DETERMINANTS OF THE COSTS OF OPERATING LARGE-SCALE PRISONS WITH IMPLICATIONS FOR THE COST OF CORRECTIONAL STANDARDS

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This paper explores the determinants of the costs of prisons. An economic model relates cost to output, input prices, and a number of variables controlling for differences in the type of outputs and inputs for each prison. Data from the federal prison system are used to estimate the model. Our results indicate that a minimum-cost prison would be quite large (1,000 to 1,600 inmates) and that the improvement of some correctional standards (e.g., single-bed cells, more living space) may serve to decrease rather than increase prison operating costs.

I. INTRODUCTION

This paper analyzes the determinants of prison costs. We explore the ways costs are affected by the price and type of labor and capital utilized, type of inmate, rehabilitative activities, security arrangements, prison size, and other prison characteristics. We assume that costs are a function of prison output, the prices of inputs, and a number of variables controlling for differences in output and inputs (e.g., rehabilitative activities, staff characteristics, etc.). Using Federal Bureau of Prisons data, we estimate a specific, but fairly general, cost function. From the estimated coefficients of this cost function, we are able to determine how various factors

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affect costs and then estimate the cost effects of a number of possible prison arrangements.

We believe that our results will be of interest to prison administrators and other decision makers. They provide information on the way costs vary with prison size, type of inmates incarcerated, and type of staff and facilities. Findings regarding the way prison costs vary with size may be particularly relevant given the recent rapid growth of prison populations,[1] their projected growth at least until the mid 1980's,[2] and the resulting need for new facilities.[3] In June, 1977, there were almost 21,000 more prisoners in state and federal prisons than the rated capacities of these facilities (Rutherford *et al.*, 1977: 107). In response to this overcrowding and to expected further increases in population, state and federal prison systems planned to increase capacity by over 67,000 beds, at a cost of over $1 billion, between June 30, 1977, and December, 1982 (Rutherford *et al.*, 1977: 120).

Currently, decisions regarding the size of prisons are made primarily on the basis of prevailing correctional philosophy; cost considerations seem to have little impact. The failure of decision makers to consider costs does not stem from a lack of interest in such considerations, but rather from a lack of appropriate data and analyses. For example, the California legislature asked the California Department of Corrections to "compare and analyze the program benefits and cost effectiveness of small, medium and large institutions" (California Department of Corrections, 1978, Vol. II: 1). After reviewing their own data, consulting professional associations and organizations, and convening a colloquium of correctional experts, the Department concluded:

> We found that there are no data on the cost effectiveness of different sized institutions. The current consensus on the need for small institutions was developed on other than cost effectiveness considerations (California Department of Corrections, 1978, Vol. II: 173).

The General Accounting Office has suggested that cost considerations should be a factor in construction planning in the federal prison system as well (Comptroller General of the United States, 1976).

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[1] From Dec. 31, 1973, to Jan. 1, 1978, the number of prisoners in state and federal institutions increased by 40 percent (U.S. Department of Justice, 1977; Serrill *et al.*, 1978).

[2] See Rutherford *et al.* (1977) or Blumstein *et al.* (1970) for discussions.

[3] Many current policy changes appear likely to increase rather than decrease the size of prison populations. For example, Petersilia and Greenwood (1978) conclude that the current trend toward determinate sentencing will serve to further increase prison populations.

We believe our research may also be useful in future judicial decisions affecting the way prison systems operate, particularly the imposition of correctional standards. Federal and state courts have been quite active in setting prison standards; the best known case is *James* v. *Wallace* (1976), which set detailed guidelines for the operation of the Alabama prison system.[4] Unfortunately, the courts have been forced to judge correctional standards with very limited knowledge of the economic costs of their decisions.[5] We pay particular attention in this paper, therefore, to factors likely to be affected by the judicial imposition of standards on prison systems.

In section II, we survey the existing literature on the determinants of correctional costs and the cost of correctional standards. In section III we describe selected portions of three sets of standards currently advocated for prisons. In section IV, we develop a model for the determinants of prison costs. The two following sections contain our discussion of the data we use to estimate our model and the empirical measures which we use to represent our theoretical variables. In section VII, we present and discuss our empirical results. The final section contains our summary and conclusions.

II. THE LITERATURE ON PRISON COSTS

There are few analyses of the costs of prison operations.[6] So far as we are aware, only four recent studies (McGuire, 1978; McGuire and Witte, 1978; Block and Ulen, 1979; Witte *et al*., 1979) have explored factors affecting the cost of operating prisons. The studies provide valuable insights, but they are only a beginning and can be usefully extended. The earlier studies fail to consider important factors likely to affect prison system costs. For example, they include only a limited number of inmate characteristics, and they fail to include input quality variables in their cost functions. A number of policy-relevant variables (e.g., type of facilities) are frequently omitted. The most interesting finding of these studies is that costs per inmate appear to decline until prisons become fairly large and then increase for prisons of substantial size.

[4] For detailed discussions of court cases in this area see Prigmore and Crow (1976), Feldberg (1977), Ducote (1977), or Haas (1977).

