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Management Factors Affecting Police Productivity

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by

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MANAGEMENT FACTORS AFFECTING POLICE PRODUCTIVITY

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Productivity improvement has become a catch phrase for public sector agencies in the United States. Faced with fiscal crises resulting from constant or decreased revenues, and often with increasing service demands, public agencies are forced to make careful decisions regarding service delivery options. Frequently, productivity improvement has been equated with simple cost-cutting. But productivity does not mean fewer services for fewer dollars. Rather, productivity improvement results when agencies are able to get greater service output from constant (or reduced) resources.

This report explores some productivity improvement options for municipal police departments. At the local level of government in the United States, police services represent one the largest budget categories. As such, police departments have been under particular pressure to reduce expenditures or, at best, operate with relatively constant budgets. Thus, to maintain or increase service levels, police departments must learn to make better use of the resources at hand.

Police managers are frequently constrained in their selection of options for productivity improvement. Police managers find themselves bound by hiring decisions that antedate their tenure, by union and civil service work rules, by time-honored traditions, and by a lack of valid information regarding the likely effects of proposed changes.

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Lacking such information, police managers have been understandably reluctant to propose significant changes, not knowing whether such changes would make things better or worse. Rather, as Levine (1985) has recently characterized them, many police managers have pursued a "decremental" strategy, cutting resources at the margin to stay within budget constraints, and accepting attendant service reductions as inevitable.

Police managers operate in an environment where basic resource decisions are often exogenous to their control. Personnel limits are frequently set through political processes external to the department. Basic equipment complements, too, are determined exogenously. But police managers frequently have greater flexibility when deciding how personnel and equipment are to be utilized. It is these decisions and their implications for departmental productivity that are the prime focus of this research. The key variables of interest are the allocation of sworn officers among specializations within departments and, for the patrol force, the deployment of officers for field duty. Additional variables of interest in the analysis are the use of civilians and reserve officers.

The research is exploratory in nature, involving two seperate stages. In the first stage, a methodology recently developed in the management science literature is used to assess the productive efficiency of a set of police agencies relative to one another. Police service delivery is conceptualized as a production process, involving the transformation of available inputs into valued outputs. The methodology, described in the next section and an appendix to this report, identifies those police agencies which obtain the highest levels of outputs for given inputs (or, conversely, those which employ the smallest sets of inputs to obtain given outputs) and computes an efficiency rating for departments that obtain fewer outputs or require more inputs relative to these most efficient departments. The efficiency ratings computed from this methodology are used to index the productivity of each department for subsequent analysis. In the second stage, the productivity ratings are regressed on variables indicative of different management choices to determine the extent to which these choices are related to productivity. Where these variables are found to be related to productivity differences, recommendations for enhancing productivity can be made.

Conceptualizing Police Productivity

Productivity improvement, as noted above, occurs when police departments are able to produce greater service levels with constant or reduced levels of resources. Productivity in this view is indexed by the efficiency with which police departments transform input resources into valued outputs. That is, police managers are provided with a set of input factors. Managers then make choices as to how these inputs should be employed to produce police outputs. Implicitly or explicitly, they choose transformation processes. The efficiency of a given transformation process can be measured by the ratio of outputs obtained to inputs consumed. Different transformation processes (different management choices) can be compared using such ratios to allow comparative judgements about the relative efficiency of the processes.

To grossly simplify, suppose that the only input resource employed by police departments was sworn police officers and the only output of interest was the number of crimes cleared by arrest. A department that employed 25 sworn officers and obtained 200 clearances in a given year would be judged substantially more efficient in this simple world than departments that a) obtained 100 clearances while employing 25 officers or b) obtained 200 clearances while employing 50 sworn officers. The first department's ratio of 8 clearances per sworn officer is clearly superior to either of the latter two departments' ratios, 4 clearances per sworn officer. Indeed, one could say that the first department is twice as efficient as the latter two. Standardizing the first department's efficiency as 1.0, one would assign relative efficiencies of 0.5 to both of the latter. Of course the real world is more complex than this simple example captures, but the logic of relative efficiency it presents can be extended to more complex situations.

One obvious complexity of the real world is that police departments employ more than a single input factor and produce more than a single output. One could, of course, compute ratios for each output to each input and compare departmental efficiencies using the set of ratios obtained. But the results of doing so are likely to be perplexing. Some departments are likely to score well on some ratios, other departments on other ratios.[1] Deciding which ratios "really" index relative efficiency would require a subjective assessment of what is important in policing. Rather than requiring such an assessment to weight the multiple output/input ratios that are possible, it is preferable to rely upon a more objective weighting scheme, one grounded in actual police operations.

Recently this problem has been attacked with mathematical programming methods developed in management science. An early statement of the methodology was that of Farrell (1957). He proposed assessing the relative efficiency of given "firms" by computing ratios of weighted outputs obtained to weighted resources consumed, with the weights determined empirically by observations on actual firms. He contrasted his proposed methods with attempts to assess efficiency against some theoretical ideal which might be developed from engineering estimates, and argued that "it is far better to compare performances with the best actually achieved than with some unobtainable ideal" (Ibid: 255, emphasis added). Farrell showed how it would be possible to identify those firms which obtained the highest weighted ratios of outputs to inputs and to use the results obtained by these efficient firms to compute relative efficiency scores for firms that obtained lower ratios.

Charnes, Cooper, and Rhodes (1978) operationalized Farrell's ideas by developing mathematical programming codes and applying them to the measurement of relative efficiency in public sector organizations. Their technique, known as Data Envelopment Analysis, has been applied in studies of the relative efficiencies of military recruiting organizations, air force wings, national parks, hospitals, and public educational units.[2] An extension of the Charnes, Cooper, and Rhodes technique, known as Constrained Facet Analysis, was made by Clark (1982), and has been used as a decision support tool for educational productivity by Bessent and Bessent and colleagues at the University of Texas.[3]

The measure of efficiency obtained with this methodology is based upon physical measures of resources utilized and resulting outputs. It is derived empirically from a comparison of the outputs obtained by each of a set of decision-making units (DMUs) to the inputs used to obtain those outputs. Each DMU is compared to all other DMUs in a given set. The comparison is constrained such that any particular DMU will be rated no better than the DMU (or combination of DMUs) exhibiting the highest weighted output/input ratio in the set. Subject to this constraint, each DMU in the set is assigned the highest possible efficiency rating. Use of this methodology results in "an empirically determined objective measure of efficiency, based on extremal relations rather than on average expectations" (Bessent and Bessent, 1980: 59, emphasis in the original).

