AN URBAN INSTITUTE PAPER

THE DEVELOPMENT OF A PROTOTYPE EQUATION FOR PUBLIC HOUSING OPERATING EXPENSES

Robert Sadacca
Morton Isler
Joan DeWitt

209-43-1

A report on research supported by *Department of Housing and Urban Development*
Office of Policy Development and Research

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June 1975

THE URBAN INSTITUTE
WASHINGTON, D.C.

The research forming the basis for this report was funded by the U.S. Department of Housing and Urban Development, Office of Policy Development and Research. Opinions expressed are those of the authors and do not necessarily represent the views of the Urban Institute or its sponsors.

REFER TO URI-11900 WHEN ORDERING

U.I. 209-43-1
ISBN 87766-144-8

Available from:

Publications Office
The Urban Institute
2100 M Street, N. W.
Washington, D. C. 20037

List price $3.00

A/75/1M

Acknowledgments

The development of the prototype expense equation is an outgrowth of the comprehensive study of public housing management currently being conducted by the Department of Housing and Urban Development (HUD) under the Management Improvement Program. A large portion of the data base used to develop the equation was collected in the Spring of 1973 as part of a joint Urban Institute-HUD effort to identify promising, innovative techniques for improving public housing management. The contributions of the numerous people who helped collect the data is acknowledged in an earlier Institute paper, Management Performance in Public Housing, which described the initial results of the analysis of that data. The authors wish to express once again their appreciation to the Housing Authority staffs and tenants who participated in the survey and to the many individuals at HUD, the Institute, TransCentury Corporation, the National Association of Housing and Redevelopment Officials (NAHRO) and the National Tenants Organization (NTO) who provided invaluable assistance in the original development of the survey instruments.

The prototype expense equation was developed as an integral part of the Performance Funding System. The authors worked very closely with HUD officials in each step of the developmental process. ArDee Ames, Kenneth Moul, Janice Rattley, John Shaw, Milton Slifkin, and John Comerford of the Office of Housing Management contributed many suggestions which helped to shape the equation and its use. Valuable contributions were also made by Assistant Secretary H. R. Crawford and by Gerald Brittingham and other members of Mr. Crawford's staff.

Numerous members of NAHRO also played a key role in the development of the equation and the Performance Funding System. Mary Nenno and Thomas Duvall organized a number of NAHRO workshops at which the reactions of Housing Authority officials from around the country were obtained. Important suggestions were received from a subcommittee formed by the NAHRO Committee on Housing Production and Management to review the methodology employed by the Institute.

Valuable comments and suggestions were also received from expert representatives of Congressional committees, the Office of Management and Budget, NTO, various Local Housing Authorities, and several Offices within HUD who reviewed the Performance Funding System in its formative stages. These suggestions are still being received and in so far as practical will be incorporated in the future development of the equation.

The authors are particularly grateful to Tina Chen, David Grant and Frank Wann of the Institute staff for the many computer simulations and analyses they conducted before the final equation was derived.

TABLE OF CONTENTS

CHAPTER		Page
I.	INTRODUCTION	1
	Background	1
	The Essence of the Prototype Equation	7
	Use of the Prototype in the Performance Funding System	8
	A Perspective of the Prototype Expense Approach	10
	Questions Raised by the Prototype Approach	12
II.	THE DEVELOPMENT OF THE DATA BASE	13
	Sampling	13
	Data Collection Instruments	18
	Data Collection Procedures	21
	Definition of Variables	22
III.	DIVISION OF AUTHORITIES INTO HIGH AND LOW PERFORMANCE GROUPS	25
	Options for Adjusting Criterion Scores	25
	Procedure for Forming Performance Groups	29
	Selection of the Full-Control Method	31
	Reliability of the Performance Groups Division	33
IV.	GENERAL APPROACH TO DEVELOPING THE PROTOTYPE	37
	Definition of the Expense Variable	37
	Criteria for Selecting Independent Variables	39
	The Basic Computational Procedure	41
	Prediction Errors	43
	The Problem of Forward Funding	45
V.	EARLY TRIAL RUNS	47
	The Candidate Independent Variables	47

Page

VI. THE PERFORMANCE FUNDING SYSTEM.....53

The Distinction Between the Prototype Equation and The Performance Funding System.....53
Primary Elements of the Performance Funding System.....54
Primary Elements of the Expense Equation.....55
The Use of Range Tests.....56
Use of Latest One Year of Data.....59
Use of a Single Equation.....60

VII. THE INFLATION FACTOR.....63

Reasons for Using the Inflation Factor as a Multiplier....63
The Problem of Projecting Next Year's Wage Rate.....66
Choices in Forming the Regression Equation.....67
The 1974 Regression Equation and Inflation Factors.....69

VIII. THE PROTOTYPE EXPENSE EQUATION, 1974-1975.....71

The Time Framework.....71
The Final Selection of Variables.....72
Comparison of 1974 Prototypes and Budgets for the Sampled Authorities.....75
Tests of Application of the Range Tests on 1974 Prototypes.....79

IX. LOOKING AHEAD.....83

Will the Subsidies Be Adequate?.....84
What Will Happen to the Low Performance Authorities?.....86
Can Standards Be Defined for Housing Services?.....87

APPENDICES

A. CRITERION, CONTROL, MANAGEMENT, AND SWING VARIABLES.....89

Table A-1 Definition, Source, Units, Means and Ranges of the 24 Criterion Variables and the Results of Significance Tests of Mean Differences.....91
Table A-2: Control, Management, and Swing Variables.....97

B. PROCEDURE USED IN ESTIMATING THE RELIABILITY OF THE ASSIGNMENT OF AUTHORITIES INTO PERFORMANCE GROUPS.....101

C. POPULATION GROWTH FACTORS BY STATE.....109

Chapter I
INTRODUCTION

Background

In recent years, Local Housing Authorities (LHA's) have encountered severe financial problems in the operation of public housing projects. The original design of the public housing program essentially called for the federal government to pay only the costs of acquiring sites and constructing buildings. Maintenance costs were to be covered by rents paid by the tenants. However, inflation and other factors have caused operating expenses to rise faster than the tenants' rent-paying ability. The growing gap between Authority operating expenses and rental income has been the subject of considerable concern to the federal government and, of course, to the Housing Authorities themselves.

To illustrate the intensity of the problem--if an LHA's total operating expenses and rental income per dwelling unit per month (PUM) were initially balanced at $60, expenses after 8 years would exceed income by about $20 PUM if expenses rose an average of 6 percent a year and rental income rose only 3 percent a year. If the LHA had 5000 units, its annual deficit would be about $1,200,000. Two years later the annual deficit would be about 37 percent higher, rising on an accelerating curve.

Today, every one of the more than 100 large (1,250 or more units) Housing Authorities is operating at a deficit. This is also true of an increasing proportion of the smaller LHA's. Expenses began to

exceed rental income for many LHA's in the 1960's. The constraint on rental income reflected the intention that residents should not have to pay an undesirably high proportion of their limited income for rent. In spite of this intention, rent-to-income ratios of many tenants gradually increased and, by the late 1960's, some public housing residents were paying 40 and even 50 percent of their income for rent.

In 1962, however, the first help had come from the federal government in the form of a supplement of $120 per year to the LHA to house each family that was displaced by public action or that was elderly, extremely poor, or comprised of one or more adults plus four or more children. Although these funds helped to postpone the crisis, by the late 1960's it was clear that Authorities were deferring essential building maintenance and other services, using up reserves, and charging residents high proportions of their incomes for rent to avoid bankruptcy. Consequently, Congress found it necessary and desirable (in the Housing Acts of 1969 and 1970 with some later modifications) to limit the proportion of income that families would be required to pay in public housing rents and to provide a general operating subsidy to meet the difference between the resultant rental income and LHA operating expenses.

The total amount of this federal operating subsidy has risen sharply over the past few years (see Figure I). The steep increase in the

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1. The recent history of expenses and rental income is analyzed in Frank de Leeuw, Operating Costs in Public Housing: A Financial Crisis (Washington, D.C., The Urban Institute, 1970) and Frank de Leeuw and Sue Marshall, Operating Expenses in Public Housing, 1968-71 (Washington, D.C., The Urban Institute, 1973).

