	Fulton Transit Center and Permanent PATH Station
Improving New York city connection	
C	Second Avenue Subway
D	Number 7 Subway Extension
Connecting the city and the region	
E	Access to the Region's Core (NJ Hudson Tunnel timesaving Connection to Grand Centrl)
F	East Side Access (LIRR Connection to Grand Central)
Connecting to other regions and global economy	
G	LIRR and/or JFK Access to Lower Manhattan
H	Penn Station and Farley Post Office
I	PATH Extension to Newark Airport

[a] For easy identification we have used the symbols A-I to denote the 8 projects (the project marked "B" was removed from the list at a latter stage).



Map 1. The eight projects selected for evaluation.

Map 1 shows the eight projects with their respective capital costs and construction periods. A detailed description of the projects is provided by Appendix A.

As can be seen from the map, all of these projects are Manhattan oriented – some entirely within the city while others linking Manhattan with other parts of the region.

4. The evaluation methodology

The evaluation of transportation investment projects raises several critical questions, which for presentation purposes can be grouped into four categories: first, the identification and measurement of benefits from the projects, including direct transportation and indirect economic development benefits. Second, identification and measurement of the costs associated with the investments, including also costs related to the method of financing the investments and costs caused by disruptions from the construction. The third category of key questions relates to the distribution of the benefits and costs by population group and by location. The fourth category is the environmental effects of the projects under examination.

In this study we focus primarily on the first two categories. The issue of the regional distribution of benefits and costs from transportation projects is not dealt with in this study for analytical and practical reasons. In the present case, capital funding for these projects is expected to come primarily from federal and state sources. Thus, the distribution issue mainly involves the diffusion of the benefits, for which the available assessment tools are rather unsophisticated and insensitive to socio-economic and demographic variables. The problem is further exacerbated by the fact that in highly dense metropolitan areas like New York, where the in-place transit network is well developed, infrastructure improvements in one segment of the network significantly impact all others. Coupled with issues of regional connectivity, network economies, complicated trip patterns and substantial transportation congestion at the geographical core, make the analysis of the socio-economic distribution of benefits from a project quite problematic. From a practical perspective, analysis of social accessibility by different sectors requires an elaborate database, which includes observations on socio-demographics, trip behavior, and highway and transit networks' travel flows. Presently, such a database is entirely unavailable. It should also be noted that while the decision-making circles may have paid lip service to this question, their main concern is economic development at the core with special attention to Manhattan's downtown.

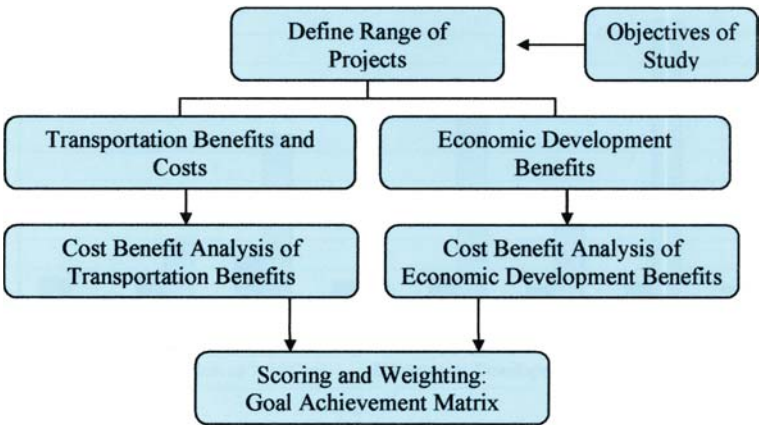


Figure 1. Structure of study.

With regard to the environmental impacts, we have decided not to deal with this issue mainly because all of the projects examined here require federal external funding, which in turn, necessitate a separate detailed Environmental Impact Statement (EIS) study. Some of these projects (e.g., the 2nd Ave., Subway) at the time of this study have already undergone such analysis. In fact, some of the data collected for the present study came from the relevant EIS reports. In any case, the analysis of environmental impacts was not within the scope of this study as defined by the sponsor.

The projects studied here are tested for two major types of impacts: transportation and economic development. The degree to which economic development benefits actually emanate from transportation investments has been the subject of lengthy debates in the literature. As noted by Banister and Berechman (2000), economic development benefits – increases in real estate values, additional square feet of office, residential or other spaces, and the creation of jobs – prevail only under a strict set of conditions, which must be shown before economic development benefits can be accepted. Issues of double counting, erroneous measurements of impacts and overestimation of benefits render such an analysis complicated. On the other hand, it is important to realize that in well-developed metropolitan areas, such as New York, where the transportation network is quite extensive and reaches almost all parts of the metropolitan area, accessibility benefits from additional transportation investments are likely to be relatively small. It is in part for this reason, as well as for political ones (mainly, the political implications of jobs creation) that major stakeholders and decision-makers at the city, state and even federal level, regard economic development benefits as key factors in their assessment of new investment projects. We return to these issues in our subsequent discussion.

Given these comments, the project evaluation methodology used in this study is composed of three main phases. First, from a large number of projects the selection of a subset for a detailed evaluation. The second phase is a cost-benefit analysis of transportation and economic development impacts. The third phase is a goal achievement matrix methodology, which was used to score, rank and prioritize the projects.