The method proceeds by computing empirically based weights for outputs and for inputs. The weights satisfy the objective of obtaining the highest possible efficiency rating for each decision-making unit,

$$\text{maximize } h_0 = \sum_{r=1}^{s} u_r y_{r0} \Big/ \sum_{i=1}^{k} v_i x_{i0} \qquad (1)$$

subject to the constraint that no decision-making unit can receive a rating better than those having the best weighted output/input ratios in the comparison set,

$$\text{subject to: } \sum_{r=1}^{s} u_r y_{rj} \Big/ \sum_{i=1}^{k} v_i x_{ij} \leq 1 \qquad (2)$$

for all decision-making units $j = 1,\ldots,n$. The terms in these equations are:

h_0 = the efficiency score for a given DMU,

u_r = the calculated weight for output r ($r = 1,\ldots,s$),

v_i = the calculated weight for input i ($i = 1,\ldots,k$),

y_{rj} = the value of the rth output for DMU j, and

x_{ij} = the value of the ith input for DMU j.

An appendix to this report presents a graphical interpretation of these equations and illustrates the conceptual difference between efficiency estimates obtained with Data Envelopment Analysis (DEA) and with Constrained Facet Analysis (CFA). These estimates are identical for those units rated fully efficient, but can differ significantly for units that are not efficient. In essence, DEA overestimates the relative efficiency of less than fully efficient units in certain circumstances, while CFA underestimates the efficiency of these units (see the Appendix for details). In the analyses of contributions to efficiency below, units for which DEA and CFA yield different efficiency estimates are assigned a relative efficiency score which is the average of those computed by these two alternative approaches.

Identifying Factors Contributing to Police Productivity

The approach taken in the following analyses is straightforward. First, a set of police outputs and input resources are identified. Then, using Date Envelopment and Constrained Facet Analyses, efficiency scores are computed for representative groups of police agencies in two different size ranges (25 to 50 sworn officers and 100 to 200 sworn officers). The efficiency scores obtained are averaged for each police department and then regressed on a series of variables that represent possible approaches to productivity enhancement. The coefficient estimates for the productivity enhancement variables, after adjustment for factors external to management control, are then used to assess the apparent worth of the several approaches tested.

Police Outputs

Police in the United States perform a wide array of tasks, ranging from the mundane to the most serious. It is not possible in any analysis to consider this full array. For this analysis, the focus is restricted to what can be considered the core technology of policing, with outputs chosen to represent that core.

One mission of the police, crime fighting, clearly dominates public perceptions and discussions of police services. While police perform many services that bear little relation to crime, the expectation is that police can and do have an impact on crime through preventive efforts and the investigation of reported criminal incidents after they have occurred. The police output most closely representative of the investigative function of the police is the clearance of reported crimes through the arrest of suspected perpetrators. This output, indexed by the number of reported crimes cleared by arrest in a year, was selected as one of the police outputs of interest for this research.

In addition to investigative activities, police engage in crime suppression activities, primarily through the deployment of preventive patrols. These patrols also are the primary deliverers of the many non-crime services supplied by local police. There is no readily available measure of preventive output, i.e., the number of crimes prevented by patrol activities. Neither, for most departments, are there readily available data on the number of service requests handled in a given period, certainly none that are comparable across a large number of departments. For this reason, a proxy indicator of the output of patrol services is employed for this research. This indicator is the average number of patrol units on the street at any time during a 24 hour period. This is clearly not a completely satisfactory output indicator but, by measuring a department's capacity to provide prevention and service outputs, comes as close as available data allow to capturing the level of these outputs.

Taken together, these two output indicators account, at least as proxies, for the bulk of the work accomplished by local police departments. Attempting to solve reported crimes constitutes most of the workload of police detective and other investigative divisions. Preventive patrol and the response to service requests constitutes most of the workload of police patrol divisions. Investigation and patrol divisions together comprise the majority of officer assignments in all departments.

Police Inputs

Policing is heavily labor-intensive. Eighty-five to ninety-five percent of the expenditures of most local departments are devoted to human resources. For this research, these human inputs are measured by the number of full time sworn officers and by the number of full time civilians employed by each department. In addition to human resources, police agencies use a variety of equipment to produce services. Of this equipment, the largest expenditure is for vehicles. Therefore, the number of vehicles used by each department is also included as an input factor.

Non-Police "Inputs"

Police departments confront very different environments from jurisdiction to jurisdiction. Environmental factors may differentially affect the police production process and, in this sense, can be thought of as inputs to that process. The methodology employed to measure the efficiency of production accomodates such factors under the rubric of "nondiscretionary inputs," i.e., factors which may contribute to the augmentation or reduction of outputs from a given set of police resources, but which are not subject to manipulation by police managers. For the analyses presented here, a variety of such factors were considered, including socioeconomic and demographic factors as well as the level of crime in each jurisdiction. Of these, the one factor which was consistently related to an output variable was the level of crime. Not surprisingly, the number of crimes cleared by arrest by each department was a function of the number of crimes reported to that department, independent of the levels of police inputs employed. Other factors, the socioeconomic and demographic variables, were not consistently related to either of the output variables, however, particularly after adjustment was made for the level of reported crime. Crime levels, in essence, summarize the effects of the variety in socioeconomic and demographic characteristics of jurisdictions, at least as they impinge on the output variables of interest. Thus, the efficiency analyses were performed with the inclusion of one nondiscretionary input, the level of reported crime in the jurisdiction of each department.

The Data

The data employed for the present analyses were originally collected in 1974-75 as part of a descriptive study of the organization of police service delivery in U.S. metropolitan areas (see Ostrom, Parks, and Whitaker, 1978, for the details of this study). In that descriptive study, all police departments in 85

Standard Metropolitan Statistical Areas were surveyed and data were obtained on each department's input resources, on the utilization of those resources, on jurisdictional service conditions, and on the outputs obtained. These data supply all of the measures used for this research. The 85 SMSAs were selected as a stratified sample of all SMSAs under one million population in 1970, and they, together with the departments found in them are broadly representative of all SMSAs and police agencies in America at that time, though not of the 16 largest metropolitan areas.