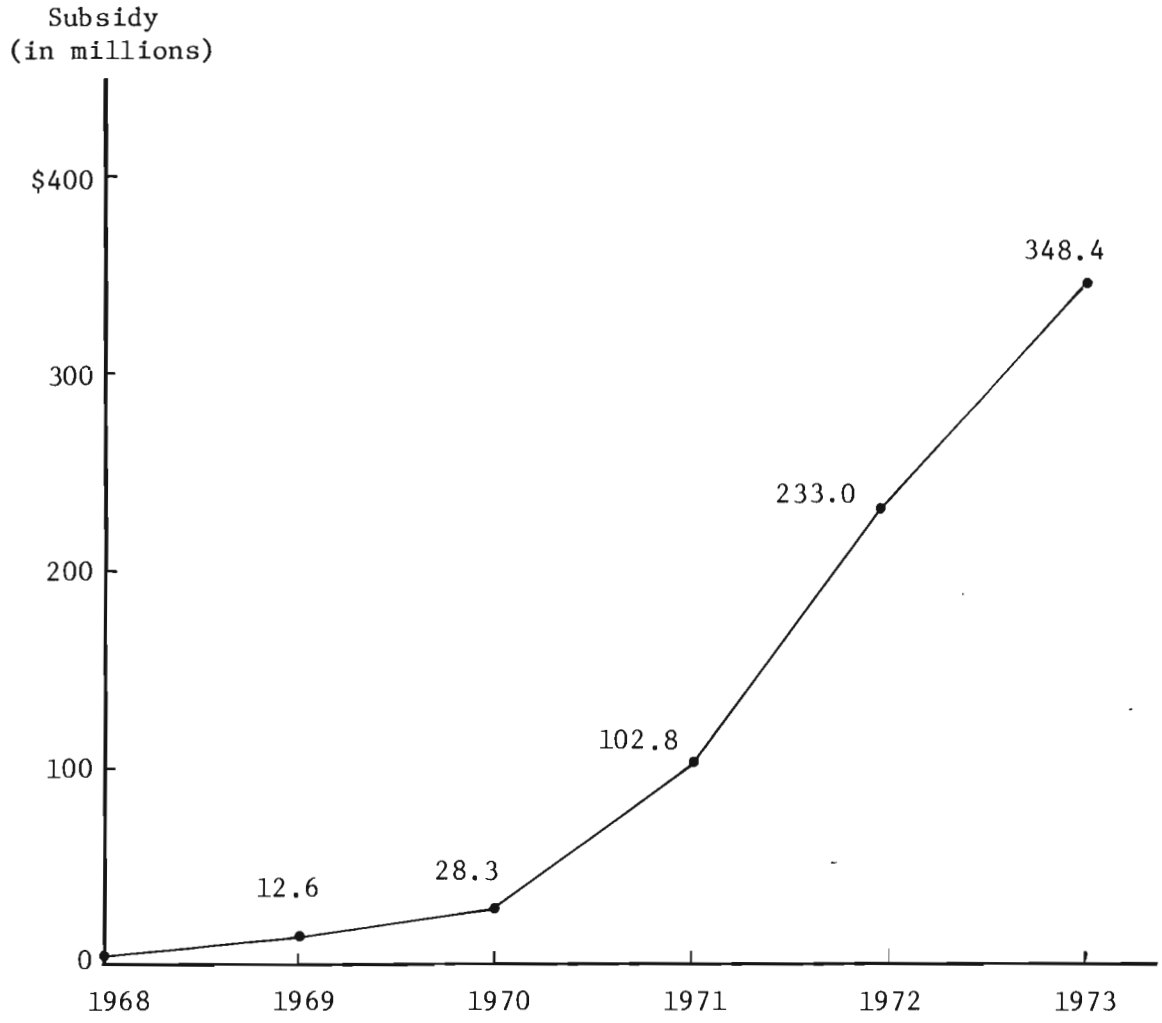

Figure I: Amount of Federal Operating Subsidy
During Period 1968-1973

subsidy level can be explained in part as a "catching up" from the depressed levels of operating expenditures of the 1960's. Even more important, however, has been the high rate of general inflation in prices and wages.

The Conference Report (No. 91-740) submitted with the Housing and Urban Development Act of 1969 made it clear that Congress was

> ...deeply concerned over cases of lax management in many public housing projects which have led to high operating costs, deterioration of property and an intolerable environment for families who live there.

Naturally, Congress wished to avoid subsidizing waste and mismanagement.

In summary, when the new operating subsidies were implemented, it was necessary to balance the following public policy concerns: (1) permitting the LHA's to house very low income families at rents in fair proportion to incomes; (2) allowing the LHA's to keep up housing services and maintain housing stock despite inflation; and (3) encouraging the LHA's to provide good management and avoid wasteful expenditures. HUD was made responsible for achieving this balance through the administration of the operating subsidies.

In 1972, while a long-term solution to the problem was sought, HUD put into effect an "Interim" funding formula which has essentially restricted the percentage increase in LHA operating expenses supportable by federal subsidy to 3 percent per year during 1972 and 1973, and 5.5 percent during 1974. Authority rental incomes are assumed to be rising at the rate of 3 percent per year in the calculation of the subsidy. Increased management efficiency, larger proportions of relatively high income households,

and the use of reserves were suggested as means by which the LHA's could meet anticipated deficits that exceeded those allowed under the formula.

The Interim formula was meant to be used only temporarily; it had some obvious weaknesses. For one thing, it uses a single inflation rate for the entire country despite the substantial variation among regions of the nation in housing prices and inflation rates. For LHA's in areas with above-average inflation rates, cuts in housing services and stock maintenance would be inevitable if the formula were imposed for a number of years.

Another deficiency of the Interim formula is its acceptance of whatever expense level an Authority had in 1972 as the base for the application of the percentage increases. If an Authority had been operating on a tight budget, the Interim formula would tend to penalize it more than others; conversely, Authorities with a high expense level were supported at that level even if they were operating inefficiently.[2] Expenses on a PUM basis vary considerably among the LHA's; many LHA's have expenses 100 percent greater than those of others. Although many differences stem from regional variations in prices and wages, it is not uncommon to find neighboring LHA's with similar operating characteristics that have a difference in expenses of 20 percent or more. The Interim formula perpetuated these differences.

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2. By no means does a higher expense level always indicate that an LHA is operating inefficiently. Some LHA's with relatively high expense levels are providing higher levels of services (e.g., better maintenance) or even services not provided at all by their neighbors (e.g., security patrols). Furthermore, the environments in which Housing Authorities operate are never precisely the same, even when the LHA's adjoin one another.

Soon after the Interim formula was adopted, The Urban Institute was asked by HUD to develop an objective means to take local prices and wages into account and to judge the reasonableness of individual LHA expense levels. Furthermore, the Institute was to work with HUD to see how those expense levels could be incorporated into a performance-oriented funding system. The project was to use and build on the Institute's past work in the analysis of housing operating costs and management quality and the detailed surveys and field interviews conducted as part of HUD's Management Improvement Program.[3]

When HUD and The Urban Institute initiated this task, it was agreed that the prototype expenses, the objective values derived from the analysis, would be separated from the Performance Funding System, which incorporates the decision rules that HUD used to derive subsidy levels from the prototype expenses. This important separation has been recognized throughout the development of the Performance Funding System, and distinctions between the system and the underlying prototype expense analysis are identified through this report.

Note also that the prototype is not, and was never meant to be, a way to "stop" the continuous rise in LHA operating deficits and

---

3. For example, Morton L. Isler, Margaret J. Drury and Clay Wellborn, Housing Management: A Progress Report (Washington, D.C., The Urban Institute, 1971); Robert Sadacca, Morton Isler and Margaret Drury, "Housing Management: A Second Progress Report" (Washington, D.C., The Urban Institute, 1971); Robert Sadacca, Margaret Drury and Morton Isler, "Ownership Form and Management Success in Private, Publicly-Assisted Housing" (Washington, D.C., The Urban Institute, 1972); Morton L. Isler, Robert Sadacca and Margaret J. Drury, Keys to Successful Housing Management (Washington, D.C., The Urban Institute, 1974); Robert Sadacca, Suzanne B. Loux, Morton L. Isler and Margaret J. Drury, Management Performance in Public Housing (Washington, D.C., The Urban Institute, 1974).

consequent increase in subsidy requirements. To the extent that inflation (e.g., rising fuel costs) widens the gap between Authority expenses and rental income, the best a performance-oriented funding system can do is realistically reflect the rising costs and fund Authorities accordingly. This system does provide incentives to improve management efficiency, but as long as inflation remains a problem, Housing Authorities will probably need increased financial assistance.

The Essence of the Prototype Equation

The prototype equation relates the actual expenses (excluding the purchase of utilities) of high performance LHA's to significant operating conditions beyond the Authorities' control, e.g., regional variations in operating costs or size (average number of bedrooms) of the dwelling units.

A very simple prototype equation looks like this:

$$\text{Prototype Expense} = xR + yB + C$$

(where R is the regional relative cost of LHA operations, where B is the average number of bedrooms in the dwelling units of the Authority, where x and y are the weights assigned to R and B in the derivation of the equation, and where C is the equation constant[4]). To derive the actual equation, 120 Housing Authorities were studied. Over 8,500 interviews were completed at these Authorities, and financial and other records were examined. This information was used to divide the

4. The equation constant is a number which operates to make the average of the prototype expenses of the high performance LHA's equal to the average of their actual operating expenses.

Authorities into High and Low Performance Groups. Data that described the operating conditions faced by each Authority were also gathered. The expense levels of only the High Performance Authorities were then mathematically related to their operating conditions.

The actual equation and its derivation are described in this report. In reviewing the details of the actual equation, some of its primary attributes should be kept in mind:

(1) The prototype expense levels are based on actual expenses of High Performance Authorities.

(2) Authority performance is determined by its relative standing on twenty-four criteria ranging from tenant and management staff satisfaction and their perceptions of the condition of buildings to ratings of the Authorities by HUD area offices.

(3) Prototype expense levels are not tied to a single Authority's performance; the average expenses of all High Performance Authorities with similar operating circumstances are defined as the prototype expense level for an Authority.

