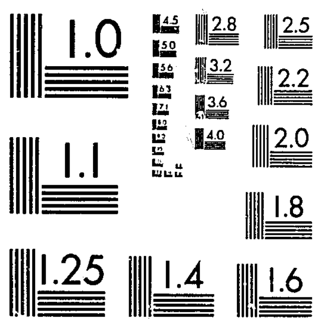

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USING STATISTICAL MODELS WHEN INTERPRETING PROBATION AGENCY PERFORMANCE: A BRIEF EXPLORATION OF QUEUEING THEORY, LINEAR PROGRAMMING, AND COST FUNCTION APPLICATIONS

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A performance measure is an instrument or indicator that can be used to describe how well an agency is operating. A performance measurement is the information or quantity ascertained for a specific agency for some specific time period. For example, the percentage of offenders who commit new offenses is a performance measure. An example of a performance measurement would be, 38% of the offenders on the caseload of probation agency A committed new offenses in 1981.

Standing alone, performance measurements simply describe what an agency achieves. They do not give the information needed to judge whether the performance achieved is adequate. For example, is a recidivism rate of 38% satisfactory or not? To judge how well an agency is doing, one must compare performance measurements with other information. This information may take the form of standards, goals or objectives, optimal or technically efficient performance levels, or the performance of other agencies.

Statistical models may generate the comparative information necessary to evaluate an agency's performance. This paper consider three models for developing this information--queueing theory, linear programming, and cost functions. Section one relates queueing theory to the timeliness of an agency's work products. Section two applies linear programming to the problem of comparing the effectiveness of one agency to another. Section three considers the feasibility of using production and cost functions to generate comparative information about an agency's efficiency. Each of these sections illustrates with probation agency examples the potential uses of the techniques.

I. The Timeliness of an Agency's Work--An Application of Queueing Theory

The first statistical model considered, queueing theory, is applied to a single important activity of probation agencies--investigating offenders before the judge sentences them. Pre-sentence investigation is a probation agency activity that needs to be completed in a timely fashion so that the judge can sentence the offender without undue delay. Suppose that the agency has a standard that a pre-sentence investigation should be completed within one month after being assigned to a probation officer. Queueing theory can help in evaluating agency performance in three ways. First, it can help determine the staffing requirement to comply with this one-month standard. Second, it can generate a reasonable standard, given an agency's actual staffing allotment and pre-sentence investigation workload. Third, it can provide a utilization index to alert the chief probation officer that completion time will not meet the standard and that he/she will need to take corrective action.[1]

A. Determining Staffing Requirement to Meet the One-Month Standard

Assume that judges direct that the probation agency conduct pre-sentence investigations on about 18 offenders a month. The investigative assignments in this example are not bunched at either the beginning or end of the month, nor are they spread evenly throughout the month. Instead, they occur on a random basis. What investigation rate is required to complete these investigations within the one-month standard? Intuitively, one might think that if 18 assignments are made during a month, a rate of 18 investigations would be the correct number to avoid creating a backlog of investigations. Because the assignments do not arrive at a uniform rate, however, and because the investigations vary in the amount of time required to complete them, a backlog

would build indefinitely if the assignment and investigation rates were equal.

The simplest queueing model assumes that the arrival of assignments can be adequately described by a mathematical distribution called the Poisson and that the time required to do the investigations can be adequately described by the exponential distribution. We can use these two distributions to estimate, assuming varying assignment rates or investigation rates, the expected time to complete a pre-sentence investigation. The equations below estimate that, with an arrival rate of 18, an investigation rate of 20 would be required to keep the expected wait plus the investigation time within the one-month standard.

Let the mean assignment rate = λ = 18, and

the mean investigation rate = μ = 20.

Then the number of offenders being investigated = $\lambda/(\mu-\lambda)$ = 18 (20-18) = 9,

the number of offenders waiting to be investigated = $\lambda^2/(\mu(\mu-\lambda))$ = 18^2 (20 (20-18)) = 324/40 = 8.1,

the length of time that it takes to complete the investigation once it begins = $1/(\mu-\lambda)$ = 1/(20-18) = .5 month, and

the length of time that the offender waits before the investigation begins = $\lambda/(\mu(\mu-\lambda))$ = 18/(20 (20-18)) = 18/40 = .45 month.

The expected waiting time of .45 month plus the investigation time of .5 month is .95 month, within the standard set of one month.