5. Basic data for the selected projects

The costs and patronage data used in this study were rough estimates, based on preliminary studies (mainly EIS), given to these authors by the various public agencies in charge. As many *ex post* studies of transportation capital investments, mainly of urban rail, have shown, cost underestimates and benefit overestimates are the norm in transportation project analysis. The key factor that was found to best explain these fallacies is deliberate deception from political pressure to paint a favorable picture of a given project, (see, Flyvbjerg et al. 2003; Flyvbjerg et al. 2004). Recall that the main objective of this study is to rank and prioritize a set of investment projects. Thus, in order to somewhat account for possible data biases in the database we have run several sensitivity tests on the costs and ridership estimates.[3] Successive constant decreases or increases across the board of the costs and ridership figures, by and large, did not alter the relative ranking of the projects. For lack of other information we have carried out the calculations reported here using the database available to us. Table 2 provides basic data for each project (see Appendix A for full project descriptions). For all projects we assumed a life span of 50 years subsequent to completion. We also assume 300 operational days per year.

6. Estimation of the transportation benefits and costs

6.1. *Estimation of benefits*

The estimation of transportation benefits from each project entails the measurement of two main variables: the expected number of riders at the completion of the project's construction period and the amount of time

Table 2. Basic data for the selected projects.

Project	A	C	D	E	F	G	H	I
Capital costs($B)[a]	2.45	12.5	2.0	4.0	5.26	2.43	1.0	0.77
PV of capital costs($B)[b]	2.60	15.3	2.16	4.63	6.02	2.63	1.08	0.81
Annual operating and maintenance costs ($M)	76.67	348.6	39.16	88.47	546.5	47.18	294.9	87.2
PV of annual costs($B)[C]	3.46	5.49	1.55	1.26	7.89	1.14	1.45	0.52
Construction period (Years)	4	17	5	10	9	5	5	5
Passengers (daily)-rides	331,000	591,000	66,400	202,000	156,736	88,213	78,783	7,125
Avg. fare ($)	1.0[d]	1.8[d]	1.8 [d]	3.5[e]	3.7[f]	3.7[f]	0	3.5[e]

[a] Excluding debt service.
[b] Including debt service during the construction period but not afterwards (i.e., during the project's 50 years life span).
[c] Including debt service and operating and maintenance costs during the project's 50 years life span.
[d] For NY City Subway.
[e] Commuter rail.
[f] Long Island Rail Road.

saved per user. It is expected that ridership will grow over time as the population grows. However, examining historic trends, it seems unlikely that ridership will grow at a constant rate. Thus, a growth model with a declining rate of growth was used to estimate the number of riders over the project's life span. The growth model is given by equation (1):

$$g(t) = \frac{g}{1 + \alpha(t - T_c)} \text{ for } t > T_c \tag{1}$$

In this model, $g(t)$ is the growth in ridership over time (t), g is the annual growth rate, T_c is the construction period and α is the attenuation rate (we assumed $\alpha = 0.1$). In this study, we set g to be 0.523% per year for all projects.[4] While there is no reason to accept the same growth rate of patronage for all projects, we did so mainly for lack of better information. This rate can be regarded as the region's long-run average.[5]

The timesavings variable includes two main components: direct time saved and indirect time saved on other applicable transit lines. The direct time saved is further composed of access and egress walk times, of in-vehicle time and reduction in over crowding where applicable. The indirect time saved consists of similar factors as well as reduction in auto travel where pertinent. To obtain the dollar value for the time saved by project, we have used federally established guidelines (adjusted for New York wages and income). These values were $24 per hour of in-vehicle time and $32 per hour of out-of-vehicle. For reduced overcrowding, we assumed 5 minutes of productive work timesavings. These basic data are presented

Table 3. Estimated transportation benefits.

Project	Annual transport benefits ($M)	For year of estimate	Year of project completion (Expected)	Annual growth rate of ridership[a]	Annual benefits for effective year of project completion ($M)	PV of transport benefits ($B)
A	237.0	2002	2007	0.523%	243.3	3.871
C	970.8	2020	2020	0.523%	970.8	8.190
D	90.6	2010	2008	2.000%	87.08	1.390
E	202.1	2020	2013	0.523%	194.9	2.231
F	333.5	2010	2012	0.523%	337.0	4.201
G	62.7	2002	2008	0.523%	64.69	0.980
H	33.3	1997	2008	0.523%	35.27	0.534
I	10.9	2010	2008	1.598%	10.56	0.161
Total						21.909

[a] See the growth model in equation (1).

in Appendix B. The overall estimated transportation benefits, adjusted for the year of project commencement, are shown in Table 3.

6.2. *Estimation of costs*

Turning to the cost side basic cost data are given in Table 2. In computing operating and maintenance costs we used data from the Budget Watch report of MTA (April 2003). Thus, for NY subway projects we used the figure of \$1.966 per ride (i.e., \$654.3 M in reported operating expense and 342.8 M trips). For the LIRR projects we calculated \$11.63 per ride (\$152.3 M reported operating expense and 13.1 M trips.). These figures are for 2002. We used 5% as the cost of capital and the discount factor. We have also tested the sensitivity of the results to lower discount rates.

In assessing the costs of these projects a further key question is whether we need to consider their respective sources of funding. This question is important for several reasons. First, the theory of public finance holds that the method of funding a project affects several major factors, which bear impact on its real costs. For example, financing a project through taxation may imply substantial deadweight loss (i.e., a welfare loss), which affects the efficient use of resources and hence the true costs of the project. Similarly, alternative methods of project funding have different impact on the opportunity costs of capital funding and, therefore, on the correct discount factor. In part we account for this problem by factoring into the NPV formula (equation 2) debt service costs, which should be borne by the project. The use of a discount factor of 5% is a federal requirement, presumably accounting for the opportunity costs of raising capital.