Use of the Prototype in the Performance Funding System

The prototype equation will serve, in the first year, as a yardstick. It will be used by HUD to determine whether the current operating budget (excluding utilities) of each Authority is an acceptable base on which to apply the system. To make this assessment, a unique prototype expense level for each Authority will be computed by inserting into the equation the current operating conditions faced by that LHA. Furthermore, to permit some variance for operating conditions not encompassed by the equation, the prototype will be expressed in a range that extends approximately $10 above and $10 below the calculated prototype expense. If

the current operating budget of an Authority is above the upper limit of its range, its budget will be considered too high; if the current operating budget is below the lower limit of its range, its budget may be raised, upon HUD approval, to the lower limit of its range.

Under a rule being considered by HUD, a current operating budget that both the Authority and HUD consider too low will not be raised in the current year in the sense that more current subsidy funds would be made available. However, the current operating budget would be raised when the budget is used as a base in the determination of next year's allowable expense level.[5] Similarly, a current operating budget considered too high will not be lowered in the current year; however, the Authority would be required to use the upper limit of the prototype range as its base in the determination of next year's allowable expense level.[6] Authorities whose current operating budgets are below or within their ranges and who do not receive approval for any requested increases would use their current budgets as the base.

The prototype equation will be used in the first year and in subsequent years to calculate the permissible change in the expense base of each Authority in view of changing operating conditions. The base amount will be updated annually in a two-step operation. Initially, the difference between the next year's prototype (based on projected operating circumstances) and the current year's prototype (based on current operating circumstances) will be added to the base amount. Then this answer will be

5. In general, requests from Authorities for an adjustment in their base levels may be submitted to HUD only during the first year of the Performance Funding System. Exceptions to this rule may be allowed under special circumstances.

6. Under the option of a "hold harmless" rule under consideration by HUD, future budgets of above-range Authorities may be frozen at their current levels until their base amount exceeds their current budget.

multiplied by an inflation factor appropriate to the location (state or county) of the Authority. The following equation summarizes both steps:

New Base = (Current Base + Next Year's Prototype - Current Prototype) x (Inflation Factor)

This new base will then be used, along with projected utility expenses, operating income, and number of unit-months availability, to determine next year's subsidy levels. Both the inflation factor and the prototype equation will be updated annually.

A Perspective of the Prototype Expense Approach

The prototype equation should provide a better basis for the distribution of operating subsidies than did the earlier approaches. It permits the subsidy to be tailored to the operating conditions faced by individual Housing Authorities, and it sets a standard measure for allowable expenses within which Housing Authorities should be encouraged to operate efficiently.

This standard, however, is relative--it reflects what it actually costs the better-performing Housing Authorities to operate under different conditions. Therefore, the approach does not address the questions, "What level of services should a Housing Authority provide its residents, and how much should it cost Housing Authorities to provide these services?"

Many individuals who have commented on the prototype have expressed a preference for setting (and costing out) absolute standards for Housing Authority performance rather than for the relative approach taken in the prototype system. It was the judgment of HUD, after consideration of recommendations by the Institute, that an approach that relied on absolute standards was not feasible due to time constraints. To set

absolute standards, one must determine quantitative and qualitative levels of many kinds of housing services,--e.g., heat, hot water, grounds cleaning and care, building repair responsiveness, personal security, property security, and privacy. Even if standards could be set for all these services, it would be difficult and time consuming to establish them.

In setting levels of services, moreover, there is the question of local options and trade-offs--residents in different localities may prefer different levels of individual services and be willing to sacrifice quality or quantity in one service to obtain higher levels of another. Furthermore, it would be necessary to determine who should make the judgments involved in setting the standards. There are many interested individuals and groups: Congress, state and local government officials, LHA staffs, public housing residents, HUD, and the federal Office of Management and Budget. Standards must be related to the customs, values and ethics of our society and would surely be controversial.

Finally, even if one did determine what types and levels of housing services <u>should</u> be provided to public housing residents, one would still have to attach expense levels to the services in a manner that would consider the wide differences in Authority operating conditions. The decision was made, therefore, to determine how much it <u>does</u> cost relatively high performance Authorities to operate and how operating conditions affect these Authorities' levels of expenditures.

Questions Raised by the Prototype Approach

Even posing the question in relative rather than absolute terms raises difficult questions. What criteria does one use to determine the performance level of Authorities? How does one weight these criteria? What level of relative performance should be considered high--above the 50th, the 75th or the 90th percentile? What operating conditions should be considered in defining prototype expense levels? For example, should differences in tenant composition be considered?

Throughout the development of the prototype expense equation, these and many more questions were faced. The next four chapters describe the general methodology employed. Chapters II and III describe how the data base for the study was developed and how the Authorities were divided into High and Low Performance Groups. Chapters IV and V describe the computational approach used to derive the prototype equation and the results of early trial computer runs.

Chapter VI describes the Performance Funding System and discusses the impact on the prototype expense equation of decisions made in the development of the system. Chapter VII describes the derivation of the inflation factor for specific locations and explains its role in the prototype expense equation. The next chapter gives the equation for 1974-75 and compares 1974 prototypes obtained through use of the equation with the approved budgets of the sampled Authorities. Finally, Chapter IX gives an overview of the Performance Funding System and discusses the need to closely monitor the System to assure that it provides adequate subsidy levels to all Housing Authorities.

Chapter II
THE DEVELOPMENT OF THE DATA BASE

Sampling

In order to gather data economically, sampling procedures were used at three levels. First, a sample of Authorities was drawn. Then, within each selected Authority, samples were taken of Authority central office staff and of the LHA's housing projects. Within each selected project, samples were drawn of project staff and residents.

The procedures for selecting each sample are described briefly[1] below.

Housing Authority Sample

The total sample of 120 Housing Authorities was comprised of three subsamples of 40[2] Housing Authorities each:

(1) Large Housing Authorities with 1,250 or more units under management;[3]

(2) Medium Housing Authorities with 500 to 1,249 units under management;[4]

---

1. A more detailed presentation of the sampling procedures is contained in Management Performance in Public Housing, op. cit., pp.3-8.

2. Puerto Rico is one of the 40 Large Housing Authorities included in the sample. However, because the Puerto Rico Housing Authority has unique operating characteristics, its data has been excluded from this analysis.

3. New York City and the Virgin Islands were excluded from the Large Authority sample due to their unique qualities. The Large Authority sample included the 13 Housing Authorities funded under HUD's Management Improvement Program. Statistical tests were run to ascertain that the inclusion of these Authorities had not biased the sample.

4. Alaska was excluded from the Medium sample due to the uniqueness of this Authority.

(3) Small Housing Authorities with 100 to 499 units under management.

Within each size group, Housing Authorities were randomly selected in a manner designed to make the number of sampled Housing Authorities in each HUD Region proportional to the total number of Housing Authorities in that size group and Region. Table I depicts how many Housing Authorities of each size fell into the sample in each HUD Region.

TABLE I

HOUSING AUTHORITIES IN SAMPLE BY SIZE AND HUD REGION

HUD Region	Large (1,250+ Units)	Medium (500-1,249 Units)	Small (100-499 Units)	Total
I	3	4	3	10
II	5	4	3	12
III	6*	6	3	15*
IV	10	11	14	35
V	7	7	6	20
VI	3	5	6	14
VII	1	0	1	2
VIII	0	0	1	1
IX	4	1	2	7
X	1	2	1	4
TOTAL	40*	40	40	120*

*Includes Puerto Rico

Housing Project Sample

Within each Housing Authority, a sample of housing projects was randomly drawn based on the total number of projects in the Authority.[5] Projects that were entirely composed of scattered-site units and leased housing projects were excluded from the sample altogether.[6] If a project was a mix of scattered-site and conventional units, the scattered sites were not considered in obtaining project data.

To test whether the sample was representative of all the Authority's projects, the sample projects were compared with all the Authority projects on six characteristics: the number of units in the project; whether the project included a high-rise building (five or more stories); whether there were 50 percent or more elderly tenants; whether there were 50 percent or more minority-group tenants; whether the turnover rate was 7 percent or more; and whether the vacancy rate was 3 percent or more. If the sample either over- or under-represented the population on any one of the six characteristics, a new sample was drawn.

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5. The number of projects drawn at each Authority depended upon the total number of projects in the Authority--using the formula for sampling from a finite population, the standard error of the mean of the selected projects was made approximately equal for all Authorities. The aim was to make Authority-wide scores derived from project characteristics equally reliable across the 120 Authorities.

6. Leased housing will not receive operating subsidies through the current prototype formula. Scattered-site housing is included, but the number of such units is extremely small in proportion to the total number of LHA dwellings, and they were excluded for reasons of economy.

Housing Authority Staff Sample

The Chairman of the Board of Commissioners (or equivalent) and the Executive Director were interviewed for each Housing Authority in the sample. The project managers of all housing projects included in the sample were also interviewed.

Separate samples were drawn from each Authority's central office staff and from the employees (other than the managers) who worked at the sample projects, as described below.

Central Office Staff Sample. Within each Housing Authority, a sample was drawn of Authority employees who worked at least eight hours a week on Housing Authority business and who worked primarily at the Central or Management District Offices. If the total number of employees was 15 or less, all employees were included in the sample; if the total number of employees was more than 15, a random sample of between 15 and 25 was drawn (with the exception of Puerto Rico where, because of the large staff, the sample size was 30).