From the 469 municipal police departments with 10 or more full time sworn officers found in these 85 metropolitan areas, two subsets were selected for the present analyses. The subsets consisted of departments in two size ranges, those employing between 25 and 50 full time sworn officers and those employing between 100 and 200 officers. Separate analyses of productivity and possible productivity improvements were conducted for each subset. The reasoning underpinning this selection of limited subsets was that departments of very different sizes might be expected to produce services in quite different ways. Since the methodology computes efficiency of departments relative to other departments that are similar, it would be inappropriate to include the full range of department sizes in a single analysis. The choice of size ranges was somewhat arbitrary, though departments in these two ranges of size are quite common in American local policing. Where significant factors affecting productivity were identified for these subsets, additional analyses could be performed in the remaining size ranges to determine whether comparable patterns existed.

Sixty-two police departments were included in the efficiency analysis of departments in the 25 to 50 sworn officer subset, while 49 departments were included in the 100 to 200 subset.[4] Table 1 presents summary data on the output and input variables for departments in each of these subsets, together with three output/input ratios for these departments. Police managers reading this report can make reference to these summary data to determine the comparability of their own departments to the ones analyzed.

Comparison of the three output/input ratios for the two subsets provides support for the decision to analyze their efficiency separately. That is, there appears to be a difference in the emphasis placed on the production of the two outputs between the two subsets. The departments in the 25 to 50 sworn officer range appear to emphasize patrol deployment more than crime clearance, while the reverse appears true in the subset containing larger departments. In the 25 to 50 officer subset, the median department deploys one patrol unit for each seven sworn officers, while the median larger department deploys one unit for each 10 sworn officers. Thus, the smaller departments obtain relatively higher patrol productivity from their sworn officers than do the larger. On the other hand, the larger departments obtain higher productivity in the clearance of reported crimes. Whether indexed by the number of crimes cleared per sworn officer or by the clearance rate, departments in the 100 to 200 sworn officer range score higher than those in the 25 to 50 sworn officer range. A partial explanation for this higher clearance productivity among departments in the 100 to 200 officer subset is the higher volume of reported crimes in their jurisdictions. The median

TABLE 1. Outputs, Inputs, and Selected Output/Input Ratios.

	25 to 50 Sworn Officers (N = 62)			
	Median Value	Interquartile Range	Lowest Value	Highest Value
Average Patrol Units on the Street	5	4-6	3	8.5
Clearances by Arrest	104	56-225	13	461
Full-Time Sworn Officers	34	29-39	25	50
Full-Time Civilians	4	2-6	1	14
Number of Police Vehicles	8	7-11	4	24
Total Crimes Reported	706	381-998	145	1,787
Average Patrols per Sworn Officer	.140	.125-.150	.070	.200
Clearances per Sworn Officer	3.31	1.62-6.11	0.45	11.91
Clearances per 100 Crimes Reported (Clearance Rate)	16.4	12.0-23.1	3.6	36.7

TABLE 1. Outputs, Inputs, and Selected Output/Input Ratios (continued)

	100 to 200 Sworn Officers (N = 49)			
	Median Value	Interquartile Range	Lowest Value	Highest Value
Average Patrol Units on the Street	13	11-16	6	27
Clearances by Arrest	856	540-129	286	2,154
Full-Time Sworn Officers	125	112-150	100	194
Full-Time Civilians	25	16-35	4	57
Number of Police Vehicles	38	30-52	20	81
Total Crimes Reported	4,091	3,041-5,156	1,386	8,147
Average Patrols per Sworn Officer	.103	.087-.124	.049	.182
Clearances per Sworn Officer	6.50	4.51-9.86	2.13	14.00
Clearances per 100 Reported Crimes (Clearance Rate)	22.0	16.7-28.8	8.8	36.9

department in this range recorded approximately 31 crimes per sworn officer in 1973, while the median department in the 25 to 50 sworn officer range reported approximately 20 crimes per sworn officer in that year. As noted above, total crimes reported was a significant predictor of total crimes cleared, independent of the level of discretionary resources. Thus it is to be expected that the larger departments obtained more clearances per sworn officer. Further, the larger volume of crimes in their jurisdictions appears to lead to a shift in production emphasis toward crime-solving activities, with the result that clearance rates are higher, while the deployment of patrol units for on-street duties is correspondingly lower.

Relative Efficiency

Efficiency analyses were performed separately in each size range. The output variables were the total number of crimes cleared and the average number of patrol units deployed for street duty. The discretionary inputs were the number of full time sworn officers, the number of full time civilian employees, and the number of police vehicles. One nondiscretionary input, the total number of reported crimes was also included in the computations.

Table 2 presents the ranges of relative efficiency computed in these analyses. In both size ranges the same proportion of departments (24%) were computed to be fully efficient. Among those found to be less than fully efficient, the range of efficiency values was wider in the subset of larger departments than in the smaller department subset. That is, the inefficient smaller departments were, on average, less inefficient relative to the best departments in that subset than were the inefficient larger departments relative to the

TABLE 2. Ranges of Relative Efficiencies.