[5] See Finkelstein (1978) for a discussion of court use of statistical material.

[6] However, a number of studies have attempted to project prison costs. These studies usually simply extrapolate past costs. See, for instance, Blumstein *et al*. (1970); Blumstein (1975); Hann *et al*. (1975); Tabasz (1975).

As existing analyses of prison costs fail to include major factors likely to be affected by prison standards, these studies provide few insights concerning the potential effects of improving such standards. We are aware of only one attempt to estimate the cost of corrections standards (Singer and Wright, 1975). However, since this study preceded studies of the determinants of prison costs, it was forced to make relatively simple assumptions concerning these costs. Specifically, it assumed that prison construction costs depend only on the number of beds and the level of security—and implicitly, that annual capital costs per bed will not vary with prison size. The first assumption ignores the fact that architectural style, layout (e.g., centralized *vs.* dispersed support facilities), cell size, and other factors are likely to affect construction costs. Recent work on the determinants of prison cost suggest either that the second assumption may be seriously in error or that operating costs other than capital costs vary markedly with the size of prison (for example, see Witte *et al.*, 1979).

In this paper we seek to synthesize and extend this work. Specifically, we develop a specification of prison cost function which is based on economic theory and on our experience working in three prison systems (federal, California, and North Carolina). This theory, and an extensive data set for the federal prison system, allows us to estimate models which include many more cost-relevant variables than had been possible in previous studies. We are careful to include variables which are likely to be affected by the imposition of improved correctional standards.

III. EXISTING STANDARDS FOR PRISONS

In this paper we will concentrate on assessing the way in which total prison operating costs are likely to be affected by major standards espoused by the National Advisory Commission on Criminal Justice Standards and Goals (1973), in *James* v. *Wallace* (1976), and by the Commission on Accreditation for Correction (1977). We believe that these standards have had the most wide-ranging effects and are likely to be viewed as minimum standards in the future. The *James* v. *Wallace* standards have the force of law in the Alabama system. They have served as an example for prison cases in other states. They will probably continue to affect the actions of systems seeking to avoid litigation. The Commission on Accreditation for Correction is leading a nationwide effort, through accreditation, to make all state and federal prisons conform to its minimum standards. The National Advisory Commission's standards tend to be the most generous to the inmate and have the influence of the federal government and a prestigious advisory commission behind them.

Table 1 summarizes the major standards which we will attempt to evaluate in this study. Most of these standards relate to the quality of physical facilities—what we later call "capital quality." Specifically, these standards relate to the overall size of the prison (500 inmates or unspecified), cell size (60 to 80 square feet), cell type (unspecified or single cell), and sanitary facilities (one toilet or urinal per 15 inmates or one toilet per cell).

Table 1 also contains simple statistics summarizing corresponding variables for the federal correctional institutions (FCI's) in our sample. Note that, for the most part, these FCI's are considerably larger than the Commission on Accreditation's standard of 500 inmates. On average, prisons satisfy the living area standard requiring 60 square feet per inmate, but none provide 80 square feet. Only 58 percent of the beds are in single-bed cells, and one prison has no single cells at all. None of the units have one toilet or urinal per inmate.

IV. THE MODEL

This study bases its model on the economic theory of production. Output is viewed as a function of the inputs and technology used.[7] The total cost of producing this output is then determined by the level of output (denoted Q), the prices of the inputs (denoted P_i), and the technology used (indicated by the unspecified functional form f). Average cost (denoted AC), usually a more convenient measure, is merely total cost divided by output and is, therefore, determined by the same variables. Formally, the economic model of average costs states:

$$AC = f(Q, P_i) \qquad (1)$$

[7] We are considering production in the long run where capital (buildings, equipment) are allowed to vary. See any current microeconomic text (e.g. Ferguson and Gould, 1975) for a fuller discussion of the economic model of production. When using this model, one may estimate either production or cost functions and obtain exactly the same information about production if the conditions necessary for duality hold. We choose to estimate cost rather than production functions because we believe that costs are under greater control of prison administrators than is output, the level of incarceration. Note that the level of incarceration is determined largely by groups outside prisons—courts, parole board, and the executive. See Witte *et al.* (1979) for a detailed discussion.

Table 1. Summary of Standards and Corresponding Sample Statistics

Standard	*James* v. *Wallace*	Commission on Accreditation	National Advisory Commission	The Sample Statistics
Prison Size	None specified	Maximum of 500 inmates	Small enough so superintendent can develop a personal relationship with each inmate	mean 822 inmates maximum 1542 inmates minimum 495 inmates
Cell Size or Living Area	60 sq. ft. per inmate	60 sq. ft. for inmates locked up 10 hours or less per day. 80 sq. ft otherwise	80 sq. ft	mean 63.8 sq. feet maximum 76.2 sq. feet minimum 49.5 sq. feet
Cell Type	None specified	Single bed cell or room	Single-bed cell or room	mean 58% single cells maximum 100% single cells minimum 0% single cells
Sanitary facilities	One toilet and one urinal per 15 inmates	One toilet in each cell or room	One toilet in each cell or room implied but not specified	mean .42 urinals and toilets per inmates maximum .63 urinals and toilets per inmates minimum .20 urinals and toilets per inmates

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The specification of f is important and depends on what we know or are willing to assume about the way in which prisons operate. We currently know relatively little from an analytic perspective about the way prisons operate. However, existing studies do indicate that the average cost of operating a prison is not constant, but rather varies with the number of inmates incarcerated. The functional form selected allows the average cost curve to take on a number of shapes and so allows us to test whether or not average cost is constant, increasing, decreasing, or a combination of these (as in the U-shaped average cost curve).