Project Staff Sample. At each project, a random sample of employees who worked at the project itself was drawn. The sample size ranged from zero to five.[7]

---

7. The same general principle that was used to determine the number of projects to be sampled in an Authority was used to determine the number of staff and households to be interviewed at a given project. The standard error of the mean of the selected employees or households was made approximately equal for all projects.

Household Sample

The number of households included in the sample at each project was determined by the total number of units in the project. The size of the household sample ranged from five to eighteen. Households were selected randomly; four attempts, one of which had to be in the evening or on the weekend, were made to contact each household before a replacement was randomly selected.

HUD Area Offices

Each HUD Area Office which served a Housing Authority in the sample was visited and interviews were conducted with the person(s) designated as the most knowledgeable in the day-to-day operations of the Housing Authorities in the sample. A total of 38 HUD Area Offices were visited.

Summary

Table II lists the sample sizes for each type of interview, broken down by size category of Housing Authority.

TABLE II

SAMPLE SIZE FOR EACH TYPE OF INTERVIEW

Size Group	Board Chairman	Executive Director	Central Office Staff	Project Manager	Project Staff	Household
Large	39*	40	714	178	640	2,989
Medium	40	40	291	125	257	1,907
Small	40	40	110	98	131	1,301
TOTAL	119	120	1,115	401	1,028	6,197

*One Board Chairman was unavailable and there was no suitable substitute.

Data Collection Instruments

Prestructured questionnaires were used to interview the selected respondents. Trained interviewers administered the questionnaires, except for the central office staff questionnaire which was self-administered.

The questionnaires were developed at The Urban Institute, with suggestions from personnel at HUD, the National Association of Housing and Redevelopment Officials (NAHRO), and the National Tenants Organization (NTO). In the case of the project manager and household questionnaires, earlier Urban Institute housing management studies were a major source of questionnaire content. Detailed analyses of questionnaire responses in these studies had shown which questions elicited the most useful information for evaluating management practices. Because these earlier questionnaires were primarily aimed at private, subsidized housing, questions that related specifically to public housing were added.

Four types of questions were used in all seven questionnaires: (1) factual questions (e.g., about the respondent, the Authority or the project); (2) questions asking for an evaluation (e.g., of the condition of the units, the performance of Authority employees); (3) questions asking for amount of satisfaction (e.g., with the employee's job, with the tenant's apartment, with the services offered by the Authority); and (4) questions asking an opinion (e.g., how much the respondent agreed or disagreed with statements concerning the policies of the Authority, the behavior of the tenants). Table III lists the topic

TABLE III

QUESTIONNAIRE CONTENT BY TOPIC AREA
(Shown in percent)

Total Area	Board Chairman	Exec. Dir.	Central Office	Project Manager	Project Staff	House-hold	Area Office
Sample Characteristics	5%	9%	40%	9%	44%	22%	0%
Authority Characteristics & Policy	12	20	7	3	6	1	14
Organization Structure	17	11	1	2	0	0	0
Management Process	33	32	18	27	20	11	0
Maintenance	0	3	1	17	3	10	0
Cleaning and Trash	0	2	0	3	3	4	0
Security	0	2	0	3	3	4	0
Social Services	4	9	0	6	1	11	0
Perception of Management	8	2	23	4	11	5	0
Authority Relations with HUD	8	3	4	1	3	0	76
Neighborhood Characteristics/Groups	8	4	1	3	0	9	10
Project Characteristics	0	0	0	12	0	13	0
Tenant Participation in Management	4	3	4	2	3	5	0
Perception of Tenants	1	1	1	6	1	5	0
Total Number of Questions:	N=101	N=299	N=78	N=370	N=66	N=315	N=21

areas and the percentage of each type of question for the seven questionnaires.[8]

To permit quick machine processing of the large volume of data collected (over 9,000 completed questionnaires), alternative responses to the questions were generally precoded in the questionnaires. For all respondents except the project staff and tenants, the precoded questions soliciting an opinion, evaluation, or the amount of satisfaction allowed a range of four answers. (The project staff and tenant questionnaires provided a range of only two responses because of the difficulty these respondents had during pretests in choosing among four answers.)

Additional data were collected from the following HUD records:

HUD-52599--Low Rent Public Housing Statement of Operating Receipts and Expenditures. Total operating expenditures less utilities were collected from this form for Authorities whose fiscal years ended September 30, 1973; December 31, 1973; and March 31, 1974. (In addition, data were collected for the years 1970-72. That information was used in the computer simulations described in Chapter V.)

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8. A more detailed description of each topical area and the questionnaires can be found in Management Performance in Public Housing, op. cit., pp. 10-12.

HUD-52564--Operating Budget. Total operating expenditures less utilities in the approved budgets for fiscal years ending June 30, 1974 through June 30, 1975 were collected from this form. (If an Authority did not have an approved forward funding year 1974 budget, its 1973 budget, multiplied by 1.03, was used instead.)

HUD-53090--Funding Formula Collection Form. This form was sent to the sampled Authorities in June 1974. It contains information from which average building age and height, average bedroom size, and percent occupation by elderly were calculated for each Authority.

U.S. Census data were used for such items as population of the geographic area and the wage rates of local government employees. Other outside data sources provided information on such items as the average January temperature of the area.

Data Collection Procedures

The 120 Housing Authorities and 38 Area Offices were notified in advance by HUD of the forthcoming visits by The Urban Institute. Before a Housing Authority was visited, the HUD Area Office that serves the Housing Authority was visited by Urban Institute personnel. The purpose and method of the study were explained, and a brief questionnaire was administered to the personnel of the Area Office most knowledgeable about the day-to-day operations of the Housing Authorities in the sample.

After the visit to the Area Office, the Housing Authorities in that Area were visited by The Urban Institute. An average of one and a half days was spent at the Central Office of each Housing Authority. The Institute representative interviewed the Chairman of the Board and the Executive Director and drew the sample of projects.

A survey research firm was employed by the Institute to draw the sample of Authority staff and households and conduct the remaining interviews. The Institute provided the subcontractor with manuals explaining the sampling procedures and the administration of the project manager and household questionnaires.

Definition of Variables

Two hundred-twenty-five variables[9] were identified initially from the questionnaires and other data sources for inclusion in the analyses. Selection of variables was based on relationships found among variables in previous Urban Institute studies and on the judgment of Urban Institute and HUD staff members as to the importance of these variables.

All variables for the analyses are defined at the Authority level. That is, responses to questions which were asked of more than one respondent in an Authority were averaged, and that average score was considered as an Authority score. Some variable scores are the average of responses from similar respondents (e.g., the managers' evaluation of the condition of units is the average[10] of all project manager responses)

9. The 225 variables and their data sources are identified in Appendix II, Management Performance in Public Housing, op. cit.

10. For this particular variable and for many others including all variables derived from the household data, the Authority-level scores were obtained through weighting project scores by the number of dwelling units in the projects.

and some scores are the average of responses from different types of respondents (e.g., the evaluation of how well the Authority is meeting its objectives is the average of the responses from the Board Chairman, the Executive Director, and other Authority staff). Of course, some variables are derived from a single response (usually from the Board Chairman or Executive Director).

The 225 variables were first divided into four categories--Criterion Variables, Control Variables, Income and Expense Variables, and Management Variables.

Criterion Variables. Criterion Variables are the measures of the overall performance of the Authorities. Because there is no single measure of Housing Authority success, 24 Criterion Variables were specified. The particular variables used in the study were selected on the basis of earlier Urban Institute research on housing management and the judgment of a committee composed of HUD, NAHRO, NTO, and Institute personnel. These variables are derived from data from all seven types of respondents.[11]

Control Variables. Initially, fifty variables were defined as Control Variables. These measure environmental factors and Authority characteristics over which the Authority has little or no control at this time, but which influence Authority operation, e.g., neighborhood conditions and age and number of projects.

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11. The definition, source, units, means, and ranges of the 24 Criterion Variables are contained in Appendix A.

Income and Expense Variables. Sixteen Income and Expense Variables were defined. These comprise various components of the actual income and expenses of the Authorities during 1970-72. In the final analyses leading to the prototype equation, however, only total operating expenses less utilities was used.

Management Variables. One hundred-thirty-five variables were defined as Management Variables--those that describe management policies, decision-making procedures, and the specific practices and attitudes of Authority staff. Measures of tenant involvement in management are included in this category.

Chapter III
DIVISION OF AUTHORITIES INTO HIGH AND LOW PERFORMANCE GROUPS

Through a statistical process, the Authorities were divided into High and Low Performance Groups within each size classification--Large, Medium and Small--based on their scores on the 24 Criterion Variables. Before the divisions were made, the scores on the Criterion Variables of each Authority were adjusted statistically to take into account operating conditions over which Authorities have little or no control at this time. Several methods of adjusting the Criterion scores were tried out. The method that achieved the clearest differentiation between High and Low Performance Authorities was selected. Finally, the statistical reliability of the division process was measured. These procedures are described in greater detail below.

Options for Adjusting Criterion Scores

The Criterion and Control Variables were correlated statistically and, as expected, there were many significant relationships between individual variables in the two groups.[1] For example, poor Authority performance on a number of Criterion Variables was associated with poor neighborhood conditions, over which the Authority had little control.