	Median Value	Interquartile Range	Lowest Value	Number with Efficiency = 1.0
		25 to 50 Sworn Officers (N = 62)		
CFA Estimate	.798	.730-.986	.524	15
DEA Estimate	.845	.756-.986	.588	15
	Correlation of CFA and DEA Estimates = 0.930			
		100 to 200 Sworn Officers (N = 49)		
CFA Estimate	.694	.536-.990	.272	12
DEA Estimate	.796	.689-.990	.401	12
	Correlation of CFA and DEA estimates = 0.842			

best departments in their subset. This can be interpreted as indicating that there was more leeway for choosing inefficient production processes in the larger department subset than among the smaller departments. Note, however, that relative efficiencies reported in Table 2 were computed <u>within</u> each subset and, therefore, do not provide information regarding the comparative efficiency of the two subsets.[5]

The efficiency analysis technique enables the identification of outliers among the less than fully efficient units. When the lower bound efficiency estimate derived from CFA is smaller than the upper bound estimate computed by DEA, this indicates that the output and input mixes of the unit in question are not fully represented by the efficient units used to compute its relative efficiency score (see the Appendix for details). The "true" relative efficiency of such units is known to fall somewhere between the higher DEA value and the lower value computed with CFA, but its exact value cannot be specified (Clark, 1983). Among the 25 to 50 sworn officer departments, 23 percent had CFA efficiencies that were less than 95 percent of their DEA efficiencies, while among the 100 to 200 sworn officer departments, 31 percent exhibited this large a spread. This difference in CFA and DEA relative efficiencies introduces some uncertainty into subsequent analyses of productivity factors contributiing to efficiency by introducing an error into the efficiency estimate itself. As more units in the larger department set exhibit this difference than in the smaller department set, one would expect less satisfactory impact estimates for the productivity factors among departments in the larger set. This, in fact, is the case as is shown below. That is, there are more outliers in the larger set, making it more difficult to estimate factors affecting their relative efficiencies. To partially compensate for this, the relative efficiency of each department in both sets used for the productivity analyses is set at the average of the CFA and DEA computed values. This average, while still containing an error component, is closer to the true value of relative efficiency for such outliers than is either of the computed values.

Comparing Efficient and Inefficient Police Departments

Table 3 presents summary measures of output and input variables and selected output/input ratios for the departments identified as efficient and for those identified as inefficient in each of the size subsets. As one would expect, these data show that efficient departments obtain higher levels of police outputs, while employing generally lower levels of input resources.

The median number of patrol units deployed by efficient departments in the 25 to 50 officer range is 5.5, approximately 38 percent more than the median number deployed by inefficient departments in this size range. The median clearances by arrest among the efficient departments is 74 percent greater than among the inefficient departments. Efficient departments in this size range employ, at the median, more full time sworn officers and fewer civilian employees than do inefficient ones. The median values for patrols and clearances per sworn officer are substantially higher among the efficient than among the inefficient departments, as is the median clearance rate.

TABLE 3. Comparison of Outputs, Inputs, and Selected Output/Input Ratios for Efficient and Inefficient Departments.

Median Value of:	25 to 50 Sworn Officers		100 to 200 Sworn Officers	
	Efficient (N = 15)	Inefficient (N = 47)	Efficient (N = 12)	Inefficient (N = 37)
Average Patrol Units on the Street	5.5	4.0	14.0	12.5
Clearances by Arrest	172	99	958	787
Full-Time Sworn Officers	36	31	124	130
Full-Time Civilians	2	5	16	27
Number of Police Vehicles	8	9	36	38
Total Crimes Reported	547	716	3,918	4,306
Average Patrols per Sworn Officer	.157	.135	.124	.100
Clearances per Sworn Officer	3.91	3.17	7.70	5.78
Clearances per 100 Crimes Reported (Clearance Rate)	22.7	15.4	31.5	19.6

Similar output differences are found when comparing median values for efficient and inefficient departments in the 100 to 200 officer range, although the percentage differences are smaller. However, the median values for all input values among the efficient departments in this size range are lower than those among the inefficient ones, including a smaller median sworn officer complement. Here, too, the output/input ratios show significantly higher productivity values for the efficient departments.

Estimating Productivity Impacts

The intent of this research was to identify factors subject to management control which might improve the productivity of local police departments. Available data allowed the estimation of the productivity impacts of four classes of factors. These were 1) the allocation of sworn officers among various specializations within departments, 2) the substitution of civilians for sworn officers, 3) the utilization of reserve (volunteer) officers, and 4) the deployment of patrol officers in one or in two-person units.

Sworn officer allocation was measured by three variables. The first is the percent of sworn officers allocated to the patrol force. The second is the percent allocated to other direct and auxilary service production, i.e., investigation, traffic, radio communications, crime lab, and training. The third is the percent allocated to command functions and to staff such as planning and research. Civilianization was measured by the ratio of civilians to sworn officers in each department, while the use of reserve officers was measured by the ratio of volunteers to full time sworn officers. Patrol deployment was measured by the percent of patrol units deployed with a single officer assigned.

To estimate the productivity impacts of choices on each of these factors, the averages of the efficiency scores computed using DEA and CFA were regressed on them. The raw results of these regressions are shown in Table 4, and are discussed below. The sign of the estimated regression coefficients indicate the direction of productivity impact (positive, enhancing productivity; negative, reducing productivity), while the magnitude and statistical significance of the estimated coefficients indicate the degree of impact each factor has.

A variety of environmental variables were considered for inclusion as well. While none of these were consistently related to police outputs once adjustment was made for the level of total crime, environmental factors might still influence the efficiency with which input resources are transformed into outputs. From the set of possible socioeconomic and demographic variables considered, two were selected that had significant effects on productivity, independent of the effects of managerial variables. These were the percent of the population with incomes above the poverty level (as defined in 1970) and the percent of the housing stock built since 1940 (taken as a proxy indicator for the age of the community served and, by extension, the length of time an organized police force had been in existence). These two variables were included to adjust for environmental differences in the estimations of productivity impacts.

Productivity Impacts in the Smaller Departments

The set of managerial variables and environmental factors shown in Table 4 do a respectable job of explaining efficiency variations among the departments in the 25 to 50 sworn officer subset. In total, they explain 45 percent of the variation in relative efficiency among

TABLE 4. Productivity Impacts of Managerial Variables.

Managerial Variables:	25 to 50 Sworn Officers			100 to 200 Sworn Officers		
	b	s.e.	sig.	b	s.e.	sig.
Resource Allocation:						
% of Sworn Officers Allocated to Patrol	.006	.002	.000	-.000	.003	.881
% of Sworn Officers Allocated to Command and Staff Positions	.003	.002	.141	-.007	.004	.039
Civilianization:						
Ratio of Civilians to Sworn Officers	-.991	.251	.000	-.648	.495	.198
Use of Reserves:						
Ratio of Volunteers to Sworn Officers	.044	.035	.212	.055	.142	.698
Patrol Deployment:						
% One Officer Patrols	.002	.001	.000	.001	.001	.620
Environmental Factors:						
% of Population Above Poverty Level	-.006	.002	.019	-.003	.005	.603
% of Housing Built Since 1940	.001	.001	.510	.002	.001	.101
R2/R2	0.45/0.38			0.20/0.06		
N	62			49		

these departments. Three of the five managerial variables are highly significant ($p < .001$), while the other two just miss statistical significance.