Federal and state funding raises another important question, relative to the incidence of costs and benefits from the projects. Since capital funding is external to NY should we then consider the net welfare gains from these projects as accruing to NY only or to society as a whole? This important question, which is at the heart of fiscal federalism, is beyond the scope of this study. Suffice 1 to say that this kind of transfer payments are prevalent throughout the federal system as the large majority of transportation infrastructure projects receive federal and state capital support to one degree or another.[6]

7. Transportation cost-benefit analysis

Next, we carry out a Cost Benefit Analysis (COBA) of the transportation benefits. To that end, equation (2) is used to compute the Net Present Value (NPV) of the transportation benefits. Essentially, this equation is based on the computation of consumer and producer surplus, the capital costs, debt service and maintenance and operating costs.

$$NPV(C, T_c, B_t) = -\left[\sum_{t=1}^{T_c} \frac{\left(\frac{C}{T_c}\right) + r \cdot C}{(1+r)^T}\right] + \sum_{t=T_c}^{T+T_c} \frac{B_t \cdot \left[(1+g(t)^{(t-T_c)})\right] + (R) - (MO) - (r \cdot C)}{(1+r)^t} \quad (2)$$

In this equation, T_c is years of construction, C is total capital costs, r is the discount factor (5%), $r \cdot C$ is debt service, which is assumed to be paid during the construction period and then during the life span of the project; B_t is annual transportation benefits for effective year of project completion (see Table 3),[7] $g(t)$ is the ridership growth function (equation 1), R is fare box revenue, MO is maintenance and operating costs, t is year index, T is the life span of a project (assumed 50 years). Table 4 presents the various economic criteria that were calculated.

In Table 4 criterion 1 shows the calculated benefits per ride. Criterion 2 is the estimated NPV for the direct transportation benefits. Evidently, for each of these projects the direct benefits are insufficient to generate a positive Net Present Value. Criterion 3 is the computed minimum benefits per ride necessary for the project to break even. Subsequently, criterion 4 shows the percent of actual benefits (criterion 1) out of minimum benefits necessary for the project to breakeven (criterion 3). Criterion 5 is the rate of return on the investment under the minimum benefits.

Under fully competitive conditions, all transportation benefits from a new facility are captured by the timesaving on this facility. In most instances, however, the overall transportation system operates under non-

Table 4. Results of transportation COBA.

Criteria	A	C	D	E	F	G	H	I
1. Calculated benefits per ride ($)	2.43	5.47	3.58	3.1	7.16	2.44	1.49	4.94
2. Project's NPV ($B)	−2.2	−12.64	−2.62	−3.66	−9.71	−2.79	−2.00	−1.17
3. Minimum benefits per ride ($)	3.83	13.92	12.18	8.19	23.73	9.4	7.08	40.91
4. Actual benefits as percent of min. benefits	63.4	39.3	30.0	37.8	30.1	25.9	21.0	12.0
5. ROR for minimum benefits (%)	2.32	1.35	1.72	1.27	2.31	1.43	2.34	1.63
6. Other transport benefits[a]	3.77	8.61	10.25	5.48	12.20	6.58	3.00	12.00

[a] In units of network time saved per ride.

competitive conditions, for example, due to inefficient fare structure. We have, therefore, also estimated benefits that accrue to users of other facilities, mostly in the form of congestion relief on parallel subway lines. Criterion 6 in the Table 4 shows these results.[8]

8. Economic development analysis

Theoretically, economic development benefits from a transportation investment project can arise due to three main factors. The first is the investment multiplier effect, which results from the sizeable construction expenditures flowing into the regional economy (and often also to adjacent regions). These effects are of relatively short duration, as they last only throughout the construction period and, therefore, are not regarded as long-run economic growth benefits. The second set of economic development benefits arises when travel costs and time savings from the project are capitalized in other markets, most noticeably the residential, commercial and office-space markets. Unless doubly counted with the transportation cost savings, these pecuniary benefits constitute real long-run economic growth benefits from the project. Finally, if accessibility improvements indeed alter land use patterns, for example, by inducing firms' agglomeration, additional growth benefits in the form of increased employment and output, can be expected. In assessing the magnitude of these three benefit types the tricky task is to correctly define and then measure them while avoiding double-counting and unrealistic expectations about future markets.

These difficulties notwithstanding, given the importance which decision-makers at all levels attribute to economic growth benefits, mainly employment and real estate development, this study further forecasted the economic development benefits that could flow from each project.[9] To that end, low, medium and high levels of commercial, residential and retail development that could be directly spurred or enabled by investment in these projects were estimated. The analysis took into account job levels, incomes and tax flows. The calculations are based on a core set of assumptions and also included business executive, real estate and developer interviews and insight from other experts. This core set of assumptions is:

1. Residential Property was valued at \$350,000 per unit[10]
2. Commercial Space (average sale price) values: Midtown: \$600/sq. ft.; Far West: \$550/sq. ft.; Lower Manhattan: \$550/sq. ft.; Brooklyn: \$440/sq. ft.; Long Island City: \$440/sq. ft.

3. Income levels were based on borough averages from the Bureau of Labor Statistics;
4. Average (borough) retail spending was based on 2000 Census data;
5. Office jobs required 200 sq. ft. of space per employee;
6. Expected increase in residential real estate values (for all projects) was 10%.

With these assumptions next the NPV of the economic development benefits are calculated for each of the projects. While present value calculations were made over a 50-year period, it is assumed that the current distribution of population and income would remain as it is today.[11] Table 5 presents these results.

