FINANCIAL SIMULATION MODEL: ASSESSING PROJECT RISK AT THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

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ABSTRACT

Many firms approach the problem of evaluating the risk element of investment proposals in informal ways. A decision-maker will often express his assumptions about the key factors affecting future costs, revenues, and investment requirements in terms of single-point or "most-likely" estimates. On the basis of these most-likely estimates, the financial picture may look very bright. However, this picture depends on each of the most-likely estimates coming true in actuality, something that rarely occurs.

The authors of this paper have utilized a technique for incorporating the uncertainty of certain key assumptions into the financial planning and evaluation of an investment proposal. Future annual cash inflows and outflows are simulated and are used to evaluate a project in terms of three measures of overall financial feasibility. This paper describes the technique, which involves the construction of a computer simulation model, and outlines the application of this technique to an actual Port Authority investment proposal representing a potential capital outlay of $400 million.

INTRODUCTION

The Port Authority of New York and New Jersey is a self-supporting corporate agency of the two States. It was created as The Port of New York Authority in 1921 under the terms of a bi-state treaty, and given responsibility to plan, develop, and operate terminal, transportation and other facilities of commerce, and to improve and protect the commerce of the bi-state Port without burden to the taxpayer. In 1972, the Authority's name was changed to identify more accurately its status as a bi-state agency of New York and New Jersey.

The Port Authority is responsible for operation of six interstate tunnels and bridges, a regional system of four airports and two heliports, seven marine terminals, a bus terminal, two union motor truck terminals, the World Trade Center and a network of nine Trade Development offices. In addition, the Port Authority Trans-Hudson Corporation (PATH), a subsidiary of the Port Authority, has responsibility for operation of the PATH rapid transit system, which links Newark, Jersey City and Hoboken with lower and mid-Manhattan. In total, these facilities represent an investment of close to $4 billion.

In 1978 bi-state legislation was passed by both New York and New Jersey to enable the Port Authority to move into a new area of endeavor, industrial development. Actually, the passage of the legislation capped two years of preliminary planning. Part of the focus of these plans was on evaluating the economic feasibility of several inner city industrial parks, each of which was coupled with a resource recovery facility.

The Port Authority's traditional approach to evaluating the economic feasibility of a new project has been to weigh net revenues (gross revenues less operating and maintenance expenses) expected to be generated by the project, against debt service (equal annual payments based on capital costs) that would have to be paid on the investment. This computation is based on single-point or "most-likely" estimates for each of the key factors -- e.g., revenues, capital costs, inflation rates. This calculation is usually carried out for a single year, either a typical year or the first full year of operations. Implicit in this approach is the assumption that the cost and revenue flows will be relatively stable once full operation is achieved.

In a world where cost inflation rates often exceed revenue escalation, the traditional approach has proven to be less than adequate of late. Moreover, because the general area of industrial development is a new one for the Port Authority, and because there are so many uncertainties and complexities associated with developing and operating inner city industrial parks, it was decided during the planning process that the traditional approach to evaluating economic feasibility would not provide the decision-maker with adequate information on the project's risk/return trade-off. It was felt that what was needed was an approach that would combine the variabilities inherent in all the relevant factors, resulting in an evaluation of risk at each possible level of return. The objective of such a method is to provide the decision-maker with a clear picture of the relative risk -- i.e., the range of possible outcomes and the probable odds of financial success or failure in light of uncertain foreknowledge. Port Authority top management also wanted to know which of the many assumptions about the future made in the financial analysis were most critical and just how much the expected financial results would be affected by changes in those key assumptions.

It seemed clear that some sort of computer simulation would be necessary. Although the technique of computer simulation had never been used at the Port Authority for financial analysis, it had proved useful in operational analyses -- e.g., PATH train scheduling, airport passenger and baggage flow, and World Trade Center elevator systems. Hence, to meet current needs in the area of financial analysis, a study team comprised of staff from the Management Services, Planning and Development, and Finance Departments developed a financial simulation model to obtain the expected return and dispersion about this expected return for an investment proposal under specified assumptions. This model was used specifically for performing risk and sensitivity analyses on one of the proposed industrial park complexes. While similar approaches have been used in the private sector, this model represents, to our knowledge, one of the first uses of such an approach in the public sector.

METHODOLOGY

In general, the methodology is to assign values to each of a set of critical (basic) variables in accordance with assigned probabilities, and then to calculate annual revenue and cost flows over the project's life based on these values. The yearly cash flow data is then integrated into three measures of overall financial impact. This process is repeated a number of times to provide the basis for risk and sensitivity analyses.