Resource Allocation

The allocation of sworn officers to patrol duties has a significant positive influence on relative efficiency among these departments. The coefficient for percent of sworn officers allocated to patrol, a positive .006, indicates that a ten percent increase in this allocation would increase relative efficiency by .06. For the median department in this size range, this means that increasing the percent of sworn officers allocated to patrol duties from its present value of 69 percent to an allocation of 79 percent would increase relative efficiency from 0.82 to 0.88, a seven percent increase in efficiency. The coefficient for officers allocated to command and staff positions is also positive, although not statistically significant.[6] It suggests that less efficient departments in this size range may underinvest in these functions relative to more efficient ones.

Use of Civilians and Reserves

The ratio of civilians to sworn officers exhibits a strong negative relationship with relative efficiency among these departments. The median department in this size range has a ratio of 0.12 civilians for each sworn officer (or about one civilian for each eight sworn officers). From the coefficient estimate shown in Table 4, a doubling of this ratio, increasing civilians from 4 to 8, would reduce relative efficiency by nearly 0.12, a reduction of some 14 percent for this median department. Of course some of this reduction would be offset in dollar terms by the lower cost of civilian employees, but the sign of the coefficient (negative) indicates that such cost savings are outweighed by losses in the outputs of interest here. The coefficient for the ratio of reserve to full time sworn officers is positive but quite small (and not statistically significant). This means that reserve officers contribute little to these departments' efficiencies.

Patrol Deployment

Deploying patrol officers in one person units instead of two has a positive and significant impact on the relative efficiencies of these departments. In this size range, most departments do, in fact, use almost exclusively one officer patrols. Those that do not pay a penalty in reduced relative efficiency. If, for example, the median department were to shift from exclusive use of one officer patrols to a mix that included half two officer patrols, its relative efficiency would drop from 0.82 to 0.72, a reduction of twelve percent.

Summary

Summarizing the productivity impacts for departments in the 25 to 50 sworn officer range, some recommendations may be offered for managers of similar departments. First, when allocating sworn officers among specializations within the department, consider bolstering the patrol division first. The results presented above suggest that officer assignments to this division are the most significant in enhancing departmental efficiency. Second, deploy patrol officers in one officer rather than two officer units. This deployment, too, enhances departmental efficiency. Third, consider whether additional personnel are needed in command and staff positions. The results above suggest that less efficient departments underinvest in such assignments. Last, be wary of recommendations to substitute civilians for sworn officers. While civilian personnel are less costly, their contribution to departmental productivity is lower than that of sworn officers, and the results above suggest that such substitution can reduce departmental efficiency.

Productivity Impacts in the Larger Departments

Unfortunately, very little can be said about the impact of the managerial variables included in this research on relative efficiency among departments in the 100 to 200 officer range. Only one of the variables considered is marginally significant. The coefficient for this variable, the percent of sworn officers allocated to command and staff positions, exhibits the opposite pattern from that found for the smaller departments. Its negative coefficient suggests that less efficient larger departments overinvest in command and staff ranks rather than underinvest. Police managers in similar departments, therefore, may wish to review their allocations of officers to such positions, questioning whether more productive assignments may be found for some command and staff officers. As with the smaller departments, civilianization is negatively related to relative efficiency among the larger departments, though the coefficient for this variable falls short of statistical significance. Its substantial negative magnitude, however, suggests that managers of departments in this larger size range, like their colleagues in smaller departments, should be wary of substituting civilians for sworn officers. Other than these two rather weak relationships, the remaining managerial variables had essentially no relationships with relative efficiency. Obviously there are other factors at work which explain the differences in relative efficiency among these departments, but they could not be ascertained in this research.

Conclusions and Speculations

This report documents research aimed at identifying factors subject to managerial control which could be manipulated to enhance the productivity of local police departments. The research was exploratory in that it attempted to bring some recent methodology developed in management science to bear on this question. As with much exploratory research, the results are mixed. Analyses were conducted on two sets of police agencies. For one set, police departments employing between 25 and 50 sworn officers, managerial factors were identified that were significantly related to police productivity. Based on this identification, it was possible to recommend management strategies for these departments - increasing resource allocation to patrol, deploying officers in one person units wherever possible, and limiting the substitution of civilians for sworn officers. For the second set, departments employing between 100 and 200 sworn officers, the results were not satisfactory. While the methodology successfully identified the more efficient departments in this size range, the managerial factors analyzed were not consistently related to variations in departmental efficiency.

A possible explanation for this difference in results lies in the nature of managerial factors which could be explored in this analysis. The methodology employed for computing the relative efficiency of a set of agencies embodies an assumption that the units analyzed are "similar." That is, the underlying process for transforming inputs to outputs is common among the units studied. The data were analyzed in two size subsets because it was clear from an examination of outputs supplied that the two subsets differed significantly in their relative emphases, the subset of smaller departments emphasizing patrol related outputs and the larger subset emphasizing investigation related ones. The managerial factors which did a satisfactory job of explaining productivity variations among the small, but not among the larger departments, are relevant for departments with a patrol emphasis, but much less so for departments emphasizing investigative outputs. For departments having such an emphasis, further analysis is required to identify factors enhancing investigative productivity.

Footnotes

1. Lewin, Morey, and Cook (1982) provide a vivid example of the difficulty in assessing efficiency using ratio analysis. Examining ten output/input ratios for 30 judicial districts in North Carolina, they found no consistent patterns of districts scoring well (or poorly) across all such ratios. They conclude with respect to such ratios that "(i)t is clear that no simple rule can distinguish between the districts, which are to be ranked efficient and inefficient, without making subjective judgements as to which ratio measure is most important (408-9)."