B. Generating a Reasonable Standard

Suppose that the agency is given enough resources to complete pre-sentence investigations at a rate of 20 per month. Our previous estimate indicates that with these resources the one-month standard is a reasonable basis against which to evaluate the agency's performance, provided the assignment rate in fact averages 18 a month. If, however, the assignment rate is more than 18 a month, the one-month standard is not a fair comparison unless the agency receives additional resources, permitting it to increase its investigation rate. If additional resources are unavailable, then new standards need to be developed to evaluate the agency's performance. The same equations described above can be used to generate these standards, based upon the waiting time plus investigation time expected for various assignment rates. Table 1 suggests reasonable standards for four different arrival rates. One can see that investigation plus waiting time increases dramatically as the arrival rate approaches the investigation rate.

Table 1

Completion Time Standards for Various Assignment Rates, Given a Fixed Investigation Rate of 20 Offenders per Month

Assignment Rate	Investigation Rate	Number of Offenders Being Investigated	Number of Offenders Waiting to Be Investigated	Expected Investigation Time (months)	Expected Waiting Time (months)	Reasonable Standard for Workload Compared to Available Resources (months)
18	20	9	8	.5	.45	.95
19	20	19	18	1	1.05	2.05
19.5	20	39	38	2	1.95	3.95
19.8	20	99	98	5	4.95	9.95

C. Alerting the Chief Probation Officer to Take Corrective Action

Assume that the probation agency is operating under a mandate to complete pre-sentence investigations within one month. Further assume that the chief probation officer wants to allocate the minimum staff effort to meet this one-month standard and that he has discretion in allocating probation-officer

effort between the pre-sentence investigation activity and other activities, such as supervision of offenders on probation. From Table 1, one can see that the utilization rate (assignment rate divided by investigation rate) required to achieve the one-month standard is .9. By monitoring the utilization rate, the chief probation officer could increase or decrease the investigation rate each month to keep his/her agency's performance within the one-month standard.

II. Comparing Performance Among Agencies--An Application of Linear Programming

Performance measurements most usefully indicate how well an agency is performing when measurements can be compared with each other. While comparisons can be made against an agency's previous track record or against standards or goals, many observers of corrections agencies have a keen interest in comparing performance measurements across agencies. The great diversity of corrections agencies, both in terms of what these agencies do and what they intend to accomplish, requires that one exercise special care when making interagency performance comparisons. Interagency performance comparisons are most appropriate when these conditions are present:

(1) When process measurements are used to compare performance, agencies share common <u>processes</u>.

(2) When <u>efficiency</u> or product measurements are used, agencies share common work <u>products</u>.

(3) When <u>quality</u> measurements are used, agencies should share common <u>service characteristics</u>.

(4) When <u>equity</u> measurements are used, potential client groups are similar.

(5) When <u>effectiveness or cost-effectiveness</u> measurements are used, the types of <u>outcomes</u> expected are similar among agencies that are compared to each other.[2]

(6) Agencies use the same definitions, data collection and reduction procedures, and measurement display formats.

(7) Data collection and reduction techniques are practical and relatively cheap.

(8) Agencies have an opportunity to explain unusual situations.

(9) Timely data collection and reporting occurs.[3]

Even when all these conditions are present, additional information may be needed before one agency's performance can be fairly compared to another's. Linear programming may be especially helpful for developing appropriate comparisons among agencies that operate under different laws, procedural regulations, or resource constraints.[4] Consider the case of two probation offices that share common processes. Both offices conduct pre-sentence investigations and supervise offenders placed on probation. In both offices, supervision consists of some contacts with probationers that are made in the field and other contacts that are made in the probation office. Both chief probation offices have the problem of deciding how to allocate the effort of their probation officers among pre-sentence investigations, field contact, and office contacts. Each chief wants to allocate the time of his/her officers in the way that will best achieve the goals of his/her office. Although the same processes, goals, and total resources may be available to each chief, the optimum allocation of probation officers' time may be different when the offices must operate under different regulations or laws. A direct comparison of performance measurements between the two offices (e.g., the percentage of offenders who complete their probation term without violation) would fail to recognize the different constraints under which the two offices operate and would be unfair to the office operating under the greater set of constraints.

To illustrate this point, we make the following assumptions about the available resources, efficiency, effectiveness, and decision rules of two probation offices, A and B:

1) Both offices have the same size staff and the same number of officer hours a month that can be allocated among the investigation and supervision activities (2200 hours).