The simulation model is composed of four basic components:

Selection of Basic Dynamic Variables

Monte Carlo Simulation

Revenue/Cost Generator

Measures of Financial Impact

In the following sections we describe these components in some detail and outline how they were applied to the Port Authority's industrial development project.

SELECTION OF BASIC DYNAMIC VARIABLES

The first step in building the model was to select input variables (BDV's) that fulfilled two basic criteria: (i) they were expected to significantly affect the outcome of the project; and (ii) they were believed to be subject to a significant degree of uncertainty. For the industrial park project, the following eight BDV's were chosen by a multidisciplinary study team:

1. Marketability Schedule - the number of years to market the industrial park to 100% capacity.
2. Resource Recovery Construction Schedule - the number of years to construct the resource recovery plant.
3. Revenue Inflation Rate - the annual rate at which Port Authority revenues escalate.
4. Cost Inflation Rate - the annual rate at which capital and operating costs escalate.
5. Resource Recovery Total Construction Cost - the uninflated total capital cost for constructing the resource recovery plant.
6. Ground Rent/Sq. Ft. - the annual ground rent per square foot of land to be charged by the Port Authority to tenants of the industrial park.
7. Tipping Fee - the amount in

dollars per ton that the municipality will contract to pay the Port Authority for disposal of its garbage.

8. Tenant Power Ratio - the proportion of resource recovery power output to be sold by the Port Authority to tenants of the industrial park. Any remaining power will be sold to the local utility.

These eight were judged by the study team as the most critical of over fifty variables identified in the formulas for calculating annual revenues and costs.

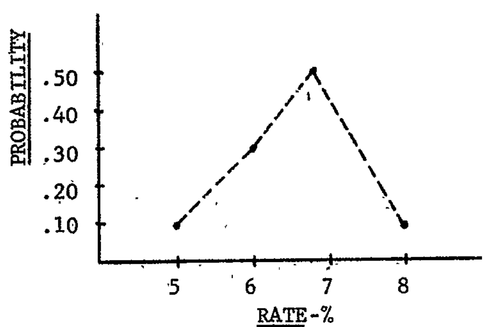
MONTE CARLO SIMULATION

Once the BDV's were selected, an uncertainty profile (probability distribution) was developed for each. Because of the subjective nature of this task and the need for detailed knowledge of the project, the uncertainty profiles were developed jointly by team members possessing expertise in financial, engineering and marketing areas. For the eight BDV's involved in our application, both normal (skewed and unskewed) and discrete distributions were permitted. Illustration 1 is an example of an uncertainty profile for "Cost Inflation Rate," one of the project's BDV's.

ILLUSTRATION 1

COST INFLATION RATE
UNCERTAINTY PROFILE

VALUE	PROBABILITY
5%	.10
6%	.30
6.75%	.50
8%	.10



Note: The above distribution is hypothetical.

Once the probability distributions were assigned, a Monte Carlo Simulation, utilizing a computerized random number generator, was performed. For each run, individual values for each of the BDV's were selected independently, based on their individual probability distributions, and random combinations of these BDV values were obtained, simulating future situations. For the Port Authority's industrial development project, 200 combinations were simulated to insure a statistically valid sample. (In order to obtain an error of no greater than $\pm .05$ in the Revenue/Cost Ratio (one of the measures of financial impact defined in a subsequent section), with a 95% confidence level, it was necessary to simulate 200 combinations.)

REVENUE/COST GENERATOR

Once the desired number of BDV combinations were formed, they were input, one set at a time, into the Revenue/Cost Generator (R/C Generator) program, which simulated the annual cash flows of the proposed project over its 30-year life. Based on the values of the BDV's, formulas contained within the R/C Generator calculated yearly revenues and costs associated with the construction and operation of the industrial park complex. Table 1 contains a list of the revenues and costs generated for our application.

For each of these revenues and costs, many of which were dependent on one or more of the BDV values selected, appropriate formulas were stored in the R/C Generator program. As an example, Land Selling Costs (in thousands of dollars) were calculated as follows. (Please note that the numerical values stated below are hypothetical.)

For Years 1 and 2:

$$Cost_1 = 400$$
$$Cost_2 = 350$$

For Years 3 to X:

$$Cost_i = \left[Cost_{i-1} - \frac{350-200}{X-2}\right] Y_i$$

where X is the first year of full occupancy (one of the BDV's) and Y_i is the appropriate cost inflation factor (another of the BDV's) for Year i.