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1. For a discussion of the interrelationships among the Criterion and Control Variables, see Management Performance in Public Housing, op. cit., pp. 25-36.

In this case, low tenant satisfaction may reflect neighborhood conditions rather than LHA management. Conversely, an Authority operating under very favorable conditions might have high Criterion scores even if its management were relatively poor. To account for these environmental relationships, the Criterion scores were adjusted for Control Variable differences before the Authorities were divided into High and Low Performance Groups.

In making these adjustments, two problems had to be faced. First, not only were many Control Variables associated with the Criterion scores, but many Management Variables were associated with Control Variables and the Criterion scores.[2] This meant that unless the management differences among Authorities were also considered in making the adjustments for Control Variable differences, the adjustment procedures could eliminate the very management distinctions that were sought between the High and Low Performance Groups.

Second, some variables did not fall clearly into either the Control or the Management Groups. Some variables that were put in the Control Group, but that might have been considered Management Variables, reflected conditions that Authority policies cannot alter in the short run, but that could be modified by the Authority over a period of time. Examples are number of children per adult and number of people per dwelling unit. Similarly, variables originally defined as Management Variables which could have been considered Control Variables included aspects of management over which the LHA may have little real control;

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2. Ibid. pp 44-69.

for example, the number of unions involved with the Authority may be a function of the extent and type of unionization of municipal and state employees in the region of the country in which the LHA is located.

To overcome both these problems, the following procedure was employed to adjust the Criterion Variable scores:

(1) Fifty Management Variables were singled out because they had many significant correlations with the Criterion Variables across all 119 Authorities.

(2) With the 50 Management Variables used as independent variables, a multiple regression equation was computed for each of the 24 Criterion Variables in each of the three LHA size groupings (72 equations in all).[3] The equations retained only those Management Variables that were significantly related to the criterion measures. The typical equation, therefore, included only 3 or 4 Management Variables.

(3) Management Variables which appeared in the 72 equations less than twice were eliminated. (The rule was adopted to eliminate variables likely to be appearing in the equations by chance. On a purely chance basis, a variable had slightly more than 50 percent probability of getting into at least one equation.) Twenty-four of the 50 Management Variables were thereby eliminated.

(4) Steps (2) and (3) were repeated for all 50 Control Variables. Twenty-three Control Variables were eliminated as a result.

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3. Biomed program BMD02R was used to select the variables comprising the equations. This program adds variables to the equation one at a time. The variable added is that which can most increase the multiple correlation of the equation composite with the criterion (in this case, one of the 24 Criterion Variables). A statistical test is provided to determine whether the addition of each variable significantly increases the composite's relationship with the criterion. The .01 significance level was used. See BMD Biomedical Computer Programs, W. J. Dixon, Editor (University of California Press, 1970), pp. 233-247.

(5) HUD and Urban Institute staff judged which of the 53 remaining Control and Management Variables should be considered only as Control Variables, which should be considered only as Management Variables, and which could be considered as either. Those that could be either were classified as "Swing Variables". Appendix A identifies the 53 variables and their classifications.

(6) The multiple regression computation of step (2) was repeated with the 53 Control, Management, and Swing Variables to obtain 72 equations of the following form:

$$P = C + M + S + (R + e) + K$$

Where: P is the unadjusted performance score on any one Criterion Variable

C is a component of the Criterion score attributable to Control Variable differences*

M is a component of the Criterion score attributable to Management Variable differences*

S is a component of the Criterion score attributable to Swing Variable differences*

R is a component of the Criterion score not attributable to the 53 variables used in the generation of the equations

e is an unpredictable component of the Criterion score attributable to measurement error (with available data it is inseparable from R)

and K is an equation constant related to the average level of public housing performance on the Criterion Variable.

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* The C, M, and S components consist of the sum of the products formed by multiplying the selected variable scores by their respective regression weights.

(7) By manipulating the components of this general formula, the Criterion scores were adjusted in four different ways for application in the final step of forming the performance groups:

a. Part Control--The Authority Criterion scores were adjusted by subtracting the component attributable to Control Variable differences:

$$P_{adjusted} = P - C$$

b. Full Control--The Authority Criterion scores were adjusted by subtracting the component attributable to Control and Swing Variable differences:

$$P_{adjusted} = P - C - S$$

c. Part Management--Only that portion of the Authority scores that could be accounted for by Management Variable differences was left in the Criterion Scores:

$$P_{adjusted} = P - C - S - (R + e) - K = M$$

d. Full Management--Those portions of the Authority scores that could be accounted for by Management and Swing Variable differences were left in the Criterion scores:

$$P_{adjusted} = P - C - (R + e) - K = M + S$$

Procedure for Forming Performance Groups

Within each size classification, Authorities were divided into High and Low Performance Groups according to their scores on the 24 Criterion Variables. This division was done five times, with the unadjusted

criterion scores and the four different sets of adjusted scores described above. Each time, three basic steps were followed:

First, it was determined for each Authority whether the Authority was above or below the mean of each of the 24 Criterion Variables.

Second, those Authorities which were above the mean on well over a majority of Criterion Variables were placed in the "High" Performance Group; those Authorities which were below the mean on well over a majority of Criterion Variables were placed in the "Low" Group. The Authorities that had close to half their Criterion scores above and half below the sample means were placed in the High or Low Group depending upon the extent to which their scores were above or below the means.[4]

In the third step, the placements obtained in the second step were subjected to successive discriminant function analyses[5] until each Authority was assigned into the group for which the analyses indicated it most probably belonged. When the statistical probability was not very high that an Authority belonged in the Performance Group in which it fell, the discriminant function analyses was repeated with the Authority switched

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4. Extent was measured in terms of the standard deviation of the Criterion Variables, that is, "z-scores" were obtained:

$$z = \frac{\text{Authority Performance - Sample Mean}}{\text{Sample Standard Deviation}}$$

5. Biomedical program BMD05M was used. This program computed a set of linear functions for use in classifying individual cases into groups. The probability of each individual case belonging in each group was computed on the basis of the closeness of the Authority's Criterion scores to the Criterion means of all cases assigned to the group. Cases were assigned to the group in which they most probably belonged. The program was used iteratively until each case was classified in the same group at the end of the computer run as it had been at the beginning of the run. See BMD Biomedical Computer Programs, op. cit., pp. 196-206.

to the opposite group to see which assignment resulted in the larger probabilities and D-Square statistic.[6]

Selection of the Full-Control Method

After performance groupings obtained by the five methods of adjusting criterion scores were compared, the "Full Control" method was selected. This method was considered superior for the following reasons:

(1) By the Full Control method, the High Group Authorities were significantly[7] better than the Low Group Authorities, on 23 of the 24 Criterion Variables--a greater proportion than was obtained with any other method tested.[8] The mean values of the Criterion Variables are given in Appendix A.

(2) The number of Control Variables that were significantly different between High and Low Groups formed by the Full Control method was less than in any of the other four methods. This is advantageous because the fewer the differences between Performance Groups on the factors over which the Authorities have little or no control, the more confidence we have that differences in performance between the Groups may be attributed to factors over which the Authorities do have control.

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6. Computer program BMD05M also computes a generalized Mahlonobis D-Square statistic, which was used to test the hypothesis that the set of 24 Criterion means was the same in the Performance Groups.

7. The means of the High and Low Performance Groups or Large, Medium, and Small samples are "significantly" different if the differences among the means are so large that it is reasonable to infer that the differences did not arise by chance. The probability values in this report give the probability that differences as large as those obtained could have resulted by change.

8. The Mahlonobis D-Square statistic was also on the average highest across the samples (Large, Medium, and Small), with the Full Control Method. It was significant at the .001 level in all three samples, averaging 410.4, a value which indicated that the Performance Groups were distinctly different in mean criterion performance.

(3) The 119 Authorities were most evenly divided into High and Low Groups with the Full Control method. As shown in Table IV below, close to a fifty-fifty division was achieved in each size group. Moreover, the High and Low Performance Authorities were not disproportionately distributed across HUD Regions (a chi-square test indicated that the proportion of all Authorities in each Region assigned to each Performance Group was not significantly different across the Regions).

TABLE IV

NUMBER OF AUTHORITIES IN HIGH AND LOW PERFORMANCE GROUPS BY HUD REGION

HUD Region*	Large		Medium		Small		Total	
	High	Low	High	Low	High	Low	High	Low
I & II	2	5	2	6	2	4	6	15
III	2	4	4	2	1	2	7	8
IV	6	4	6	5	7	7	19	16
V & VII	5	3	5	2	3	4	13	9
VI	2	1	1	4	3	3	6	8
VIII, IX, X	2	3	1	2	2	2	5	7
TOTAL	19	20	19	21	18	22	56	63

*Data for contiguous Regions were combined to avoid revealing the Performance Group into which specific Authorities fell.

Reliability of the Performance Groups Division

Because the subsidy allocations depend on data derived from Authorities found to be high performers, the formation of the performance groups had to have demonstrable reliability.[9] Unfortunately, the technique of assessment-reassessment reliability requires another data collection at the sampled Authorities. The use of this technique must await the analysis in 1975 of a recently completed second round of data collection. In the meantime, the reliability of the division process was estimated by creating equivalent subportions of the existing data. And because of the large effort involved, this method was applied only to the large LHA's.