With regard to the pecuniary and land use economic impacts of these investments, a key weakness of this analysis is that it does not answer the question what part of the expected economic development benefits reported above, would have accrued in any case from regular economic activity in the studied areas. To investigate this question requires the use of a regional equilibrium land use-transportation model. Presently, the regional MPO (NYMTC) is engaged in developing such a model.

Figure 2 presents the eight projects with the transportation and economic development benefits of each project calculated as a percent of capital cost. The figure shows how both sets of benefits would yield different returns.

Table 5. Range of present value of economic development benefits ($B)[a].

		Low	Medium	High	PV of ED per annual Ride ($)[b]	ED ratio (%)[C]
A	LM hub (Fulton T.C. + PATH)	12.0	18.0	45.3	780	15.0
C	Second Ave. subway	11.1	14.1	21.3	98	12.6
D	N0. 7 extension	10.7	14.1	207.8	1,250	13.8
E	Hudson tunnel to penn	0.9	4.1	12.3	75	2.5
F	LIRR to grand central east side access	7.2	12.2	61.8	251	9.7
G	LIRR and/or JFK access to lower manhattan	5.0	8.5	75.9	185	6.7
H	Penn station/Farley post office	6.3	12.6	12.0	1,230	9.5
I	PATH to newark airport	0.1	0.1	14.0	19	0.1

[a] Includes job growth, commercial development and residential development.
[b] For the medium range estimates.
[C] Indicates the ratio of PV of ED to the PV of the capital costs.

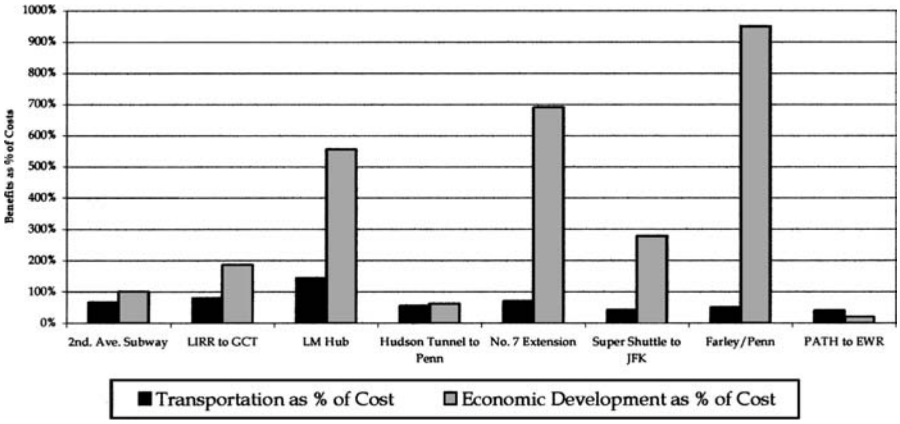


Figure 2. Transportation and economic development benefits as % of capital costs.

What is illuminating about the results shown in Figure 2 is the magnitude of the calculated transportation benefits relative to the calculated economic development benefits. Clearly, on the basis of transportation benefits alone the majority of these projects should not be implemented. This then raises the crucial question of whether transportation projects should be accepted primarily on the basis of their calculated economic development benefits. We return to this issue below.

9. Projects' selection and prioritization

As in all cases of public investment projects, resource limitations require the use of a procedure to rank and then prioritize the set of assessed projects. In previous sections we have examined two sets of results from the projects: transportation and economic development benefits and then presented them side by side as in Figure 2. But can this exposition alone be used to rank and select projects? Doing so necessarily biases the selection results because, in the decision process, it implicitly assigns a much larger weight to the economic development benefits than to the transportation benefits. Given the magnitude of the former and the relatively small transportation impacts, the projects, in fact, will be selected exclusively on the basis of their potential economic development benefits. This is clearly depicted by Figure 2 above. While economic development impacts are important to stakeholders and political decision-makers one cannot ignore the fundamental fact that the rationale for transportation investments, first and foremost, is the generation of transportation benefits.[12] To account for this critical deficiency we have employed a Goal

Achievement Matrix (GAM) approach for the ranking of the above projects.

9.1. *The goal achievement matrix framework*

In this analysis we have used the well-known Goal Achievement Matrix (GAM) approach (Hill 1968), in order to provide a common yardstick for a systematic and unambiguous ranking of all projects considered. Briefly stated, the GAM method requires that all criteria used for the evaluation and all projects be put in a matrix form whose entries are normalized scores assigned to each project for each criterion. Since not all criteria are considered equally important, a vector of weights is produced showing what decision makers regard as the relative importance of each criterion. By multiplying the matrix by this vector we produce a weighted score matrix. Summing across each project yields a vector of ranked projects.

Obviously, the critical component of the GAM method is the weights, since it might be asked whose weights should be used. There are various ways to generate them with varying degree of inherent subjectivity. For this study the authors have adopted a modified Delphi approach in which a panel of experts was used to elicit the weights the panel deemed as appropriate for these projects. This panel consisted of regional transportation experts with considerable experience in subway and rail transit analysis and with ample knowledge of the transportation and urban issues of the NY metropolitan area. Admittedly, the panel did not include different stakeholders to allow for their subjective weights to influence the ranking results. Underlying this approach was the study's stated objective of obtaining aggregate efficiency measures rather than reconciling political conflicts. However, we have further carried out a sensitivity analysis in which the weights were systematically altered to elicit their implications for the ranking results. Table 6 presents the various criteria and the corresponding weights.[13]

9.2. *Application of the GAM approach*

Since the measures and scores are recorded in different units we next need to normalize the results, where a "100" is the highest score for each criterion.[14] Subsequently, the standardized scores are multiplied by the weights, which add up to 100%. The results are given in Table 7.