For Years (X+1) to 30:

$$Cost_i = 50Y_i$$

TABLE 1

REVENUES AND COSTS

	Capital Costs	Operating Costs	Revenues
Land:	Stabilization Utilities Paving Landscaping Contingency Engineering Appraisal	Selling Insurance Security and Maintenance General Administration Payments in-Lieu-of Taxes	Ground Rent Government Aid
Buildings:	Construction	None*	Building Rent
Resource Recovery:	Construction	Operating and Maintenance Supplemental Fuel** Payments in-Lieu-of Taxes	Tipping Fee Fuel Sales Ferrous Metal Sales Government Aid

*It is assumed that tenants will pay for all Operating and Maintenance costs related to the buildings.

**It is assumed that power will be purchased from the local utility and provided to the tenants at a reduced cost until the resource recovery plant is operational.

After formulas such as the above were used to calculate all of the costs and revenues listed in Table 1, the R/C Generator produced output consisting of many sets of combined annual revenues and costs over the 30 years of the project's life.

MEASURES OF FINANCIAL IMPACT

The next task was to calculate financial measures for each set of revenues and costs generated in the previous step, which allowed runs of model to be compared easily. This task required that some criterion of financial success or failure be defined. Three measures were chosen as being the most suitable to our needs:

1. Present-Valued Revenue/Cost Ratio (R/C Ratio) - This measure is obtained by discounting all revenues and costs to present value using a projected cost of capital as the discount rate. The discount rate used in our case was 7.25%. The ratio is then calculated by dividing the cumulative present value of 30 years of net revenues (revenues minus operating costs) by the cumulative present value of capital costs. Stated as formula:

$$\text{R/C Ratio} = \frac{\text{P.V. All Revenues} - \text{P.V. All Operating Costs}}{\text{P.V. All Capital Costs}}$$

2. Internal Rate of Return (IRR) - This measure is obtained by computing the discount rate at which the cumulative present value of revenues equals the cumulative present value of total costs (capital plus operating).

3. Time-Valued Payback Year (TVP Year) - This measure indicates

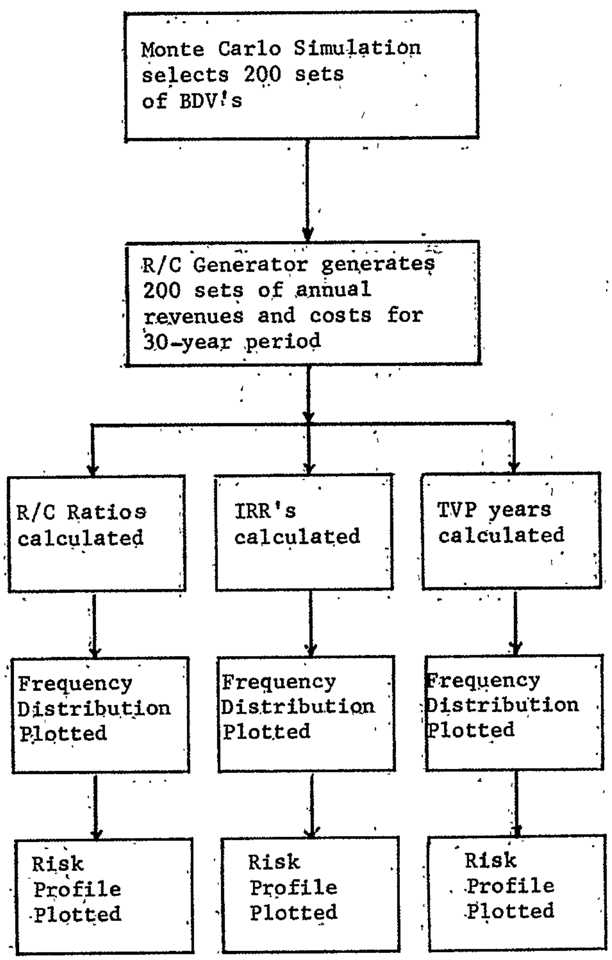
the first year in which the cumulative present value of revenues equals the cumulative present value of total costs -- i.e., the time at which the capital funds invested would be recovered through net revenue flows.

SIMULATION MECHANICS

Illustration 2 flowcharts the mechanics of the simulation used to perform the risk analysis.