Several possible sources of unreliability were considered. These included unreliability attributable to the particular 24 criterion measures and the specific questionnaire items defining these measures, unreliability attributable to the sampling of tenants and Authority employees, and unreliability attributable to the initial grouping of the Authorities on the basis of their z-scores. Unreliability attributable to the sample of projects could not be considered, since division of the sample of projects (which had been checked for representativeness) into subgroups would result in nonrepresentative subsamples in the case of some LHA's.

Furthermore, it was prohibitive, considering time and resources, to adjust the criterion scores for control variable differences as part of

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9. The reliability tests were one recommendation of a subcommittee established by the NAHRO Committee on Housing Production and Management to review the development of the equation midway in the process.

the reliability determination. The analyses had shown, however, that adjustment under the Full Control Method resulted in performance groups whose average criterion scores were more significantly different than performance groups obtained on unadjusted scores. Therefore, it was felt that a reliability estimation that did not include criterion score adjustment would probably be lower than one that did, and that if the reliability of the No Control Method were adequate, the reliability of the Full Control Method would also be adequate.

The procedure used to determine reliability is described in detail in Appendix B. Essentially, the assignment procedure was applied twice. First, the procedure was used with half the criterion variables, half the questionnaire items for each variable, and half the tenants, Authority staff, and project staff. Then it was repeated with the other 12 criterion variables and the remaining respondent data. The allocation of items or respondents to one subgroup or the other was random.

The reliability coefficient obtained was .78. The principle source of unreliability apparently lay in the set of criterion variables used to divide the Authorities into performance groups. (The 24 criterion variables were selected by representatives of HUD, NAHRO, NTO, and the Institute without the benefit of empirical data). Further analysis indicated that the reliability could be raised to .90 simply by eliminating two of the criterion variables: proportion of rent delinquent units (V19) and ratio of delinquent rents to dwelling rent schedule (V20). These two Criterion Variables were generally unrelated to the other criteria and were not significantly related to each other.

Factor and item analyses are being employed to improve all of the variables. When these analyses are completed, the Institute will recommend changes in the criteria used to determine the performance groups.

Chapter IV
GENERAL APPROACH TO DEVELOPING THE PROTOTYPE

The preceding chapters have described how the sample of Housing Authorities was selected and how the LHA's were divided into High Performance and Low Performance Authorities. This chapter and the one following describe the process of developing the prototype equation, based on operating conditions of the High Performance Authorities.

As described in the introduction, the equation consists of an expense variable (the dependent variable) that is related to conditions over which the LHA's have little control (the independent variables). This chapter discusses the general approach to development of the equation and includes discussions of: 1) the definition of the expense variable, 2) the criteria used to select the independent variables, 3) the basic computational procedures, 4) what was done about prediction errors, and 5) the problem of forward funding that requires additional procedures to make the equation appropriate to a future year.

Definition of the Expense Variable

The expense variable used in the derivation of the prototype was each Authority's total operating expenditures less utilities. As suggested by its title, this measure included all operating expenditures except sewerage fees and purchases of water, gas, oil, electricity or coal. The variable, however, does include LHA labor expenses associated with the maintenance of utility systems and the LHA labor involved in the

purchase or delivery of the energy sources or water.

Three considerations led to the exclusion of energy and water purchases from the prototype:

(1) The 1973-74 energy crisis had caused the prices of fuels to soar unpredictably. Therefore, the rates charged LHA's for their utilities could deviate markedly from previous rates. Furthermore, because some Authorities had energy contracts with relatively fixed prices, the effects could vary considerably among Authorities.

(2) In early tests of the prototype equation, the inclusion of utility expenses produced a considerably higher standard error of estimate.[1]

(3) There was no significant difference between High and Low Performance Authorities in their average utility expenses per unit month,[2] even though total operating expenditures less utilities of the High Performance Authorities were significantly lower on the average. This suggested that Authorities had little control over utilities as compared to other management-related expenses.

To obtain the data for this variable, actual expenditures as recorded on HUD Form 52599 were used for Authorities in the sample whose fiscal years ended in September 1973, December 1973, and March 1974.[3] Approved

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1. The standard error of estimate is the standard deviation of the differences obtained through using the prototype equation to estimate actual expenses and the actual expenses themselves. Unless there is a multiple correlation of 1.00 (perfect prediction) between the independent and dependent variables, there are always differences between estimated and actual values.

2. Management Performance in Public Housing, op. cit., p. 96.

3. To facilitate administration, LHA's have been put into four groups with different beginning dates (October 1, January 1, April 1, or July 1) for their fiscal years. The staggered dates pose problems in data collection and analysis that are identified in various sections of this paper.

budget amounts were used for Authorities whose fiscal year ended in June 1974 because their actual FY 1974 outlays were unavailable when the formula was derived.

Criteria for Selecting Independent Variables

From the outset, it was apparent that criteria had to be established for selecting the independent variables that would be used to estimate Authority expenses. The use of these criteria profoundly affected the content of the final equation. There were seven criteria:

(1) Operating Conditions. The independent variables had to reflect those significant operating conditions that were beyond the control of the Authority to change rapidly. Variables which measured management structure, organization, and practice were excluded.

(2) Data Availability. The data necessary for obtaining the variable values for every Authority had to be readily accessible on an annual basis, either through regularly reported governmental statistics or through special forms that the LHA's could easily fill out themselves and that could be checked quickly by HUD Area Office personnel. Data were ruled out if they could only be collected through expensive special surveys. Measures of project neighborhood conditions were excluded as independent variables on this basis.

(3) Variables Likely to Have Unintended Management Effects. Several variables were eliminated as candidates because, even though they might have been considered to meet Criterion (1), they might have provoked unwanted management effects. Most such variables involved tenant characteristics; the number of children per adult is an example. This variable might be considered to meet Criterion (1) because the proportion of children among the residents is clearly related to operating costs and because current management can do little to change the mix of residents in the short run. If this variable were included in the prototype equation, however, it would result in more or less subsidy to an

Authority depending upon the proportion of children and a consequent incentive to either increase or decrease the proportion of children the LHA houses. It was felt this type of incentive should not stem from the application of the equation but, rather, that it should be left to Authority management whether to increase or decrease the proportion of children (through admissions policies) in accordance with local operating conditions. Other rejected variables of this type included:

a. Percent minority occupancy
b. Average household income[4]
c. Percent of families receiving public assistance
d. Turnover rate
e. Percent of Authority employees belonging to a labor union.

Note that these variables might not have contributed to the equation even if they had not been excluded.

(4) Reasonableness of Sign of Weight. If a variable is weighted positively in the equation, it will obviously have a different impact than if it is weighted negatively. As the sign or direction of a specific variable's weight in a multiple regression equation is determined by the interrelationships among all the variables, it is possible for a variable to have a negative weight in the equation even though the variable is positively related to expenses, or vice versa. Because an equation with apparently unreasonable weights might be generally misunderstood, a variable was included in the equation only if its weight had the same sign (positive or negative) as its correlation with LHA expenses.

(5) Consistency of Sign of Weight. Although the prototype equation is derived from the data of High Performance Authorities, it should reflect the impact of operating conditions on all Authorities. Therefore,

4. Authority expense levels have historically been related to Authority rental income levels, which in turn are related to tenant income levels. If average tenant income had been included in the prototype equation, it would have received a positive regression weight. Therefore, Authorities having tenants with relatively high incomes might ultimately receive more federal subsidy, a result that would have raised questions of equity.

once variables had been selected on the basis of High Performance Authority data, they were tested by creating an equation using only these variables and employing the data of all sampled Authorities. Any variable whose sign changed from the first equation to the second was eliminated.

(6) Statistical Significance of Equation Weights. A statistical test was applied to see whether the weight of each variable in the equation was significantly different from zero. A variable was kept in the prototype equation only if the absolute size of its weight was large enough that it was reasonable to assume that the variable was not in the equation because of chance factors. This criterion served to eliminate some variables closely related to variables included in the equation, e.g., density level of dwelling units did not have a significant weight when building height, a related variable was included in the equation.

(7) Reduction in Standard Error of Estimate. Finally, through trials with various combinations of variables, we sought to reduce the differences between estimated and actual expenses of High Performance Authorities as much as possible. Variables were eliminated that did not help diminish these differences. (The inclusion of some variables with insignificant equation weights (see Criterion 6) served to increase the standard error of estimate).

The Basic Computational Procedure

The basic computational procedure involved trying out various independent variables to see which combination best predicted High Performance Authority expenses. De Leeuw's earlier analyses[5] had indicated that fairly close correspondence between predicted and actual LHA expense levels could be obtained by weighting such factors as average

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5. De Leeuw, op. cit.

age of Authority buildings, percent of elderly tenants and local government wage levels. Based on this evidence, it was decided to use multiple regression analysis to make the predictions.[6]

In deriving the prototype equation, High Performance Authorities of all sizes were treated as a single sample, with data from the three size groups weighted in proportion to the total number of Large, Medium, and Small Authorities in the United States. The alternative procedure of deriving a separate equation for each size group was rejected for several reasons. For one, three separate equations would almost certainly result in discontinuity at the borderlines of the size groups, i.e., at around 1,250 and 500 units. If there were three equations, Authorities at the borders might have different prototypes, depending on whether they managed several more or fewer dwellings.