When modeling the way in which average costs in prisons vary with the number of inmates incarcerated and the level of input prices, it is necessary to control for the "quality" of output and the type of inputs; neither output nor inputs can be reasonably assumed to be homogeneous. For example, the incarceration of a murderer is quite different from the incarceration of a forger. Well-educated staff and single-cell facilities may imply quite different average costs than do less-educated staff and other housing arrangements, although the price of labor and capital faced by facilities using these two types of inputs may be quite similar.

Taking all of the above into consideration, we first estimated the following average cost function:

$$\ln(AC) = \beta_0 + \beta_1 Q + \beta_2 \ln Q + \beta_3 \ln P_L + \beta_4 \ln P_K + \Sigma Y_i A_i + \epsilon \qquad (2)$$

where AC is average costs, Q is a measure of output (the number of inmates times the number of days confined), P_L and P_K are measures of the unit cost of labor and capital respectively, A_i's are measures of the "quality" of output and the type of inputs utilized, $\beta_0, \ldots \beta_4$ and Y_i's are parameters to be estimated, ϵ is a random error term, and ln indicates that the natural logarithm of a variable has been taken.

We were unable to secure adequate data for input prices. Adequate measures of the opportunity cost of capital are difficult to obtain even when analyzing the costs of private, profit-making entities. These difficulties are multiplied when one is considering public organizations. When an average cost curve is estimated for an industry, an appropriate interest rate, which reflects either the interest the firms would pay if they borrowed funds or the income they would sacrifice if they were to use internal funds for capital investment, is used. For a government agency which does not maximize profits, and which draws its funds from general revenue, it is not clear how to measure the cost of capital. A number of measures were tried, and always either the sign or the magnitude of the coefficient would not conform to economic theory. Similarly, while we were able to collect data on actual wages, the average wage calculated for each institution does not measure the opportunity cost of labor. Furthermore, given the civil service framework within which these prisons operate, it is not clear that the cost of labor would affect average cost in the way economic theory would predict. Certainly, the coefficients for the cost of labor estimated in our various specifications were not consistent with economic theory.

We decided that since either our measures for input prices were not adequate, or prisons simply do not conform to the economic theory of firms, input prices would have to be excluded from the model specification. Future research on the costs of prisons will be directed toward developing an explicit economic model of a government agency, perhaps along the lines of Niskanen (1971).

V. THE DATA

We obtained data from the Federal Bureau of Prisons (FBOP) on 21 federal correctional institutions (FCI's) for the time period of October, 1975 (first month when accounting data were considered reliable) to June, 1978 (data were collected in July, 1978).[8] A short-run cost function was estimated for each FCI using time-series data.[9] Appropriate statistical tests[10] indicated that it was not possible to assume that all FCI's were using the same methods of operation. This meant that it was not possible to combine data for all FCI's to estimate the long-run cost function specified in equation 2. Again, using appropriate statistical tests, we searched among the FCI's for a subset which appeared to use broadly similar methods of operation. We found six such FCI's and proceeded to combine data for these institutions[11] for ten quarters.[12]

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8 See Chapter 7 of Witte *et al.* (1979) for a detailed description of the data set utilized.

9 These cost functions are short-run cost functions, since capital remained fixed during the period studied. See Witte *et al.* (1979: ch. 9) for a detailed presentation of the cost functions estimated.

10 The appropriate test for homogeneity of technology is a generalized Chow test. See Maddala (1977) for a discussion.

11 These institutions are Ashland, Lompoc, Lexington, Oxford, Texarkana, and Alderson. The value of the test statistic for the appropriateness of this cross-sectional pooling, which is distributed $F_{125,48}$ under the null hypothesis that pooling is appropriate, was 1.979.

12 Appropriate statistical tests were performed to ensure that this pooling of time series data was justified. We pooled data centering on the third quarter of 1977, as detailed descriptions of the capital stock were available for that

These six represent a diverse cross-sectional sample. *Oxford*, located in rural Wisconsin, is a medium-security facility housing long-term, young adult males. It was built in 1973 and has an inmate capacity of 480. Housing is in single cells or rooms. There are close-custody facilities at Oxford. *Alderson* is the only federal institution with maximum security facilities for women. Built in 1927, it is located in West Virginia. Its capacity is 580, and housing is in single rooms and small dormitories. *Texarkana* is a medium-security facility for males serving sentences of up to 10 years. It was built in 1940 and has a capacity of 430; housing is in single rooms and dormitories. *Ashland*, in Kentucky, was also built in 1940. It is a medium-custody facility for young adult males whose sentences range from 5 to 15 years. The capacity is approximately 500 with about three quarters of the inmates in single cells or rooms and the rest in cubicled dorms. *Lexington*, also in Kentucky, was opened in 1974 as a co-correctional minimum-custody facility for medium, minimum, and community-custody inmates with drug and alcohol or other chronic medical problems. It has a capacity of 950, with most men and women living in single rooms. Finally, *Lompoc* is a medium-security facility for adult males with a capacity of 1,142 and a satellite minimum-custody camp housing an additional 400 young adult males. Housing is in both single cells and dormitories. It is located in California.