ILLUSTRATION 2

RISK ANALYSIS MECHANICS

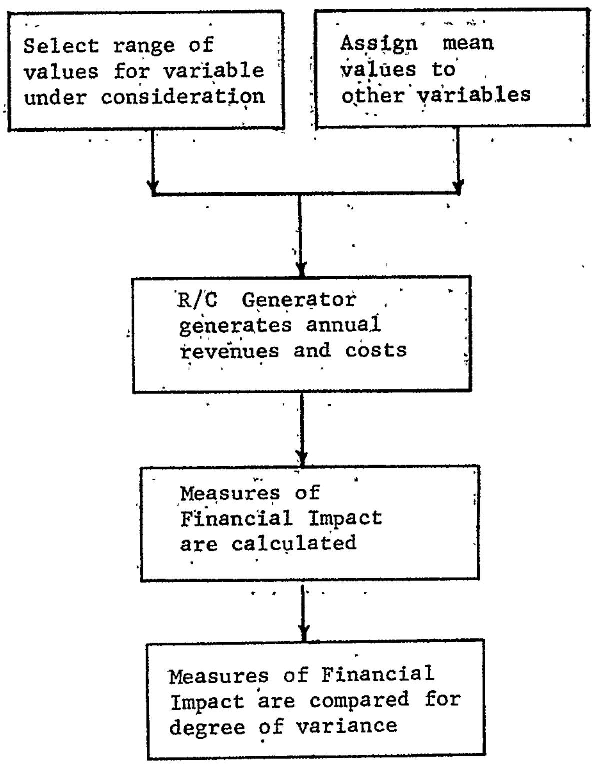


Once the model was iterated and the measures of financial impact calculated, frequency distributions and risk profiles were plotted for each of the measures. From the frequency distributions, it was possible to determine the expected (average) return of the project, and the dispersion (variability) about this expected return. The risk profiles -- or continuous probability distributions -- allowed management to ascertain the probability that the investment would provide a return greater or less than a certain amount.

In addition to plotting and analyzing the results of the 200 iterations, sensitivity analyses were performed to determine which BDV's were most critical to the project's financial outcome, as well as answering other "What-If" questions. The sensitivity analyses were performed by iterating the R/C Generator over the range of values for a single BDV, while holding the other BDV's constant at their mean values. The measures of financial impact were then calculated for each iteration and compared to determine the extent to which the individual variable would affect the results. Illustration 3 flowcharts the mechanics of the simu-

ILLUSTRATION 3

SENSITIVITY ANALYSIS MECHANICS



lation used to perform sensitivity analyses.

SIMULATION RESULTS

RISK ANALYSIS

The Financial Simulation Model was iterated 200 times in order to insure a statistically valid sample from which to predict the range of possible outcomes for the proposed industrial park complex. Illustration 4 is a frequency distribution for the range of values associated with the IRR of the project. (Please note that while the format used is the same, the numerical values presented here are purely hypothetical.) As shown in the illustration, the range of IRR values generated by the model approximates a skewed normal distribution around a mean of 14.15%, with a standard deviation of 3.824%.

The likelihoods of either achieving or bettering a specified IRR can be determined from the risk profile in Illustration 5. The risk profile shows about a 96% chance of achieving or bettering an IRR of 7.25% (the projected cost of capital), and about a 50% chance of achieving or bettering an IRR of 14.25%.