2. Military recruiting has been studied with this methodology by Lewin and Morey (1983). Bessent, Bessent, Clark, and Elam (1983) have applied it to the comparative efficiency of Air Force wings. Rhodes (1978) focused on the relative efficiencies of national parks, while Sherman (1981) and Banker, Conrad, and Strauss (1981) applied the methodology to hospital efficiency. Educational productivity has been the subject of studies by Charnes, Cooper, and Rhodes (1981), by Bessent and Bessent (1980), and by Bessent, Bessent, Kennington, and Reagan (1982).

3. Bessent and Bessent have established the Educational Productivity Council at the University of Texas at Austin. The Council is comprised of school districts in the State of Texas which use efficiency analyses to support managerial decision making in the Texas schools.

4. Because the efficiency analysis methodology employs extremal relations, it is particularly sensitive to outliers that result from possible miscodings of data. The data for departments in each of the size subsets were carefully screened before analysis, and those cases where such miscoding seemed likely were excluded.

5. In an attempt to explore this question of size-related efficiency, a subsidiary analysis was made to compare the relative efficiency of departments that were fully efficient in each subset. This analysis indicated that there was virtually no overlap in the efficient frontiers from the two subsets. That is, efficient departments in the smaller subset did not dominate efficient ones in the larger subset nor vice versa. This finding provides further evidence for a difference in production emphasis between the smaller and larger departments and validates the decision to perform seperate analyses of each.

6. The three sworn officer allocation variables are linearly related, requiring that only two be included in these regression analyses. The allocation to patrol and that to command and staff positions were selected here.

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APPENDIX

Graphical Interpretation of Efficiency Computations

This Appendix illustrates the efficiency computations in Data Envelopment and Constrained Facet Analyses. The conceptual difference between these two approaches is demonstrated, along with the difference in efficiency values obtained from each. To keep the example simple, seven decision making units are included, each of which uses a combination of two input factors to produce a single output. The level of output obtained is arbitrarily set at one unit, while the mix of inputs employed is allowed to vary among the decision making units. The data employed in this example are:

DMU	Output	Input 1	Input 2
1	1	3	6
2	1	4	3
3	1	6	2
4	1	4	10
5	1	6	7
6	1	6	3
7	1	10	2

Figure 1 is a plot of the inputs utilized by each decision making units in the production of one unit of output. In the plot, the decision making units that employ the smallest combinations of inputs one and two are those which lie closest to the origin. These DMUs, labeled D1, D2, and D3 define the production frontier for one unit of output. That is, all of the other DMUs require more of input 1, input 2, or both to obtain the same level of output. The solid line connecting D1, D2, and D3 is the empirically determined production frontier and would be identified as such by both DEA and CFA.

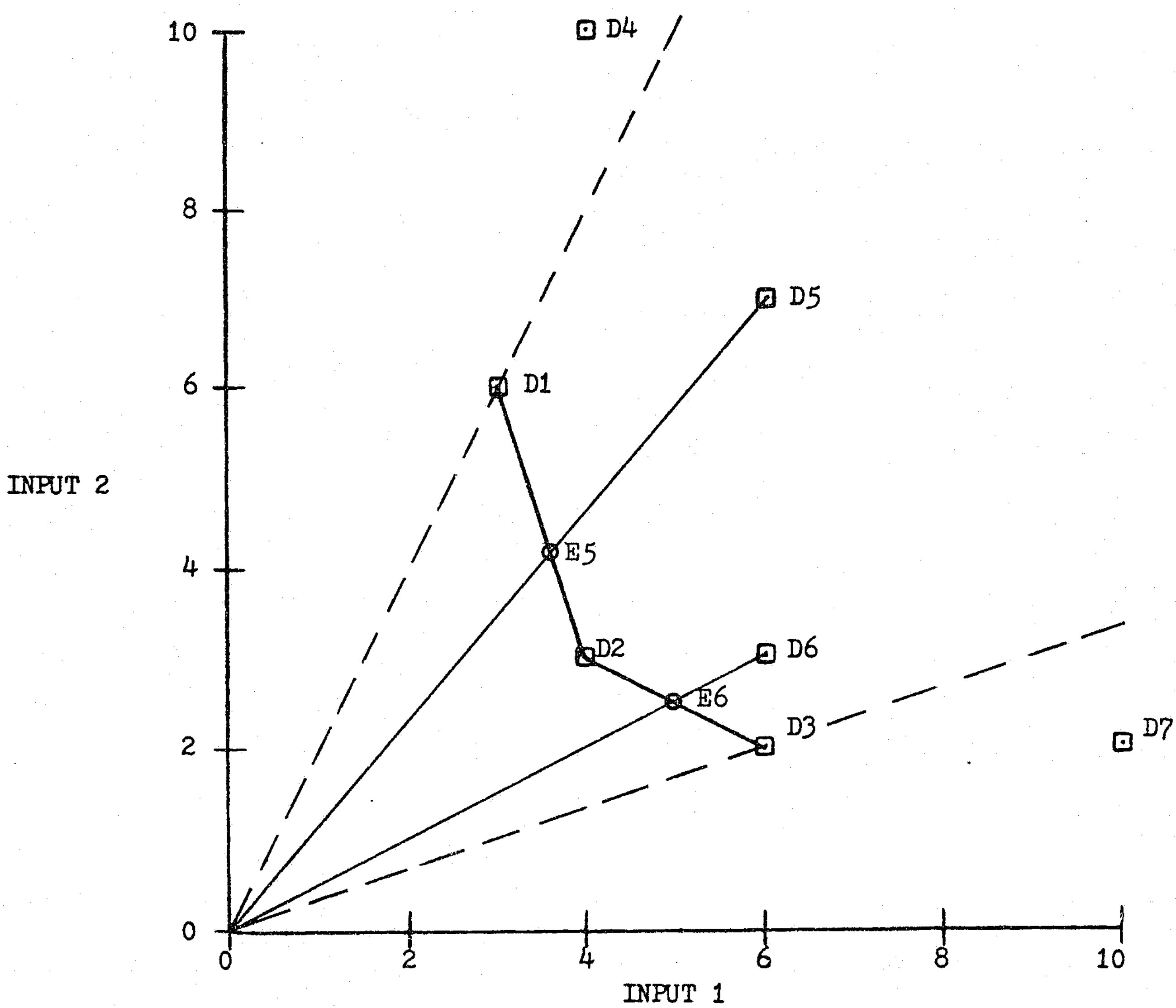
Decision making units which lie farther from the origin than DMUs D1, D2, and D3 are inefficient in that they utilize input factors in excess of those utilized by the efficient DMUs. The dashed lines in Figure 1 define a cone extending out from the origin. The cone is defined in terms of the input mixes of D1 and D3. Any other DMUs which fall within this cone (e.g., D5 and D6) are said to be fully enveloped, meaning that their relative efficiency can be directly computed relative to the efficiency of one or more DMUs on the efficient frontier. For such fully enveloped DMUs, Data Envelopment and Constrained Facet Analyses assign identical relative efficiency ratings.