The sample does not contain a maximum-security prison for men. The only such facility in the federal system is the penitentiary at Marion, Illinois, which has a capacity of 500. The results of this study, therefore, do not apply to such facilities. However, for those state systems which, like the federal, house only a small proportion of their inmate population in maximum-security facilities, this omission is not crucial. North Carolina is one such state: out of 81 facilities only one is designated for maximum security.

VI. EMPIRICAL MEASURES OF THEORETICAL VARIABLES

Our measure of cost, obtained from the FBOP's accounting system, is unusually complete. It includes the sum of actual disbursements, increments in accounts payable and non-funded costs, charges in applied costs, and normal depreciation

quarter when a complete physical plant inventory was conducted. The test statistic for the appropriateness of this time-series pooling, which is distributed $F_{45,10}$ under the null hypothesis that pooling is appropriate, was 0.794.

computed according to FBOP guidelines.[13] The measure of cost (denoted LNACOSTS) was selected in consultation with the staff of FBOP's Financial Management System, who believe that it provides the most accurate measure of resources consumed in production.

As we model only the direct output of prisons, our measure of output is the number of inmates confined multiplied by the number of days they are confined. That is, our measure of output is the number of confined days provided, where a confined day is defined as one inmate confined for one day. Since prisons do not produce a homogeneous product (confined days) in the same sense that automobile manufacturers do not produce a homogeneous product (they produce an endless variety of models and optional features), it is necessary to include a number of output quality variables to control for differences in confined days (such as rehabilitative activities, security levels, amount of violence, crowding, etc.). These variables are described in detail below. In order to allow returns to scale to vary with the number of confined days, we enter this variable in both the linear and logged forms, denoted CD and LNCD, respectively.

A number of variables were included to control for output and input quality. Only those variables which were found to have statistically significant coefficients[14] in our empirical work will be described in this article. A description of the remaining variables, which were found to have statistically insignificant coefficients, is available on request.

As a society we view a given level of incarceration (i.e., given numbers of confined days) to be of different quality if it produces different amounts of retribution and punishment (i.e., incarcerates more heinous criminals) and if it prevents more crime (incapacitates more active criminals and deters more crimes). Many, if not most, members of society, value incarceration more highly if inmates are housed under humane conditions and if they are provided with "productive" uses for their time. In addition, some of us still believe that rehabilitative programming and meaningful work experience can rehabilitate at least some offenders and thus prevent some crime. In order to control for variations in the "quality" of

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13 These guidelines use straight line depreciation and assume a 40-year life for buildings, a 20-year life for major heating and cooling equipment, and a 10-year life for smaller equipment. FBOP guidelines conform to Government Accounting Office conventions.

14 For significance, we used $\alpha = .1$ and conducted a two-tailed hypothesis test.

confined days associated with the above factors, in our original specification we controlled for the type of offense for which an individual was incarcerated,[15] many personal characteristics and some previous activity (criminal and addictive) of those incarcerated,[16] the security level of the institution,[17] the conditions under which inmates were incarcerated, and the level of rehabilitative programming. The variables which were found to be statistically significant are listed with their acronyms in Table 2.

Several variables which describe characteristics of the prison staffs were included to control for differences in the type of labor inputs used. Most of these variables were found to be significant and are listed in Table 2. All the measures included to control for capital quality were statistically significant. This is fortunate, since these variables allow us to explore the cost effects of correctional standards. These too are listed in Table 2.

Table 2. Definitions and Acronyms of Output and Input Quality Variables

Theoretical Variable	Empirical Measure and Acronym
Output Quality	
Rehabilitative activities	The number of such activities provided during the period (times 10,000) per confined day (IPRS)
Prison crowding	The ratio of average confined population to institutional physical capacity (CROWD)
Staff type	The ratio of guard's hours to the hours of other personnel (RATIO)

15 The type of offense for which the population is incarcerated should be directly related to the perceived seriousness of the offense (see Center for Studies in Criminology and Criminal Law [1978] for recent evidence) and thus to the level of retribution and punishment. It should also be associated with the criminal proclivities of the confined population and thus with the level of incapacitation and deterrence associated with a given number of confined days. See Cohen (1978) for a recent survey of the literature on incapacitation. Cook (1977), Nagin (1978), or Brier and Fienberg (1980) provide surveys of the literature on general deterrence. Witte (1980a) provides some evidence on the factors associated with specific deterrence.