As evident from Table 7, projects A, D, and H receive the highest weighted score thus judged as the "best" ones.

Table 6. Criteria and weights[a].

Criteria	Weight
1. COBA transportation	
1. Calculated benefits per ride	
2. NPV transportation benefits	
3. Minimum benefits per ride	
4. Calculated benefits as percent of minimum benefits	
1.5 Rate of Return of investments	0.50
2. Other transportation	0.125
1. Network time saved	
3. Project construction period	0.065 (0.063)
1. Years	
4. Economic development	
1. PV Econ. Develop	
2. PV of Economic Dev. per Annual Ride	
3. Econ. Develop Ratio	0.310 (0.313)
Total	1.00

[a] In parenthesis are the accurate weights.

Table 7. Summary of score using export panel weights.

Criteria	A	C	D	E	F	G	H	I
1. CODA transportation (50%)	50.00	30.18	31.97	30.53	35.55	28.32	34.31	34.75
2. Other transportation (12.5%)	6.363	12.50	7.034	5.811	9.208	5.077	2.790	7.366
3. Project construction period (6.5%)	6.5	1.59	5.2	2.6	2.88	5.2	5.2	5.2
4. Economic development (31 %)	19.552	11.001	31.00	3.024	11.891	11.642	23.026	0.854
Total weighted normalized score	82.415	55.211	75.205	41.972	59.548	50.244	65.334	48.172

9.3. *Sensitivity analysis*

To check the robustness of the results in Table 7, we ran two tests: first we weighted equally (50%) the transportation and economic development benefits.[15] Subsequently, we changed the weights to 30% and 70%, respectively. The test results are shown in Table 8.

Under equal weights projects D, A and H rank as the top ones. When the weights are set at 30% for transportation benefits and 70% for economic development the same ranking remains stable as projects D, A and H

Table 8. Summary of score with different weights.

Criteria	A	C	D	E	F	G	H	I
Transportation benefits (50%)	45.553	32.073	32.032	28.224	34.534	27.972	30.658	34.288
Economic development (50%)	31.536	17.743	50.00	4.877	19.179	18.778	37.138	1.322
Total weighted normalized score	77.089	49.78	82.032	33.101	53.713	46.75	67.797	35.61
Transportation benefits (30%)	27.332	19.222	19.219	16.934	20.72	16.783	18.395	20.573
Economic development (70%)	44.15	24.84	70.00	6.828	26.851	26.289	51.994	1.851
Total weighted normalized score	71.482	44.062	89.219	23.762	47.571	43.073	70.389	22.424

ranked as the ''best'' relative to their overall assessed contribution to economic welfare.

10. Discussion: Key findings and conclusions

Out of a sizeable number of large-scale transportation investment projects which have been proposed for New York City by many public agencies and private interest groups, eight have been selected for close scrutiny and assessment. This paper describes the methodology used by the authors to that end, and the results from the analysis. The key results and conclusions from the study are presented below under three headers: ''recommended projects'', ''decision-making issues'' and ''funding issues''.

A. The recommended projects: Of the three projects that received the highest scores relative to their aggregate contribution to transportation and economic development benefits, two are essentially hub facilities. These are the Fulton Transit Center and permanent PATH Station, and the Penn Station/Farley Post Office. This finding is quite significant as it reflects the present structure and needs of the NY transportation system. Thus, save for Penn Station and Grand Central Station, both located in the mid-Town area, there are no major hub facilities for the entire rail, bus and subway networks, where users can expediently transfer within and between modes. The lack of hub facilities, in part, is also responsible for the poor East-West accessibility in Manhattan. The third highest scoring project, the Number 7 Subway Extension, aims at linking the borough of Queens with Manhattan's west side via Penn Station.[16]

Another key result that characterizes the "best" projects is that they scored highest on *both* scales: transportation benefits and economic development benefits. While above we have recognized the limitations of the present economic development benefits analysis, nevertheless, significant economic development impacts are apparently associated with high-level transportation impacts.

Surprisingly, the Second Avenue Subway project, which has been on the drawing board in NY for over four decades, and thus has received much attention in the public and among planning agencies, is not ranked among the three top projects. This is mainly due to its massive capital needs ($12.5 billion, exclusive of debt service) and long construction period (17 years).[17] In addition, the project is located in the midst of one of the most well developed areas in the city, with major construction implications for everyday life. This raises an interesting planning question. In a world characterized by severe limitations on public resources and rapid technological changes, can such a massive project actually be implemented? Apparently, funding issues, traffic and urban activity disruptions, inability to forecast future technological developments in communication and transportation and lack of political stability during the construction period, are likely to render a project of this magnitude exceedingly problematic.

It is interesting to observe that in a metropolitan area like NY some major projects are actually advocated by the private sector. Such is LIRR/JFK Downtown Access, which is espoused by powerful real estate and financial organizations. This transportation-planning phenomenon is absolutely legitimate and one that should be encouraged. However, as done in this analysis, it should be treated as a public project relative to its contribution to transportation and economic welfare.

As mentioned at the outset, the eight projects studied here came from a long list of projects that were put forward over time by various agencies. These eight projects seemed to be the ones that stand the best chance to reach the final implementation stage. In this regard it is interesting to note the kind of projects that did not enter this "final" list. These include mainly freight and highway projects. While in this paper we did not explore in detail the reasons for this phenomenon nevertheless, it epitomizes the nature of the region and its present transportation and political idiosyncrasies.