The prototype equation was derived using a computer program[7] which allowed systematic examination of the effects of including or excluding variables from the equation. The program selects independent variables one at a time for inclusion in the equation. At each step, the variable added to the equation is the one with the strongest statistical relationship with Authority expenses, taking into consideration the interrelationships of the variables already selected. After each addition to the equation, statistical tests are run to determine whether the variable weights are significantly different from zero. Other statistical tests

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6. In multiple regression, a number of factors or independent variables are weighted so that the sum of the weighted factors has the highest possible correlation with the dependent variable (in this case, expenditure levels) one is trying to predict or estimate. The weights used are determined by a computer program that seeks to minimize the discrepancies between predicted and actual values.

7. Biomed program BMDO2R, Stepwise Regression, BMD Biomedical Computer Programs, op. cit.

indicate whether the addition of another variable would substantially lower the standard error of estimate.

This computer program was run several times with different sets of variables. Controls in the computer program were used to force different variables into the equations initially before allowing additional variables to be selected on the basis of their partial correlations with Authority expenses. Many trial equations were thereby generated. After an entire equation was obtained, the signs (positive or negative) of the weights were examined for reasonableness and consistency in accordance with the variable selection criteria. The equation finally selected was the one with the smallest standard error of estimate.

Prediction Errors

Although the computational procedure sought the smallest errors of estimate--the differences between estimated and actual expenses of High Performance Authorities--some "error" was inevitable. The application of the criteria for selecting independent variables limited the scope of explanatory measures and hence the ability to estimate expenses precisely. Some leeway seemed desirable, therefore, in developing and applying the formula to individual Authorities. This led to the concept of a range factor.

The range factor allows for any unique or unmeasured conditions that affect an LHA's operating expenses. To apply the range test, first the unique prototype expense for an Authority is calculated by insertion into the prototype expense equation of the Authority's own values for the independent variables--the conditions over which it has little control. Then the range factor is added to and subtracted from the calculated

prototype expense to create a range of acceptable expense levels. For example, if an LHA's prototype were calculated as $70 PUM, and the factor were $10, then the range of acceptable expense levels would be from $60 PUM to $80 PUM.

The range factor was not set at some arbitrary dollar amount; instead it was decided to derive the limit from the analysis itself and specifically to use the standard error of estimate. The choice of the standard error of estimate was dictated by practical considerations: To apply a more theoretically correct error value unique to each LHA's operating conditions would have been extremely difficult considering the complexity of the prototype equation and the fact that the range factor is used to test approved budgets and not actual expense levels. (LHA approved operating expense budgets less utilities have recently tended to be higher than their actual expense levels.) If we assume that errors in estimating Authority expenses through use of the equation are normally distributed,[8] the standard error of estimate defines the upper and lower limits within which the actual expenses of high performance LHA's should fall a certain percent of the time. The effect of this decision is to give LHA's more benefit of the doubt when there is more doubt, that is, when the standard error of estimate is large.

Preliminary calculations of the prototype equation indicated that use of a multiple of the standard error of estimate to set a range in which the actual expense of High Performance Authorities should fall

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8. Statistical tests of significance were run to determine whether the data were consonant with this assumption (see page 79).

90 percent of the time would result in limits that were about $10 above and below the Authorities' prototype expense levels. It seemed reasonable to allow a range of about $20 to account for unique and unmeasured aspects of LHA operating conditions.

The Problem of Forward Funding

One major problem remained in the design of procedures for developing the prototype equation. Operating subsidies are forward-funded by HUD; that is, the LHA's are told how much subsidy they will receive before the beginning of their fiscal year so that they can budget accordingly. Authority budgets are submitted about three months before the beginning of the next fiscal year, and HUD regulations require that budgets be approved within 45 days of their submission. There was a need, therefore, to fit the prototype equation to Authority expenses more than a year before the expenses actually occurred.

To meet this need, the following procedure was adopted. First, equation variables and multiple regression weights were obtained with the latest available actual expense levels and known independent variable values. Next, estimates were made of the independent variable values for each LHA at the end of its next fiscal year. The estimated independent variable values were then used in the previously derived equation to arrive at the future prototype expense level for the given LHA.

When regression weights derived from past years' data are used, the basic assumption is that the interrelationships among the variables will be approximately the same in the future as they were in the past. Because the time frame involved is relatively short, this assumption seems reasonable.

Chapter V
EARLY TRIAL RUNS

Once the general approach to development of the equation was determined, a series of trial runs was undertaken to refine the procedures. The trial runs had two major results. First, they reduced the number of independent variables to be considered. Second, they led to a decision to create a separate inflation factor. In this chapter, we list and define the most promising independent variables identified in the early trial runs. In Chapter VII we discuss the derivation of the inflation factor.

The Candidate Independent Variables

With use of the criteria and procedures outlined in the previous chapters, a final set of candidate independent variables was defined. These trial runs employed expense data from 1970-72. It may be useful here to identify some of the variables that were rejected:

- Average dwelling density, measured in dwelling units per acre;
- Average monthly temperatures in January and July;
- Whether the Authority was in a Standard Metropolitan Statistical Area (SMSA) or not;
- Whether the jurisdictional area of an Authority was the central city of an SMSA;
- The average number of elevators in the Authority's projects;
- Proportion of dwellings that had their own outdoor space;

o Average size of housing projects.

Although these variables individually correlated significantly with Authority expenses, they did not consistently reduce the standard error of estimate in the trial runs of the prototype formula because of their colinearity with more powerful variables. For example, average dwelling density would probably be included in the final candidate set of independent variables if average building height, with which it has a high correlation, had not been selected. Building height was selected over density because when density was preselected in trial equations, the stepwise regression routine did not also select building height, and the resultant standard error of estimate was greater than when height was selected. When both variables were forced into a trial equation the resultant weights did not meet all the variable selection criteria (see page 39).

As might be expected, average January temperature had a significantly negative correlation with utility expenses per unit, and this variable almost certainly would have been included if utilities had not been excluded from the expense variable.

After these variables were eliminated, the final list of candidate independent variables included the following measures:

Population of area served. The population of the jurisdiction of the Authority was determined from the 1970 Census.[1] The population was then multiplied by a growth factor for 1973, calculated by the Institute through a nonlinear (logarithmic) interpolation of estimated statewide

1. U.S. Bureau of the Census, U.S. Census of Population 1970, Number of Inhabitants, Final Report PC(1)-A (U.S. Government Printing Office, Washington, D.C., 1971).

population growth rates for the period 1970-80.[2] Appendix C lists these growth factors for each state.

To reduce the enormous variance in populations across Authority jurisdictions, two nonlinear transformations of population were tried: log to the base 10 transformations and square root transformations.

Number of unit-months availability. The size of the Authority was measured by multiplying the number of dwelling units in the Authority by the number of months the units were available for occupancy. The logarithmic and square root transformations of this variable were also tried.

Average number of bedrooms. The total number of bedrooms[3] in all the LHA's dwelling units was divided by the total number of dwelling units to arrive at the average number of bedrooms per unit. The logarithmic and square root transformations of this variable were also tried.

Proportion of units occupied by elderly people. The total number of units in which the head of household was 62 years or older was divided by the total number of units to arrive at the proportion of units occupied by senior citizens.

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2. The estimated 1970-80 statewide growth rates were obtained from U.S. Bureau of the Census, Series I-E Projections, "Population Estimates and Projections", Current Population Reports, Series P-25, No. 477, March 1972, p. 6.

3. Efficiency apartments were considered to have no bedrooms.

Average age of projects. The date each housing project in the Authority was initially occupied was first subtracted from the end date of the LHA's 1973 fiscal year to arrive at the age of each project. The age of each project was then multiplied by the number of units in the project and the sum of all products was divided by the total number of units in the Authority to arrive at a weighted average project building age. Illustrative calculations are given below for an Authority with three projects whose fiscal year ended March 31, 1974. The logarithmic and square root transformations of this variable were also tried.

Project	Date of Initial Occupancy	Age		Number of Units	Product
A	10/62	11.5		200	2300
B	1/64	10.25		100	1025
C	4/68	6.00		125	750
			SUM	425	4075

Average = $\frac{4075}{425}$ = 9.59 years

Average height of project buildings. The weighted average project height, measured in number of stories, was obtained through computations similar to those used for the weighted average project age. If a project's structures had different heights, the height of the tallest building was used. The logarithmic and square root transformation of this variable were also tried.

The relative cost of operating Authorities within the HUD Region. The average actual total operating expenditures less utilities during 1973 was obtained for a separate random sample of 30 Small Authorities

(100-499 units) in each of the 10 HUD Regions.[4] Each individual HUD Region average was then divided by the average of all 10 regional averages and finally multiplied by 100. For example, if the regional average for Region I was $50.00 PUM and the average of all regional averages was $40.00, the calculation would yield a relative cost of 125 for Region I. All Authorities within a given region were assigned the same relative cost. Table V lists the relative costs found for each HUD Region.