2) Both offices are equally efficient in conducting their investigation and supervision activities. The average time requirements are 6 hours to complete a pre-sentence investigation, 2 hours for a contact made in the field, and 1 hour for a contact made in the office.

3) Both offices are equally effective in translating their activities into goal attainment. Further, for both offices, the relative importance of the three activities toward goal attainment is that an office contact contributes twice as much as a pre-sentence investigation and a field contact contributes 5 times as much as a pre-sentence investigation. (We ignore, for the moment, how this relative importance was determined.)

4) Both offices have the same caseload and the offenders in their caseloads have similar characteristics. Each month an average of 100 new cases is added and 100 cases are terminated. The total average caseload is 1100.

5) For new offenders, the first contact for both offices must be in the office, not the field. All offenders must be contacted at least once a month, either in the office or the field.

6) An average of 150 offenders are sentenced each month. Probation office A is in a jurisdiction where the judges require pre-sentence investigations for all offenders before sentencing. Probation office B is in a jurisdiction where the judges require pre-sentence investigation on only about one third of the offenders before sentencing.

Keeping in mind these assumptions, we can use linear programming to develop a fair basis for comparing the performance of two offices that differ only in the pre-sentence investigation requirement. We want to maximize goal attainment (say, the percentage of offenders completing their probation term without violations), taking into account the resource and policy constraints enumerated above. The objective function to be maximized is

$$\text{Maximize goal attainment} = 2X_1 + 5X_2 + X_3,$$

where X_1 = the officer hours allocated to office contacts, X_2 = the hours allocated to field contacts, and X_3 = the hours allocated to pre-sentence investigations. The coefficients are the relative weights described in assumption 3) above.

This objective function is subject to the following constraints for probation office A:

a) $X_1 \geq 100$ (all the new cases must be contacted in the office the first month)

b) $X_1 + X_2 \geq 1100$ (all cases must be contacted at least once during the month)

c) $X_1 + 2X_2 + 6X_3 \leq 2200$ (the effort devoted to all three activities must not exceed 2200 hours during the month)

d) $X_3 = 150$ (all 150 offenders must be investigated before sentencing).

The optimal allocation of officer effort under these constraints is the following:

a) Spend 100 hours on office contacts for new cases.

b) Spend 900 hours on investigations of 150 offenders. ($X_3 = 150$)

c) Spend 400 hours on 200 field contacts. ($X_2 = 200$)

d) Spend 800 hours on 800 office contacts. (X_1 = 100 from a) + 800 from d)

By changing constraint d) to $X_3 = 50$, the optimal allocation for probation office B would be the following:

a) Spend 100 hours on office contacts for new cases.

b) Spend 300 hours on investigations of offenders. ($X_3 = 50$)

c) Spend 1600 hours on 800 field contacts. ($X_2 = 800$)

d) Spend 200 hours on 200 office contacts. (X_1 = 100 from a) + 200 from d)

While each office would have made the best possible allocation within its set of constraints, the differing constraints mean that agency A cannot under our assumptions be as effective in attaining its goal as can agency B. We can substitute the hours allocated into the objective function for each office to compare their relative optimal effectiveness:

$$\text{Maximize goal attainment} = 2X_1 + 5X_2 + X_3$$

$$\begin{aligned}\text{Max (office A)} &= 2\ (900) + 5\ (200) + 150\\ &= 1800 + 1000 + 150\\ &= 2950\end{aligned}$$

$$\begin{aligned}\text{Max (office B)} &= 2\ (300) + 5\ (800) + 50\\ &= 600 + 4000 + 50\\ &= 4650\end{aligned}$$

The optimal effectiveness for office A is only about 63% (2950 ÷ 4650) of that for office B. Thus, it is not fair to office A to expect that its effectiveness should equal B's and to make a direct comparison between the performance of the two offices. Their different constraints suggest that the two offices should be operating against different effectiveness standards and, further, that the standard for office A should be set at about 63% of the standard for office B.

Two additional comments are pertinent to this application of linear programming. First, a simple measure based upon these results can be constructed to guide the chief probation officer when allocating officer time between field and office contacts. For office A, the optimal allocation would be 900 office contacts to 200 field contacts or 82% (900/1100) of the contacts made in the office. For office B, the optimal allocation would be 27% (300/1100) of the contacts made in the office. Thus, on a monthly or weekly basis the chiefs can guage the extent to which they are maximizing goal attainment by comparing the actual percentage of contacts made in the office to the optimal percentage (82% and 27% for offices A and B, respectively). Whenever any of the constraints change, it is easy to use linear programming to reestimate the optimal percentages.