B. Decision-making issues: The methodology used in this analysis is composed of two major parts; computation of the overall net benefits from each project and, subsequently, the ranking of these projects. Benefits were assumed to be comprised of direct transportation benefits, mainly travel time and costs savings and increased ridership, and economic development benefits, in terms of additional real-estate development and job creation. The computation of net transportation benefits, while accounting for the value of the invested resources, shows that the projects cannot be justified on the basis of these benefits alone. On the other hand, most of the projects generate positive net economic development benefits. This reality of negative net transportation benefits and positive net economic development benefits raises theoretical and practical questions regarding the acceptance of transportation projects. Should transportation investments be carried out if the expected transportation benefits are insufficient to cover the costs involved, even if other non-transportation benefits are substantial? On the practical level, if we to accept projects that engender inadequate net transportation benefits on the basis of their external benefits, in the decision-making process, should the latter benefits receive the same weight as the former ones do? For the policy sciences theorist under these conditions-why invest in transportation? Why not in education, heath care, housing, etc?

As noted above in this study we did not examine issues related to the distributions of benefits and costs by population. Yet, at time of implementation, various population segments, who may regard themselves as "losers" relative to the distribution of costs and benefits, could delay the investment by many years to come, adding substantially to its already very high costs. Like the economic development impacts, at present, tools for assessing the distribution of costs and benefits from transportation investment projects are unsophisticated and insensitive to socio-economic and spatial variables. Nonetheless, a clear understanding of this question is essential for successful project completion.

Another issue that this study raises is the role of public planning organizations. That is, transportation investment decision-making processes have always been political-balancing political stakeholder demands, equity and resources availability. These are all strong dimensions not readily modeled. What then is the role of professional public planning agencies in the project selection process? Forty to fifty years ago models and techniques used for project evaluation and planning were technically rather crude, quite restricted and largely inaccurate, leaving plenty of room for fuzzy decision-making processes where rough estimates, conjectures and even personal values, played a major role. The advancement of computation and data storage capabilities along with highly sophisticated mathematical, GIS, and economic models and techniques, render planning and evaluation schemes quite versatile, more accurate and, most importantly, available for routine use by planning professionals and stakeholders alike. Yet, public agencies, evolved since the Post WW2 period, have adopted a fortress-like attitude toward their methods, data collection and sharing and ultimate decision-making. Some of this attitude is reflexive, especially in an environment such as New York. Agencies become reticent to share information, making public evaluation of mega-projects and their alternatives difficult and often contentious. This, of course raises the difficult but pressing question, "what is the relationship of planning to project realization in the early 21st Century?" (Paaswell 2002).

C. Projects' funding issues: Since the late 1970s, finding sufficient financial support for both maintaining and renewing infrastructure in the U.S. has been a major national issue.[18] The availability of capital for infrastructure investments has strong influence over local project selection. Rather than starting with the fundamental planning question, "what project-or combination of projects – is good for the region"? too often the starting influence is "what projects are immediately eligible for funding?" Capital comes for a number of sources. The sources are US DOT and state governments for subsidies, State and local governments for the issuance of debt, in rare instances from the fare box, and occasionally from the private sector in some joint ventures. For all of the projects studied here, substantial amount of federal and state subsidy would be needed; without the possibility of such subsidy, project planning would be delayed or foregone.[19] The projects located in Lower Manhattan are eligible for FEMA funding – funding as "insurance" for the September 11 disaster. But again, FEMA funds are too scarce to meet all of the proposed projects. So planning becomes confounded over the issue of multiple agencies with competing proposals, and multiple funding sources that are not fungible.

Ultimately, project decision-making comes from political strength. The projects of course must have merit; projects that reach the open discussion and subsequently the planning phase, have developed strength through addressing a problem for which political help is appropriate. Nevertheless, the projects selected might be sub-optimal as no one has asked the open question: "what transportation does the New York region need, in order to remain globally competitive, culturally diverse, the capital of finance, or any of a number of appropriate goals". Then the question asked would be, for each project, "does this move us to that goal"? To some extent, this is a failure of regional planning, i.e., the engagement of the set of regional players in setting a vision and choosing strategies to implement this vision. The work here is a start to beginning a rationale for a more balanced and coherent discussion.

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Appendix A: Description of projects

A. Fulton transit center and permanent PATH station

The central pieces of transportation infrastructure planned for Lower Manhattan are the transportation hubs located at the World Trade Center site and the Fulton Street Transit Center. The two transportation hubs, tied together via an underground walkway, will help ease travel across Lower Manhattan by providing east-west connections and improve transfers among the various transit services. Both hubs will also be designed to create new public space with highly visible entrances, improved station mezzanines and open connections for transfers. The WTC Hub will feature a new PATH Station, with expanded capacity and improved facilities, as well as a New York City Transit station serving the AlCIE/l/2/3/9 subway lines. This transportation hub will be linked with an underground walkway to the new Transit Center at the Fulton Street Subway Station, providing connections to the A/C/N/R/J/M/ZJ2/3/4/5 subway lines. The pedestrian walkway will also connect the transportation hubs west to the World Financial Center, Battery Park City, and the ferry terminal.