16 The literature on incapacitation and recidivism suggests that these factors should be related to the criminal proclivities of the confined population and thus associated with the level of incapacitation provided by a given number of confined days. See Monahan (1980) or Witte (1980b) for recent surveys of the recidivism literature.

17 The security level of the institutions and the number of escapes should be related to the level of incapacitation. The level of other incidents should be related to the humaneness with which inmates are held.

Sentence	Average length, in years, of the sentences of the confined population (LENGTH)
Age	The average age of the inmate population in months (AGE-I)
Racial composition	The percent of the inmate population whose race is nonwhite (RACE-I)
IQ	The average Beta IQ of the inmate population (BETAIQ)
Occupation	The percent of the inmate population whose longest held job prior to incarceration was professional, technical, managerial, or in accounting (WCOLLAR)
Addiction	The percent of inmates with a history of significant alcohol use (ALCOHOL); the percent of inmates with a history of significant drug use (DRUGS)
Crime	Percent of the confined population sentenced for crimes against property (O-PROP)
Marital status	The percent of inmates who are married (MARRIED)
Labor Input Quality	
Race	The percent of staff who are nonwhite (RACE-S)
Age	The average age of the staff (AGE-S)
Sex	The percent of staff who are male (SEX-S)
Capital Input Quality	
Age of prison	Number of years since prison opened (as of 1977) (AGE-P)
Living area	Square feet of living area per bed (SQFPER)
Housing arrangements	Proportion of design capacity housed in single-bed cells or rooms (SINGLE)
Sanitary facilities	Number of toilets and urinals per design capacity (SANPER)

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VII. EMPIRICAL RESULTS

Table 3 contains the results of estimating the average cost curve using a generalized linear regression model.[18] Only the final specification is shown. The initial specification was reduced by eliminating the variable with the lowest t-statistic for each run until all remaining variables were judged significantly different from 0 at the 0.1 level of confidence.

The final specification explains a large proportion of the variation in average cost: at least 85 percent.[19] We find, first of all, that rehabilitative activities tend to increase costs only slightly. However, based on our previous work with the data (Witte *et al.*, 1979), we suspect that a somewhat closer investigation of this variable would reveal a U-shaped relationship. That is, as IPRS increases, costs would first fall and then rise. Most output quality and labor input quality variables affect costs in a reasonable manner. For instance, costs rise with sentence length and with an increase in the proportion of inmates with alcohol and drug problems. Interestingly, costs rise when the proportion of inmates with professional and managerial backgrounds rises. It is surprising that O-PERS, the proportion of inmates convicted of crimes against persons, is not significant.[20] The effect of O-PERS, which one would expect to be positive, may be masked by a high correlation with SINGLE (.81). The prisons in our sample, it seems, tend to house violent offenders in single cells and other offenders in dormitories (the correlation between O-PROP and SINGLE is .210).

Average cost varies in fairly complex ways as the number of confined days changes. The solid line in Figure 1 depicts this variation. Note that in constructing this "average cost curve" we have controlled for other factors affecting costs. Specifically, we have assumed that variables other than output have their mean values in the sample, and we have used the parameter estimates of our model to adjust for their effects on

[18] A generalized linear regression model is used because of the violation of the ideal conditions of the ordinary least squares regression model introduced by the pooling of cross-section and time-series data. This model corrects for heteroskedasticity, mutual correlation, and autoregression. The method is described in Kmenta (1971: 512-514).

[19] This figure is based on the R^2 when the final specification is estimated using ordinary least squares; an R^2 cannot be calculated when a generalized model is used. Since the generalized model is a more efficient estimation technique than is ordinary least squares, the R^2 can be considered a lower bound.

[20] Time-series regression on each institution in the sample shows that, with SINGLE constant, an increase in the proportion of inmates convicted of crimes against persons will generally increase average cost.

Table 3. The Final Specification and Descriptive Statistics

Variable	Coefficient (t-statistic)	Mean (Standard Deviation)
Intercept	52.505 (10.059)	—
CD	2.333×10^{-5} (4.828)	75258.467 (29541.391)
LNCD	−2.926 (−6.930)	11.164 (0.350)
IPRS	3.223×10^{-4} (5.852)	609.145 (194.909)
CROWD	0.287 (2.701)	1.235 (0.225)
RATIO	−2.936 (−6.097)	0.287 (0.155)
LENGTH	0.151 (3.472)	6.682 (2.013)
AGE-I	−0.054 (−4.650)	29.652 (3.846)
RACE-I	−0.061 (6.270)	45.480 (12.837)
BETAIQ	−0.080 (−3.449)	103.178 (2.787)
WCOLLAR	0.046 (6.791)	27.836 (8.886)
ALCOHOL	0.0168 (1.880)	7.944 (3.319)
DRUGS	0.023 (7.142)	37.158 (15.384)
O-PROP	0.009 (1.868)	58.624 (7.861)
MARRIED	0.013 (2.224)	25.304 (7.268)
RACE-S	0.055 (4.903)	14.381 (5.930)
AGE-S	−0.205 (−8.445)	40.296 (2.384)
SEX-S	0.019 (3.004)	78.510 (18.520)
AGE-P	0.028 (11.567)	24.833 (17.883)
SQFPER	−0.033 (−2.952)	63.778 (8.063)
SINGLE	−1.091 (−5.756)	0.585 (0.307)
SANPER	−3.975 (−8.960)	0.422 (0.169)