Consider first DMU D5. A ray extending from the origin to D5 intersects the efficient production frontier at point E5. This means that if DMU D5 were to be fully efficient, it could produce one unit of output using the input combination represented by point E5. The relative efficiency of DMU D5 is computed as the ratio of the lengths of line segments OE5 and OD5. That is,

$$\text{Relative efficiency for D5} = \text{OE5/OD5} = 0.60,$$

and DMU D5 is said to be similar to DMUs D1 and D2, the DMUs which define the portion of the frontier that includes E5. Using the same logic, the relative efficiency of DMU D6 is computed as the ratio of line segment OE6 to line segment OD6 yielding a value of 0.83, and DMU D6 is said to be similar to the efficient DMUs which define the portion of the frontier that includes E6, in this case DMUs D2 and D3. As noted above, the relative efficiency estimates for the fully enveloped DMUs, D5 and D6, are computed identically by Data Envelopment and Constrained Facet Analyses.

Figure 1. Efficiency Analysis for Fully Enveloped DMUs.



Relative Efficiency Ratings for:

D1 = 1.0	D5 = OE5/OD5
D2 = 1.0	D6 = OE6/OD6
D3 = 1.0	

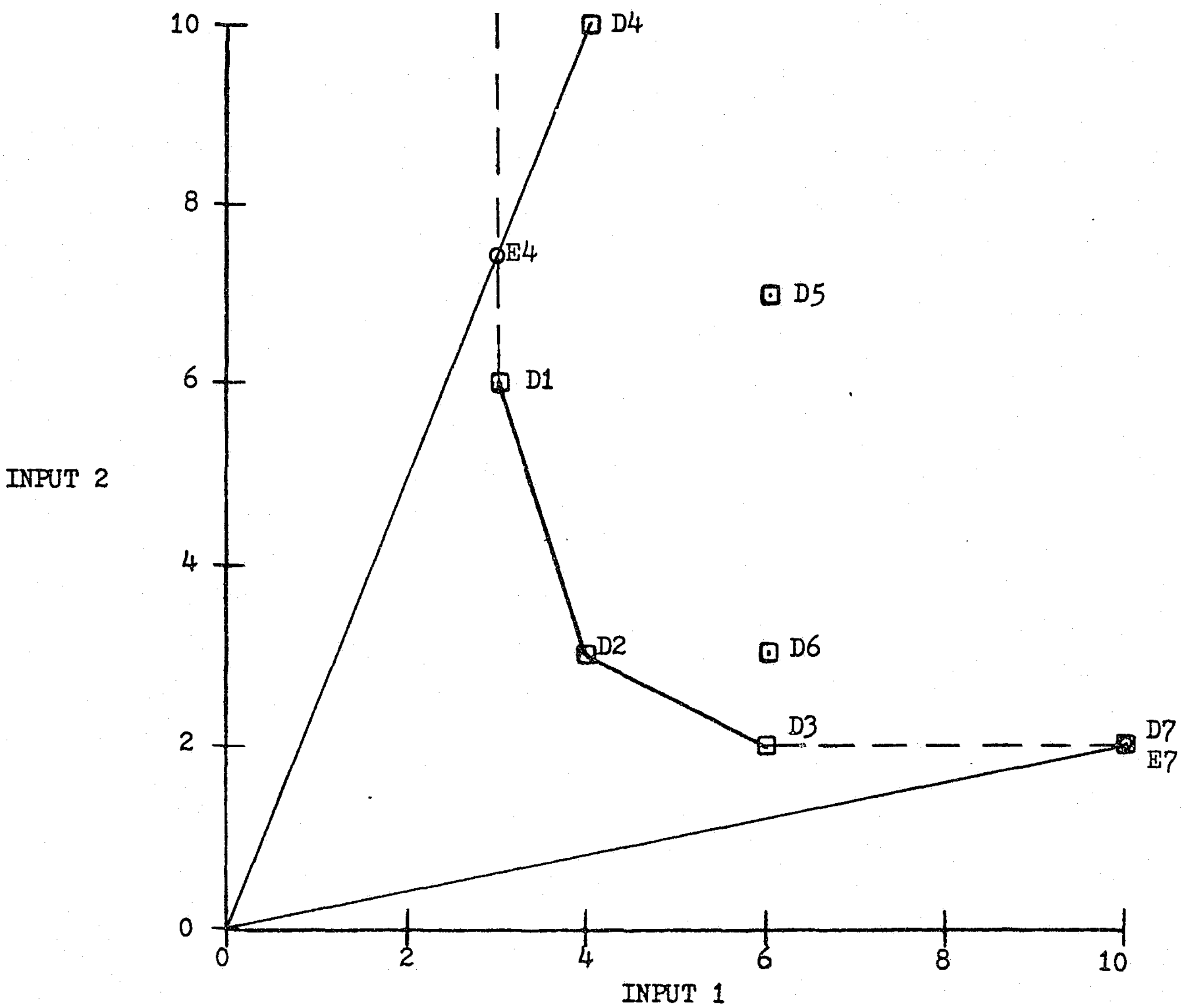
Decision making units D4 and D7 lie outside the cone defined by D1 and D3 and are not fully enveloped. The distinction between the efficiency computations in Data Envelopment Analysis and Constrained Facet Analysis turns on the way that these two methods extend the production frontier to envelope units like D4 and D7.

Figure 2 shows the extension of the production frontier as it would be done in Data Envelopment Analysis. The frontier is extended from an observed DMU lying on the production frontier by constructing a pseudo frontier parallel to the appropriate input axis. The dashed lines in Figure 2 represent such extensions, with the pseudo frontier extended from D1 parallel to the input 2 axis and a pseudo frontier extended from D3 parallel to the input 1 axis.