The second comment concerns assumption 3), stipulating the relative contribution of each activity toward attaining the goal. Determining these relative contributions is not a simple matter. One method of estimating the relative contributions empirically would be through a two-stage production function.[5] In the first stage, the agency's outputs would be estimated. In the second stage, these outputs would be entered as independent variables along with other influencing variables to estimate the outcomes or goal attainment. The coefficients of these independent variables in the second-stage production function could be used to develop weights reflecting the relative importance of the activities toward goal attainment.

Decision theory provides two other methods of estimating the activities' relative contributions to goal attainment. Both these methods are subjective, depending upon the judgment of knowledgable individuals for setting the relative weights. Multiattribute utility theory is an analytic approach to eliciting these judgments.[6] Social judgment theory is a holistic approach for achieving the same end.[7]

III. Efficiency--An Application of Cost Functions

Technical efficiency means producing the maximum output from a given input bundle. This concept can be applied to corrections agencies to estimate the reduction in cost possible if technical efficiency prevailed. Assume, for example, that the cost at optimum efficiency (i.e., the cost of operating under the condition of technical efficiency) of a corrections agency is equated to 100%. Cost comparisons based on this concept could be made as illustrated below for hypothetical agencies.

Optimal cost	100%
Agency A cost compared to optimum	114%
Agency B cost compared to optimum	108%

Applied to some processes, this concept is relatively straightforward.[8] For example, in examining the efficiency of steam-electric generating plants, Schmidt and Lovell[9] have a single output--electricity generated. Their production function includes three inputs--capital, fuel, and labor. Inputs and the output are measured as follows:

Capital	- actual cost of plant
Fuel	- actual consumption measures in BTU
Labor	- design labor force measured in total employee man-hours (total employees x 2000)

Finally, they assume a Cobb-Douglas functional form for the production function: $y = a\prod_{i=1}^{n} X_i^{\alpha_i} e^{\varepsilon}$, where y is the amount of electricity generated by a plant, the X_i are the capital, fuel, and labor used in the production process, ε is a random disturbance, and a and the X_i's are parameters to be estimated.

Before such a procedure is applied to correctional agencies, several questions need to be answered. These questions are raised below within the context of probation agencies.

Suppose that we agree that the output for probation agencies is supervision and that the quantity of supervision can be measured by the number of offenders on probation times the number of days that each is on probation. If we assume three inputs, labor (measured in employee man-hours), capital (measured as actual cost of facilities used), and material (actual cost of equipment, supplies, and travel), we can assume a theoretical model of probation production as follows:

Quantity of supervision = f (labor, capital, material)

We might then wish to assume Cobb-Douglas to be the form of this production function, as was the case for the electric generating plants. By measuring the labor, capital, and material consumed by different probation agencies and the quantity of supervision produced by each, we can use this production function to determine which agency is most technically efficient.

The first question that needs to be raised is, "is this finding of the most technically efficient program useful to anyone?" To assume either that it is "good" per se to be technically efficient or that the technically inefficient agencies ought to emulate the technically efficient agencies requires that we agree on two points. The first point of agreement is that the three inputs, as measured, adequately capture the important aspects of the probation process. A second point upon which we must agree is that quantity of supervision adequately captures probation output. Given this formulation of the probation production function, it seems obvious, even before going to the expense of collecting data, that the efficient probation agencies will be those with the greatest number of probationers per probation employee. Would not a finding that "the larger the caseload per probation employee, the more efficient is the organization," be trivial?

It may be argued that "quantity of supervision" does not capture important qualitative variation in the outputs of different probation agencies. This argument is especially relevant when the audience for the research is concerned both with technical efficiency and with allocative efficiency (whether the marginal benefit is equal to the marginal cost and output is produced at the lowest cost). The results of benefits that may accrue from X days of supervision--e.g., employment stability and abstention from criminal activity by the offender--may differ markedly, depending upon the nature of the supervision and supporting services rendered. Most advocates of correctional reform advocate changes in agency processes, not because they are interested in technical efficiency, but because the nature of the process is believed to affect the quality of the output and the impact of the agency upon the offender directly and society indirectly. If this concern is to be addressed, then it will probably be necessary to enrich the production function by including a vector of output quality attributes.