Transformed regression MSE. 1.081
N 60

average costs. The average cost curve is symmetrically U-shaped with the cost increases associated with very small facilities exceeding those associated with very large facilities. The average cost of a confined day is lowest for a prison which confines, on the average, 1371 inmates.[21] The daily cost of confining inmates in such a "minimum" cost facility is $13.24 per inmate per day. As noted above, costs rise for prisons either larger or smaller than 1371 inmates. Note that a prison which confines an average of 1000 inmates (approximately 375 less than least-cost size) has an average cost per confined day of $15.10 (approximately 14 percent more than "minimum" cost), while a prison with an average population of 1750 (approximately 350 more than least-cost size) has average costs of $14.56 (10 percent more than "minimum" cost). The implications of our results are fairly obvious: prisons, at least the prisons in our sample, are cheapest to run when they are quite large, but not overwhelmingly so. To indicate the robustness of our cost curve estimate and to point up the fact that all of our estimates could be somewhat larger or somewhat smaller than indicated, we have determined the 95 percent confidence interval for each size prison.[22] The curves implied by these intervals are given by the dashed lines in Figure 1.

Consider next the differential costs associated with prisons housing 500 inmates, a size recommended by the Commission on Accreditation. We estimate that the average cost per confined day in a prison of this size having other characteristics equal to the means in the sample would be $39.45, over twice the daily cost in a facility of minimum-cost size. The difference in costs between a prison meeting the Commission on Accreditation standard and the minimum-cost size prison may be viewed as an upper bound estimate of the cost of imposing the proposed standard. While altering no other factor, confining 1371 inmates in prisons housing 500 rather than the minimum cost number of inmates would result in increased prison system costs of $13,115,877 per year, assuming that our results can be generalized and that both prisons had the same

[21] This point estimate is calculated by solving for $\partial AC/\partial CD = 0$. The result is 125,415 confined days per quarter. Assuming 91.5 days in a quarter, this is equivalent to an inmate population of 1371.

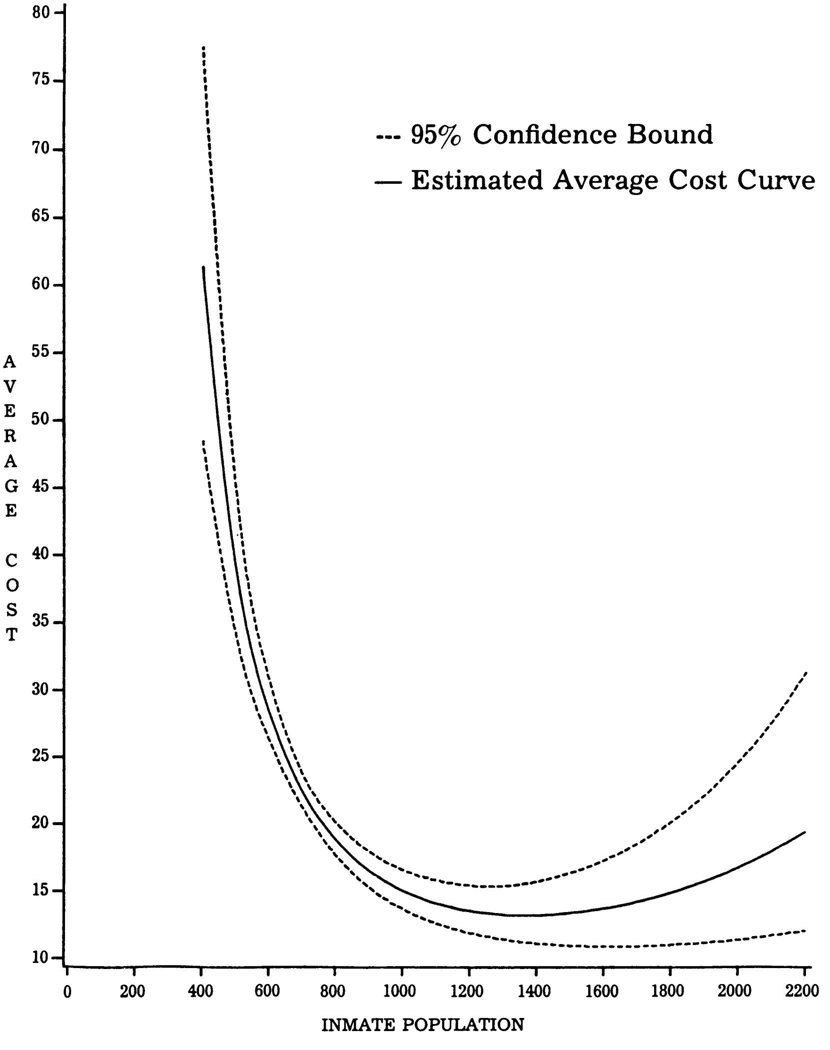
[22] The 95 percent confidence limits are

$$1.96 \times \sqrt{X_f V(\hat{\beta}) X'_\epsilon} \pm \text{LNACOSTS}_f$$

where X_f is the vector of forecast values of the explanatory variables, $V(\hat{\beta})$ is the variance-covariance matrix of the estimates, and LNACOSTS_f is the log of average cost predicted by the values of X_f.