Data Envelopment Analysis computes the relative efficiencies of units that are not fully enveloped by making use of these extended pseudo frontiers. The relative efficiency of DMU D4, for example, is computed as the ratio of line segment OE4 to line segment OD4 with a resulting efficiency score of 0.75. The relative efficiency of DMU D7 is computed by Data Envelopment Analysis as equal to 1.0, since it lies on the extended pseudo frontier.

Constrained Facet Analysis uses a different method to extend a pseudo frontier. As shown in Figure 3, the pseudo frontiers in CFA are created by extending the nearest empirically defined frontiers. The dashed lines in Figure 3 represent such extensions, with a pseudo frontier extended from D1 with the same slope as the empirically defined frontier segment linking D1 and D2. The second pseudo frontier extension is that from D3, simply extending the empirically defined frontier segment linking D2 and D3.

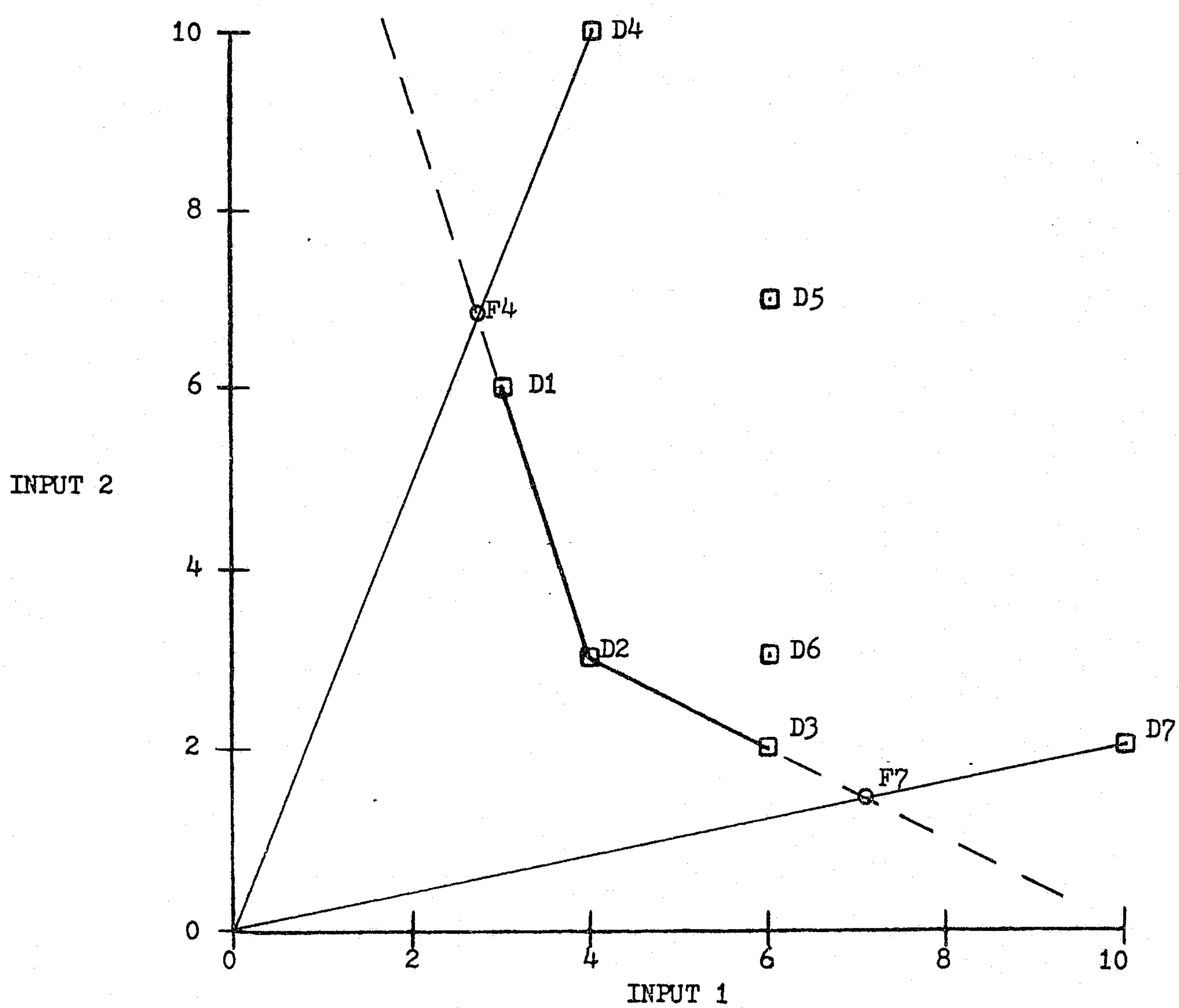
Figure 2. Data Envelopment Analysis for DMUs That Are Not Fully Enveloped



Relative Efficiency Ratings for:

D4 = OE4/OD4 D7 = 1.0

Figure 3. Constrained Facet Analysis for DMUs That Are Not Fully Enveloped



Relative Efficiency Ratings for:

D4 = OF4/OD4   D7 = OF7/OD7

Constrained Facet Analysis computes relative efficiencies of units that are not fully enveloped using these extensions of empirically based frontier segments. The relative efficiency of DMU D4, for example, is computed as the ratio of line segment OF4 to line segment OD4 in Figure 3, yielding a value of 0.68. The relative efficiency of DMU D7 computed using CFA is the ratio of line segment OF7 to line segment OD7, with a resulting value of 0.71.

The relative efficiencies computed using each method, together with the average relative efficiency using both methods are:

DMU	CFA effic.	DEA effic.	Average effic.
1	1.0	1.0	1.0
2	1.0	1.0	1.0
3	1.0	1.0	1.0
4	0.68	0.75	0.715
5	0.60	0.60	0.60
6	0.83	0.83	0.83
7	0.71	1.0	0.855

As noted in the text of this report, decision making units for which the DEA and CFA efficiencies differed were assigned a relative efficiency equal to the average of the efficiency values computed using each method.