C. Second avenue subway

The Second Avenue Subway would provide a new 8.5 mile subway line with 16 new stations extending the length of Manhattan's east side corridor from 125th Street to Hanover Square in Lower Manhattan. The line would provide two subway services in the corridor, one running between 125th Street and Hanover Square on a new rail line, and the other running from 125th Street to 63rd Street, where it would join the existing Broadway line providing express service along Seventh Avenue and Broadway before heading over the Manhattan Bridge into Brooklyn. The added capacity provided by the new subway would improve service for passengers traveling into and through the east side of Manhattan by easing congestion on the Lexington Avenue line and improving access to the currently underserved communities on the far east side of Manhattan. The Second Avenue Subway would also ease transfers by providing connections with 15 other subway lines. While new development from this project might not be as intense as proposed for the under developed far West side, the sustaining and growing of employment are well linked to access and resulting productivity of workers. Decreases in reliability and increases in inconvenience as congestion continue to grow are arguments for economic development, just as higher and better use of under developed land is.

D. Number 7 subway extension
The Number 7 Subway Extension would provide subway service to the Far West Side of Midtown, as part of a larger effort to promote development in the area. From its current terminus at Times Square, the #7 Subway line would run west under 41st Street to 11th Avenue, and turn south under 11th Avenue. An intermediate station would be constructed at West 41st Street and 10th Avenue, with the terminal station at West 33rd Street and 11th Avenue. This would improve east-west transportation across Manhattan, and bring subway service to an underserved area. The extension of the No.7 subway line is based upon economic development proposals put forth by the City of New York;

E. Access to the region's core
Access to the Region's Core would provide a new rail tunnel under the Hudson River. The tunnel would run from central New Jersey into Penn Station, with the possibility of additional connections to Grand Central Terminal and the Sunnyside Rail Yards in Queens. The tunnel would primarily serve New Jersey Transit and Amtrak, allowing an increase of as many as 21 trains during the peak hour. Access to the Region's Core may also allow Metro North trains to reach Penn Station and allow increased service frequency for Long Island and Metro North Rail Roads due to decreased station and track congestion and improvements to tracks, platforms, and the passenger circulation system at Penn Station.

F. East side access (LIRR connection to Grand Central Terminal)
East Side Access is a plan to bring Long Island Rail Road trains into Grand Central Terminal on the East side of Manhattan midtown. Trains will utilize an existing tunnel running under the East River, entering Manhattan at 63rd Street then proceeding to Grand Central Terminal. A new LIRR station will be built at Queens Boulevard in Sunnyside Yards,

Queens. East Side Access will provide direct access to East Midtown for LIRR commuters, expand seating capacity on the LIRR system and reduce train congestion at Penn Station.

G. LIRR and/or JFK access to lower manhattan
A proposed Super Shuttle service linking Lower Manhattan and downtown Brooklyn to Long Island commuters and the JFK AirTrain – a recently completed dedicated rail link from JFK airport to Jamaica, Queens, LIRR Station. Improved connections between Lower Manhattan and the region's airport, primarily JFK, are being billed by some as crucial to New York City's ability to compete globally. The airport connection has been proposed in many forms, with Brookfield Properties' plan calling for utilizing existing subway tunnel capacity, and Mayor Bloomberg proposing the construction of a new tunnel underthe East River. Both plans would serve Long Island Rail Road passengers as well as AirTrain passengers by the existing LIRR connection between Jamaica and Downtown Brooklyn. Our analysis is based on the Brookfield proposal. In terms of economic development impacts this project is likely to have a medium impact. It could add 3 million square feet of office space to downtown Brooklyn and 1 million square feet to Lower Manhattan. Nevertheless the proposed Super Shuttle could still yield more than double its capital cost in economic development benefits. It would also open up Lower Manhattan to the Long Island workforce and improve access to JFK airport.

H. Penn station and Farley post office
Relocation of Pennsylvania Station to the Farley Post Office building site on the West side of Manhattan midtown. The Farley Post Office renovation will create a new waiting area for Amtrak, New Jersey Transit and Long Island Rail Road passengers, replacing the current underground facilities at Penn Station. This will help increase passenger capacity at Penn Station and provide a new public space with passenger and visitor amenities.

I. PATH extension to Newark Airport
By extending the PATH system 2.5 miles from Downtown Newark, a direct link could be created from Lower Manhattan to the Newark Airport. The extension would connect the PATH system with the Port Authority's AirTrain system at the Newark International Airport Station, which is currently served by New Jersey Transit and Amtrak. This will provide direct rail access to the Newark airport from Lower Manhattan.

Appendix B: Basic travel time and cost saving data

Table B1. Estimated annual transportation benefits.[a]

	Direct Benefits			Indirect Benefits					
	Project	Walking And waiting time ($M)	In-vehicle travel time ($M)	Exposure to over crowding ($M)	Walking and waiting time ($M)	In-vehicle travel time ($M)	Exposure to over crowding ($M)	Externalities of auto use ($M)	Total ($M))
A	Fulton transit center and PATH station	$185.2	$0.0	$42.8	$0.0	$9.0	$0.0	$0.0	$237
C	Second avenue subway	$557.7	$54.3	$0.0	$1.8	$118.5	$229.3	$9.1	$97C
D	No.7 subway extension	$37.0	$53.6	$0.0	$0.0	$0.0	$0.0	$0.0	$9C
E	Access to region's core	$85.9	$42.3	$66.3	$0.0	$0.0	$0.0	$7.7	$202
F	East side access	$269.2	−$28.9[b]	$0.0	$63.4	$0.0	$0.0	$29.8	$333
G	LIRR/JFK downtown access	−$15.0[b]	$88.4	$0.0	−$10.7[b]	$0.0	$0.0	$0.0	$62
H	Penn station/Farley post office	$33.3	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$33
I	PATH extension to newark airport	$0.0	$10.9	$0.0	$0.0	$0.0	$0.0	$0.0	$1C

[a] These benefits were calculated for various years depending on data availability. Subsequently, in the CORA calculations, they were adjusted for actual year of project completion (See Table 4)

[b] A minus sign indicates that the projects has actually increased walk or wait time or the in-vehicle time due to a new location or a new alignment.