value of other variables affecting cost. Given FBOP's population of 29,803 inmates in 1978,[23] we estimate that it would have cost the system $285,114,870 more per year to house these inmates in facilities with populations of 500 rather than in facilities of the minimum-cost size. This cost differential is only an estimate but is substantial and should be carefully considered when imposing standards which require prisons of small size. While small prisons may well have substantial

Figure 1. Average Cost of a Confined Day in Federal Prisons of Varying Size



[23] See U.S. Department of Justice, 1980.

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benefits (e.g., personal contact, more humane conditions) which are not reflected in our modeling effort, these benefits must be weighed against the likely markedly increased costs associated with the operation of such prisons.

As may be seen in Table 1, the mean population of prisons in our sample was 822 inmates, approximately two-thirds of the size of the minimum cost prison. Housing all inmates in the federal prison system in 1978 in prisons of this size, rather than in the minimum-cost size prison would result in increased system operating costs of $55,151,942 per year under the previously detailed assumptions. Again this figure is only illustrative, but it does point up the potential significance of cost in prison construction decisions.

Firms invest in costly capital in order to lower operating costs and thus lower average cost. That a prison might be able to lower the average cost of confining inmates by providing single-bed cells, greater living area, and more privacy, is not obvious. Nevertheless, our estimation indicates that, all other things equal, such prisons do have lower average costs.[24] Indeed, the elasticities associated with the coefficients on these variables[25] indicate that a 1 percent increase in living area reduces average cost by 2.1 percent; a 1 percent increase in the proportion of single-bed cells reduces costs by 0.64 percent, and a 1 percent increase in the provision of sanitary facilities reduces costs by 1.68 percent.

Further investigation is necessary to determine if these capital quality characteristics reduce costs for other types of prisons as well, and if they do, why they reduce prison costs. The National Advisory Commission (1973: 355) provides one possible reason for such cost reductions. "Without privacy and personal space, inmates become tense and many begin to react with hostility. As tension and hostility grow, security requirements increase; and a negative cycle is put into play."

Table 4 illustrates the cost implications of some of our findings. Column A shows the estimated average cost of a prison having the mean number of inmates for prisons in our sample (822), mean living area (63.8), and mean proportion of single cells (.58). Column B shows the estimated average cost

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24 The estimations for all the variables is valid only within the observed ranges of the variables. This is not a constraint in the case of SINGLE, since our observation varied from a minimum of no single cells to a maximum of all single cells. However, SQFPER varied from 49 sq. feet to 76 sq. feet and SANPER from .2 to .6.

25 All elasticities are calculated at the mean values of these variables. The elasticity of variable X is $\partial AC/\partial X \cdot X/AC$.

Table 4. Average Costs For Prisons Of Various Capital Configurations

	A	B	C	D	E	F	G
	The "Average" Prison (CD = 822 SQFPER = 63.8 SINGLE = .58)	The "Minimum-Cost Size" Prison (CD = 1371 SQFPER = 63.8 SINGLE = .58)	A "Large Living Space" Prison (CD = 822 SQFPER = 70 SINGLE = .58)	The "All-Single-Cell" Prison (CD = 822 SQFPER = 63.8 SINGLE = 1.0)	"Living Space and Single Cells" Prison (CD = 822 SQFPER = 70 SINGLE = 1.0)	"Minimum-Cost Size, Living Space and Single Cells" Prison (CD = 1371 SQFPER = 70 SINGLE = 1.0)	The "Up to Standards" Prison (CD = 500 SQFPER = 70 SINGLE = 1.0)
Average Cost (95% confidence interval)	$18.31 (17.12-19.58)	$13.24 (11.21-15.63)	$14.92 (12.94-17.21)	$11.64 (9.71-13.95)	$9.48 (7.67-11.72)	$6.86 (4.88-9.65)	$20.43 (17.45-23.92)
Difference in costs per confined day: relevant column-column A)	—	−5.07	−3.92	−7.20	−9.36	−11.98	+2.12

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of a prison which is similar except that it houses 1371 inmates, the least-cost number. We see that a prison with the characteristics described in column B would have an average cost per confined day of $5.07 less than a prison with the characteristics described in column A. Column C gives the cost implications of increasing living area to 70 square feet per inmate[26] while holding other characteristics constant. Such an increase results in cost savings of similar magnitude to increasing prison size from the mean to the minimum cost size. Columns D, E, F, and G present cost figures for other types of prisons. Note that the cheapest prison to operate (the prison described in Column F) would be relatively large (house an average of 1371 inmates), would provide a good bit of living space (70 square feet per inmate), and would provide an individual cell for each inmate. While this prison may seem unattractive due to its size, the other amenities associated with it may make it more acceptable to both correctional staff and inmates. The cost of the type prison described in column G may be of particular interest as this type prison is most likely[27] to meet the standards of the Commission on Accreditation. Note that this type of prison would cost $2.12 more per inmate day to operate than the "average" prison of column A. This is a fairly small cost penalty since the cost reduction due to increased living area and single cells nearly offsets the increased costs due to small prison size. On the other hand, compare columns F and G to see how small prison size affects costs for prisons which otherwise satisfy the standards.