ILLUSTRATION 4

INTERNAL RATE OF RETURN FREQUENCY DISTRIBUTION

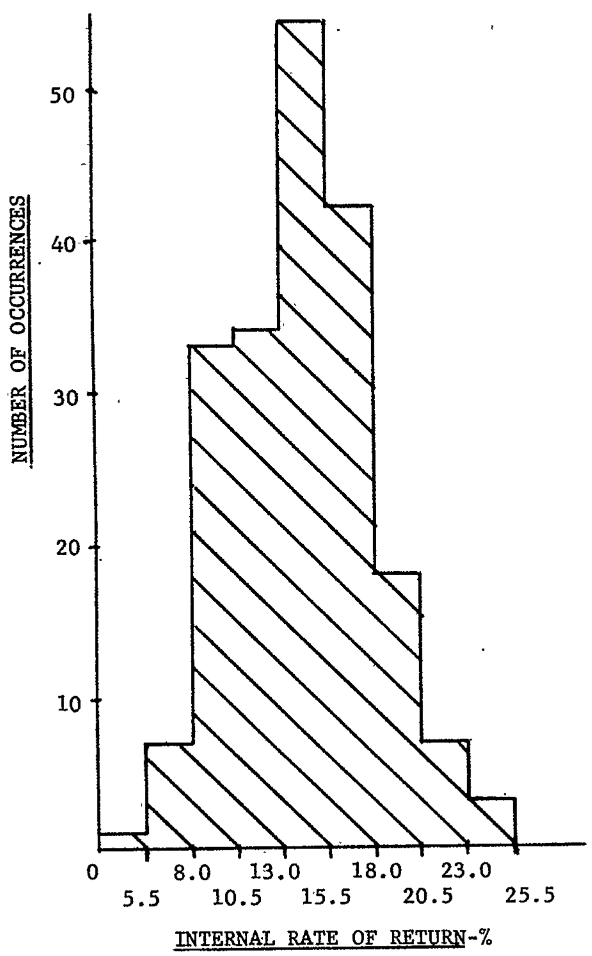
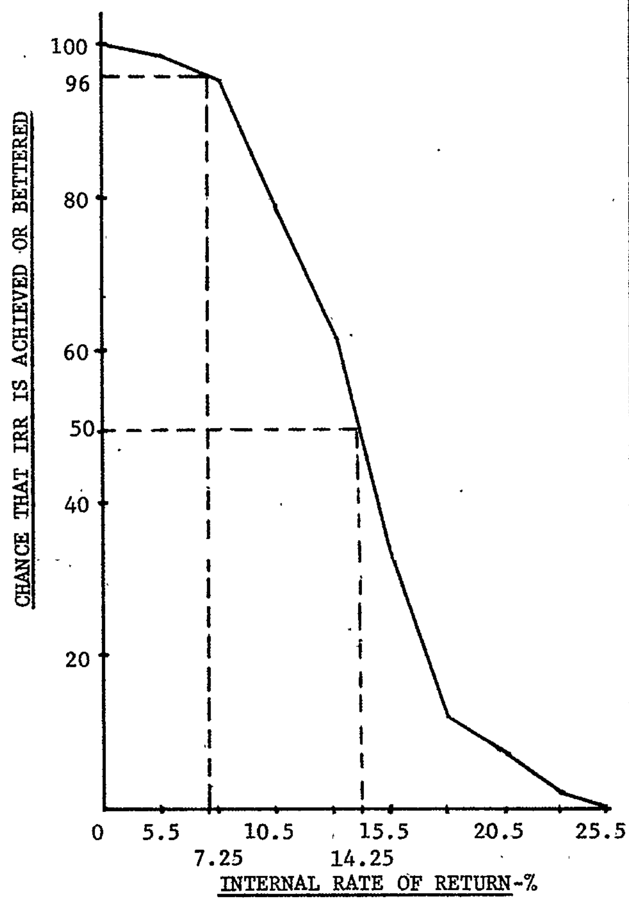


ILLUSTRATION 5

INTERNAL RATE OF RETURN RISK PROFILE



SENSITIVITY ANALYSES

Sensitivity analyses were performed for all eight of the chosen BDV's. In each case, the value of the variable under consideration was changed while holding the others constant at their mean values. The statistical range (the highest value minus the lowest value) of the resulting set of R/C Ratios was used as a measure of the relative impact of the variable on the project's outcome. The analyses identified for the decision-makers the factors that would most critically influence the financial feasibility of the project. In addition to the sensitivity analyses based on the BDV's, other assumptions were changed to provide answers to "What-If" questions. These included such changes as eliminating government aid, and not financing certain types of construction in the park.

Through the sensitivity analyses the relative importance of the different major variables was determined. More importantly, management attention was directed toward those critical factors which could be influenced through contractual agreements, controls or negotiations so that the financial results could be improved.

CONCLUSION

The Financial Simulation Model described in this paper represents a first attempt in the Port Authority to make explicit -- i.e., quantify -- the risk associated with a major capital investment proposal. The essential difference between the simulation method and the Port Authority's conventional approach to financial analysis is the fact that with the former, many combinations of values of the key variables are evaluated to determine the full range of possible outcomes. For project analyses like the one described, in which no single measure of return is typical or fully indicative of the total project's future prospects, and in which there are many uncertain elements, we believe that the simulation approach is superior to the conventional method. In addition to providing the decision-maker with important information on the risk/return trade-off of a specific project, it also generates insight that is valuable in determining appropriate courses of action for the implementation phase of the project. This is possible through sensitivity analysis and evaluation of alternate scenarios to determine the combination of conditions most favorable to the project's outcome.

Our specific application was widely accepted by both planners and decision-makers, who will continue to utilize the model for proposed projects. Moreover, among studies currently under way are a more detailed financial model for industrial development and resource recovery in which the number of variables will be greatly increased, and a risk analysis of the long-range financial plan of a complete Port Authority department.

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