It may also be argued that the measures for labor, capital, and material do not capture important process differences between agencies. These variables define the quantitative combinations of the three inputs but they do not describe how the inputs are combined. Once technical efficiency has been determined for a group of agencies, using an output variable standardized for quality, the question, "Why is agency X technically inefficient?" needs a more informed answer than "it uses too much labor" or "it uses too little labor." The quality of the output can be affected by the way resources are used, not simply the quantity and proportions of the three inputs used.

The nature of the probation process is important for understanding why certain inputs lead to certain outputs. Understanding the process is important in order to include the appropriate quality attributes in the production function.

By developing frontier production functions we can obtain a standard of technically efficient production and can measure the relative efficiency of individual agencies against this standard. Even if the frontier production function can be appropriately specified, though, the computer programming is likely to be complex and the developmental work is likely to be time consuming and expensive.[10]

Instead of production functions, we can address the problem of making efficiency comparisons by using cost functions if certain conditions hold.[11] To develop an average cost function for probation agencies, the conditions required are the following:

1) The probation agencies included share common processes.
2) The number and types of offenders are determined by someone outside the probation agency.
3) The prices of the resources consumed by the probation agency (e.g., labor, office expenses, travel costs) are determined outside the probation agency.

These conditions seem most likely to hold for probation agencies within a single state corrections system.

Based upon the findings from research on cost functions for prisons[12] and upon our understanding of probation agencies, these variables seem important to consider in developing the cost function:

1) the quantity of outputs, such as the sum of the number of days offenders are supervised and the number of pre-sentence investigations;

2) indicators of output quality, such as the level of supervision provided, number of investigations conducted, number of referrals for services, number of regular terminations, the average caseload size;
3) offender characteristics, such as prior criminal record and severity of the offense;
4) staff characteristics, such as number of years of probation experience and turnover rate;
5) the prices of inputs, such as staff salaries, office, and travel.

For the cost function, cost is the dependent variable rather than output, as is the case for the production function. A preference for using cost rather than production functions should be based not only upon the conclusion that cost functions are easier to use but also upon the conclusion that they are theoretically more (or at least equally) appropriate. Cost functions are more appropriate when a probation agency has more control over its costs than over its outputs. It seems reasonable to conclude that the probation agency does have more control over costs than outputs. For the judge, not the probation agency, decides how many pre-sentence investigations must be conducted, how many offenders are placed on probation, and the length of their probation term. Although probation agencies have no control over the prices of inputs, they do have some control over what they purchase within their budget allotments and they have more control over how efficiently they use these inputs.

Cost functions that include vectors of variables capturing output quality, offender and staff characteristics, as well as output quantity and prices of inputs, may be helpful in comparing costs across agencies. It would be possible to estimate the effect that these other variables have upon probation agency costs. Probation agencies with similar cost-influencing characteristics could then be compared with each other instead of with the average cost for all agencies.

Summary and Conclusion

This brief exploration suggests that all three modeling techniques--queueing theory, linear programming, and cost functions--are potentially useful in developing comparative data for interpreting performance measurements. The three techniques are not substitutes for one another, however. Each affords different insights into agency performance.

Queueing theory focuses upon single activities and can be used to develop reasonable standards for time to complete those activities and agency capacity. It is the easiest of the three models to use. The model applied in this paper requires little data and only a few hand calculations. A disadvantage of queueing theory is that the mathematical model may not adequately represent the behavior of the offender and the probation officer. When that is the case, Wagner[13] recommends that the model be used to gain insight into agency operations and followed by computer simulation of the activity when precise results are required. Taha,[14] however, points out that simulation is a statistical experiment that is costly, complex, and takes a long time to carry out. Taha suggests that a more appropriate course would be to increase the class of problems that can be analyzed by queueing models by taking "advantage of the possibility that certain assumptions of available queueing models can be violated without resulting in considerable error in the system's measures of performance."[15]

Linear programming provides insight into what operational constraints cost society in terms of benefits or effectiveness sacrificed. As with queueing

theory, it can be applied to a single agency but can also be used to make performance comparisons across agencies. Linear programming requires more data than queueing models. Some linear programming models can be solved by hand, but most are better handled by computer. The assumptions upon which linear programming is based are the following:

1) Allocations of resources to activities are made under conditions of certainty.
2) Variable inputs and outputs are divisible.
3) Activities can be added together.
4) Relations between variables are proportional (i.e., constant returns to scale).

These assumptions seem to be reasonably well met in the application explored in this paper.