VIII. SUMMARY AND CONCLUSIONS

In this paper we have analyzed the determinants of costs for a selected group of federal correctional institutions. These FCI's were selected because they appeared to be using similar methods of operation, (a factor needed to uniquely determine

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26 A living area of 80 sq. feet is outside the range of our observation; therefore, the extrapolation would not have been valid. Even at 70 sq. feet the cost effect may be exaggerated. This would be the case if the effect is nonlinear. Our estimation for the effect of SQFPER would then be a linear approximation of a nonlinear effect and would become increasingly inaccurate as the distance from the mean becomes greater. If, as would be reasonable, the effect of SQFPER is subject to diminishing returns (i.e. as SQFPER increases, costs fall at a diminishing rate) then the cost savings shown in columns C, E, F, and G in Table 6 would be somewhat exaggerated.

27 The prison of column G would satisfy these standards if the ratio of cells for inmates locked up for over ten hours per day to those locked up ten or fewer hours per day is one or less.

the effect of prison size on costs)[28] and not because they were representative of prisons around the country or, indeed, even the prisons of the federal system. Nevertheless, the prisons in our sample are quite diverse, and we believe provide useful insights. It would obviously be desirable to check these insights by estimating cost curves for a more "representative" sample of prisons. However, three years of efforts to develop data for a more representative sample of prisons which use roughly the same methods of operation has not proven successful.[29]

Our analysis indicates that a prison will have higher costs, other things remaining unchanged, if it is either small or very large, if it provides fewer square feet of living space and few single cells, and if it provides few sanitary facilities. Some of our findings have implications for the construction of new prisons and the imposition of some correctional standards regarding the nature and design of prison facilities. Specifically, our results and those of other studies indicate that there are substantial cost penalties associated with building small prisons. The minimum cost per confined day will probably only be achieved with prisons of rather substantial size, say 1000 to 1600 inmates. The cost penalty associated with prisons as small as 500 inmates (advocated by the Commission on Accreditation) is likely to be substantial. Indeed, we estimate that the cost per confined day would be over twice as high in such a facility as it would be in a facility of the minimum-cost size (an estimated 1371 inmates). Since many prison systems are currently being forced to plan and build new facilities to relieve severe overcrowding, this result may be one useful piece of information to consider when deciding upon the size of facilities to construct.

Our results indicate that imposition of standards requiring more living space and single cells may actually lower rather than raise the costs of confinement. Specifically, we find that increasing the amount of living space in the facilities we studied from the current mean value (63.8 square feet per bed) to 70 square feet, holding other factors constant, would lower costs per confined day by an average of $3.92 per inmate day.

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[28] If we were to estimate a cost curve using prisons with widely differing methods of operation, we would confuse cost savings due to changed methods of operation and cost savings due to changes in prison size.

[29] The basic problem is that most state systems do not collect the data needed to estimate cost curves. A secondary problem is that the prisons currently operating in any prison system (e.g., the Federal system) are very diverse and use widely differing methods of operation.

Similarly, increasing the proportion of single cells from its current mean value (58 percent) to 100 percent, as advocated by some standards, would lower costs by an average of over $7.20 per confined day. We do not know the source of these cost savings, but conversations with prison administrators and other staff lead us to believe that they may be due to improved inmate morale and lowered security costs.

We feel quite secure in our major finding: that the optimal size prison is a good deal larger than the 500-inmate capacity called for in the correctional standards. This result is quite consistent with the findings of McGuire (1978), McGuire and Witte (1978), and Witte *et al.* (1979). It should also be noted that, while the number of observations is limited, the range of observations on inmate population is very wide: from 495 to 1542.

Our study uses data for a selected group of federal prisons, and thus our conclusions may not be valid for state prison systems or indeed even generalizable to all prisons in the federal system. We attempted to obtain data for a number of different state systems to replicate our work, but found that the extensive data needed to estimate the costs of most correctional standards were not available in any system contacted. However, the California Department of Corrections had data which allowed us to explore the shape of the average cost curve for that system. Due to data quality, the lack of input quality measures, and the disparate nature of California prisons, our results should be viewed as indicative only. However, the shape of the average cost curve we obtain is similar to that for the federal system. Average costs decline as prison populations rise (at least up to quite large prison populations). Thus, our California results also support the conclusion that small prisons are likely to be quite costly.

Although we do not believe our study to be in any way definitive, we hope that it provides some insight into the determinants of prison costs. We do not advocate that cost considerations be the only, or indeed even the central, determinant of prison construction or operation. But we do believe that in the past cost considerations have received insufficient attention.

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