Notes

1. For a more rigorous discussion of planning objectives see Willumsen and Ortuzar (2002). For a discussion on transportation as a means to affect economic development, see Banister and Berechman (2000, Chapter 5)
2. While this is the role of the MPO, projects in New York are not tested against each other, either singly or in combinations. Rather each project is examined as a self-standing ones and must be part of the test of an Environmental Impact Statement.
3. In fact, since we are looking at all projects as proposed – no construction dollars yet spent – we can assume that all carry the same estimation errors pointed at in Flyvbjerg et al. (2003a, 2004). In this regard, the projects are comparable in the same relative manner.
4. For project I (PATH to Newark Airport) the annual growth rate was estimated to be 1.598%
5. Following a comment by a referee, we have carried out several sensitivity tests involving different growth rates for different projects. While alternative growth rates had some effect on the estimated benefits, they were not significant enough to modify the ranking results. This is probably due to the overwhelming impact of each project's costs on its NPV, as well as to the weight of the economic development benefits, relative to the transportation benefits, in the ranking process.
6. Theoretically we can examine the degree to which the total benefits to New York from these projects exceed the costs to NY, taking into account the federal transfer payment. Most likely, under these conditions none of these projects would have passed the NPV test.
7. B_t is composed of benefits per ride (in \$) times the annual ridership
8. Competitive equilibrium transportation impacts can be calculated by a network analysis. Such analysis was beyond the scope of this study.
9. This part of the analysis was developed mainly by the Boston Consulting Group, part of the team that carried out this study.
10. Source: Douglas Elliman Ql 2003 report.
11. There is no question that a more robust approach would be to model job growth and changes by sector. But, in addition to this being outside the charge of this work, the complexity of such modeling would be confounded by the rapidly shifting population, high levels of population immigration, and the lingering depressive impacts of 9/11. Nevertheless, as mentioned above, some sensitivity tests were performed on the rate of growth ridership. See footnote 5.
12. Moreover, since economic development benefits from a transportation investment are projected on the basis of its transportation benefits, the degree of uncertainty associated with the estimation of the latter benefits is necessarily much smaller than that associated with the former.
13. As explained in the text the analysis of environmental impacts was outside the scope of this study and, in any case, it is carried out as part of the federal requirement for capital funding.
14. The procedure is to divide the row of each table by the row's maximum score and multiply the result by 100. Notice that for some criteria the "best" score is the lowest value as, for example, is the case for negative NPV (a lower negative NPV of –\$1.0B is "better" than a –\$2.0B). In that case, for the normalization, the lowest score becomes the numerator, i.e., we divided it by each of the scores and then multiply by 100.
15. Thus, the weight for direct transportation benefits is 36.232%, for Other Transportation is 9.058% and for and Construction Period is 4.71%. Numerically, they were computed as: $[(50/50 + 12.5 + 6.5) + (12.5/50 + 12.5 + 6.5) + (6.5/50 + 12.5 + 6.5)] \times W$, where W is the total weight of the transportation benefits ($w = 50/100$).
16. As explained in Appendix A, its implementation is predicated on the construction of a major sport stadium on Manhattan's West side, as part of the planned 2012 summer Olympic games.
17. The works by Altshuler and Luberoff (2003) and Flyvbjerg et al. (2003) clearly demonstrate that the above capital costs and construction periods figures are in all probability unrealistic and will escalate well beyond their initial estimates.

18. A seminal report on the value of infrastructure, and its costs was presented to Congress in 1988, (National Council on Public Works Improvement 1988). This report is based on extensive research and hearings on the condition of the trillions of dollars of public works investments in the US since the early 1900s. This wake-up call has had marginal impact, as short term, rather than long-term funding solutions have remained the order of the day.
19. For the No. 7 line extension, the initial thought was to finance the entire capital costs through Tax Increment Financing (TIF). This was shown to be infeasible so more traditional, i.e., federal and state subsidies will be needed.

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About the authors

Joseph Berechman is a CN Chair Professor of Transportation Economics and Planning at the University of British Columbia, Canada. Dr. Berechman has received his Bachelor degree for the Hebrew University in Jerusalem, Israel, and his Master and Ph.D. degrees from the University of Pennsylvania in Philadelphia. His major research interests are transportation economics and planning, urban modeling and policy analysis. He has published numerous journal papers and four books, the most recent one on transportation investment and economic development. Presently, his major interests focus on the evaluation and selection of large scale transportation infrastructure investment projects.

Robert Paaswell currently serves as Director of the federally supported University Transportation Research Center, located at the City College of New York.

Paaswell has been named Director of the City University Institute for Urban Systems, a university-wide initiative to examine the intersection of new technology, changing institutional structure and innovative finance on the provision of infrastructure in the 21st Century. He serves as a Distinguished Professor of Civil Engineering. Previously he served as Executive Director (CEO) of the Chicago Transit Authority, the nation's 2nd largest transit company. Paaswell is extremely active in the area of public. He has reported on governance structures for U.S. Transit organizations, Public-Private issues in New York and Chicago, Labor Union/Management issues, and training for new technologies. He is currently working on Transit Investment Strategies and Innovative Transit System Design. He served as Chairman of the Board of the Transit Standards Consortium, and on the Boards of the Transportation Research Board and the Transit Cooperative Research Program. He has published widely. Paaswell is a Fellow of the American Society of Civil Engineers and a recipient of the USDOT Secretary's Medal for Superior Service.