Cost functions can be used to make efficiency comparisons and provide insight into which variables have the greatest effect upon cost. Cost functions require multiple observations of an agency over time, observations over many agencies, or observations over several agencies over time. The amount of data required and the complexity of the statistical modeling makes it the most costly of the three techniques to use. Cost may be the most serious hindrance to its usage.

Footnotes

[1]Good introductions to queueing theory for public administrators are included in these three books: Jack Byrd, Jr., Operations Research Models for Public Administration (Lexington: Lexington, 1975), pp. 198-208; Harvey M. Wagner, Principles of Management Science with Applications to Executive Decisions, 2nd Ed. (Englewood Cliffs, N.J.: Prentice-Hall, 1975), pp. 490-539; Michael J. White, et al., Managing Public Systems: Analytic Techniques for Public Administration (North Scituate, Mass.: Duxbury, 1980), p. 224-244.

[2]Definitions for the terms underlined in these five conditions may be found in Measuring Corrections Performance (Raleigh, N.C.: The Osprey Company, 1980), pp. 148-150.

[3]Conditions 6 through 9 were adapted from Paul L. Dressel, Handbook of Academic Evaluation (San Francisco: Jossey-Bass, 1976), p. 92.

[4]A good overview of linear programming for public administrators may be found in Edith Stokey and Richard Zeckhauser, A Primer for Policy Analysis (New York, Norton, 1978), pp. 177-200. A more mathematical but still readable treatment is in Claude McMillan, Jr., Mathematical Programming: An Introduction to the Design and Application of Optimal Decision Machines (New York, John Wiley, 1970), pp. 1-77.

[5]For this idea I am indebted to Ann D. Witte, Associate Professor of Economics, University of North Carolina at Chapel Hill.

[6]Explanations of multiattribute utility theory may be found in Ward Edwards and Marcia Guttentag, "Experiments and Evaluations: A Reexamination" in Carl A. Bennett and Arthur A. Lumsdaine (eds.), Evaluation and Experiment: Some Critical Issues in Assessing Social Programs (New York: Academic Press, 1975); Ward Edwards, Marcia Guttentag, and Kurt Snapper, "A Decision-Theoretic

Approach to Evaluation Research" in Elmer L. Struening and Marcia Guttentag (eds.), Handbook of Evaluation Research, Vol. 1 (Beverly Hills: Sage, 1975); Ralph L. Keeney and Howard Raiffa, Decisions with Multiple Objectives: Preferences and Value Tradeoffs (New York: John Wiley, 1976).

[7]Applications of this approach are described in Leonard Adelman, Thomas R. Stewart, and Kenneth R. Hammond, "A Case History of the Application of Social Judgment Theory to Policy Formulation," Policy Sciences, Vol. 6 (1975), pp. 137-59; Kenneth R. Hammond, John Rohrbaugh, Jeryl Mumpower, and Leonard Adelman, "Social Judgment Theory: Applications in Policy Formation" in Martin F. Kaplan and Steven Schwartz (eds.), Human Judgment and Decision Processes in Applied Settings (New York: Academic Press, 1977), John Rohrbaugh and Paul Wehr, "Judgment Analysis in Policy Formation: A New Method for Improving Public Participation," Public Opinion Quarterly, Vol. 42 (1978), pp. 521-32.

[8]For an introduction to the theory of production and cost functions see Thomas H. Naylor and John M. Vernon, Microeconomics and Decision Models of the Firm (New York: Harcourt, Brace and World, 1969), pp. 70-108.

[9]Peter Schmidt and C. A. K. Lovell, "Estmating Technical and Allocative Inefficiency Relative to Stochastic Production and Cost Frontiers, Journal of Econometrics (1979).

[10]Ann D. Witte, "Empirical Investigations of Correctional Cost Functions," report to the National Institute of Law Enforcement and Criminal Justice, U. S. Department of Justice on LEAA Grant No. 78-NI-AX-0059, November 24, 1979.

[11]William N. Trumbull and Ann D. Witte, "Determinants of the Cost of Operating Large Scale Prisons with Implications for the Cost of Correctional Standards," (unpublished manuscript, 1980).

[12]William N. Trumbull and Ann D. Witte, op cit.; Ann D. Witte, op cit.

[13]Wagner, op cit, p. 528.

[14]Hamdy A. Taha, "Queueing Theory in Practice," Interfaces, Vol. 11:1 (February 1981), pp. 43-49.

[15]Taha, op cit, p. 48.

END