TABLE V

Relative Cost of Operating Authorities Within HUD Region

HUD Region	Relative Cost
1	122
2	132
3	97
4	84
5	92
6	72
7	75
8	90
9	132
10	105

4. If the HUD Region had 30 or fewer Small Authorities, all Small Authorities in the Region were used.

Average earnings per month of local government employees. This variable was obtained from data published annually by the Bureau of Census.[5] On the basis of earlier analyses by de Leeuw,[6] it was selected as the best single measure of relative costliness of Authority operations at the state and county level. The Bureau of Census conducts a wage survey of local governmental units in early fall of each year. Statewide average monthly wage rates are computed. Averages are also computed for 233 counties that lie within SMSA's and 61 counties with populations of 200,000 or more that lie outside SMSA's.

In a special tabulation for the prototype, the Bureau of the Census also computed statewide averages excluding the data from the counties lying within SMSA's and the populous counties outside of SMSA's. Salaries of public school teachers are excluded because teachers are paid on an annual basis in some localities and on a 9- or 10-month basis in others, and because their salaries are not classified in some places as local government wages, which creates problems of comparability.

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5. U.S. Bureau of the Census, Local Government Employment in Selected Metropolitan Areas and Large Counties (U.S. Government Printing Office, Washington, D.C.).

6. Frank de Leeuw, Operating Costs in Public Housing: A Financial Crisis, and Operating Expenses in Public Housing, 1968-71, op. cit.

Chapter VI
THE PERFORMANCE FUNDING SYSTEM

While the initial trials of the prototype equation were being run and the list of candidate independent variables was being reduced, HUD was refining the Performance Funding System. As the evolution of the System had substantial impact on the shape of the prototype equation, we must describe the Performance Funding System as it evolved before we describe the final steps in developing the equation.

The Distinction Between the Prototype Equation and the Performance Funding System

The reader should bear in mind the distinction between the prototype equation itself and how that equation is used operationally in the Performance Funding System in the determination of Authority subsidy levels. The equation estimates how much it would cost on the average to operate a high performance Authority with a specific set of operating conditions. The Performance Funding System uses the equation's estimate in arriving at the subsidy a specific LHA will receive. The System is essentially a set of decision rules for setting a subsidy level given an LHA's formula expense level or prototype, allowable operating and utility expense levels, and projected operating income.

Officials of the Department of Housing and Urban Development set the decision rules of the Performance Funding System. However, as the decision rules affect the development of the prototype equation and vice versa, Institute staff participated continuously in their evolution. The

Institute, for example, ran many computer simulations which explored the probable effect of alternate sets of decision rules on individual LHA's and on the total level of federal operating subsidies for FY 1975 and beyond.

Primary Elements of the Performance Funding System

To illustrate how the prototype equation fits into the Performance Funding System, a few simple equations are presented here.[1] The most general equation defines the level of subsidy the federal government will provide to an Authority:

$$S = (E + U - I)\ M$$

where:

S = the total federal subsidy to a particular Authority in a given year

E = the allowable expense level, per unit month (PUM), under the Performance Funding System.

U = the allowable utility expense level, PUM

I = the Authority's projected operating income, PUM

M = the number of dwelling units managed by the LHA multiplied by the number of months the units are expected to be available for occupancy (unit months available)

The equation states that the federal government will provide operating subsidies equal to the difference between the allowable expense level plus the allowable utility expenses and projected operating income. Because

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1. Technically, the equations in this section should be written with subscripts and superscripts that identify the funding year and the individual Authority, e.g., S^{A}_{y}. These have been omitted to simplify the equations for the general reader.

these components are calculated on a per-unit-month (PUM) basis, the resultant answer must be multiplied by the unit months available to obtain the total federal subsidy.

Implicit in this equation is the forward-funding nature of the process that requires estimates be made of each one of these terms about fifteen months in advance. The rules and regulations for making the estimates for the utilities expense level (U), projected operating income (I), and unit months available (M) are being formulated by HUD concurrently with the development of this paper, and will be issued separately by the Department. The remainder of this chapter, therefore, is concerned solely with the calculation of the allowable expense level (E), which is where the prototype equation is used.

Primary Elements of the Expense Equation

The basic equation for computing the allowable expense level (E) for an individual LHA is:

$$E_{y+1} = (E_y + P_{y+1} - P_y F)$$

where:

y = the current funding year (in which the estimates are being made)

y+1 = the requested budget year (next year) for which estimates are needed

E_y = the allowable expense level for the current year

P_y = the formula expense level computed for the current year for the Authority using the prototype equation (the current year prototype)

P_{y+1} = the formula expense level computed for the requested budget year (exclusive of inflation)

F = an inflation factor--the expected percentage change in local prices and wages for the Authority over the next year.

Thus, the equation states that the allowable expense level for the next forward-funding year (the requested budget year) will be the allowable level in the current year plus the difference in the prototype expenses between next year and this year, all multiplied by an inflation factor.

An extremely important attribute of the equation used to compute the forward-funded allowable expense level is the distinction between the allowable expense level in the current year (E_y) and the formula expense level or prototype for the same year (P_y). As this distinction indicates, the allowable expenses for each successive year do not derive solely from the prototype but are affected by other decision rules. The introduction of these rules shaped the entire form of the equation. Therefore, to discuss the equation further, we must understand the additional decision rules concerning (1) the use of range tests, (2) LHA requests for adjustments of their base year expense levels, and (3) transition funding.

The Use of Range Tests

As discussed in Chapter IV, the inevitability of prediction "errors" led to the concept of a range factor (derived from the standard error of estimate). The range factor creates a band of acceptable expense levels for the LHA's current year approved operating budget centered on the

prototype expense calculated for the LHA. It is this band, rather than the fixed prototype, itself, that is used to set an Authority's base year[2] allowable expense level. It is easy to see, therefore, why E_0 (the base year allowable expense level) will differ in most cases from P_0 (the computed prototype or formula expense level for the base year). Furthermore, the difference between E_y and P_y can be expected to be maintained in future years because, once the base is established, it will only be modified and not reset by the equation.

This discussion should underscore the importance of the decision rules surrounding the use of the range test to establish the initial allowable expense level. The range test is performed on the LHA's current (base) year approved operating budgets. The prototype expense for each Authority will be calculated for its base year,[3] and upper and lower limits of its prototype range will be established. The LHA's current approved budget will then be compared to the LHA's concurrent prototype expense range to set the base year allowable expense level.

Authorities whose approved budgets are <u>above</u> the upper limit of their range will have their base allowable expense level (E_0) reduced below their current budgets to the upper limit of their prototype range. Authorities whose approved current budgets are <u>within</u> or <u>below</u> the current prototype range will have their approved budgets used as the base level (E_0).

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2. The base year is defined as the LHA's budget year immediately preceding its first budget year under the Performance Funding System.

3. Because the Funding System will be implemented on April 1, 1975, this step involves two different "forward-funding years"--the timing is discussed in Chapter VIII.

Adjustment of Base Set by Range Test

Authorities whose current budgets fall within or below their current prototype range will have the right to request an adjustment of their base year allowable expense levels as established by the range tests. No appeal will be granted which would raise an Authority's base year allowable expense level above the upper limit of its prototype range. (This rule is consistent with the decision not to entertain requests for adjustments from LHA's already over the range.) An approval of a request for adjustment would not affect the amount of subsidy LHA's receive in the current year, but an approved adjustment would increase the potential subsidy level in subsequent years.

The Performance Funding System is designed to operate in the future without detailed budget reviews. In fact, once the requests for adjustment of the base year allowable expense levels are adjudicated, the budget approval process is designed to work smoothly with the updated allowable expense levels, as determined by operating conditions and the formula. Because the base year determination is so important, the Department decided to review carefully current budgets that were not above the upper limit of the prototype range at the request of individual LHA's.

HUD's concern was with Authorities whose expenditure levels had been unduly constrained under the Interim formula. The adjustment process should permit such Authorities to enter the new system with a more realistic base, and it should prevent perpetuation of any deleterious effects on housing services imposed by the constraints of the Interim formula.

Transition Funding for Above Range LHA's

Some Authorities with current budgets above the upper limit of their prototype range face sizeable budget cuts if next year's allowable expense level is based on the range limit. To avoid undue hardships to tenants and staff from a drastic budget cut, HUD is considering funding these above-limit LHA's at their current operating level until the upper limit of the prototype range catches up with the current level. Under this "hold harmless" decision rule, transition funding would be provided to make up the difference between the current or base year expense level and the allowable expense level for the requested budget year. Because wage and price inflation, aging buildings and other changes in operating conditions are currently forcing Authorities' expenses upward, the allowable expense levels calculated under the Performance Funding System should soon reach the current budget levels of most of these Authorities.

Use of Latest One Year of Data

The introduction of range tests, budget adjustments, and transition funding clearly raised the possibility that many Authorities would have differences between the prototype expense (P_y) and the allowable expense level (E_y). The potential of these differences, in turn, caused a number of changes in the original concept of the prototype equation.

In the initial development of the equation, the most recent three years of independent and dependent variable values were used. For example, the equation for 1972 was derived using values for 1970, 1971 and 1972. Each year's value was treated as a separate observation. The objective was to accurately estimate a prototype for each Authority for

the next fiscal year. The forward projections were based on the trends in the data over the three-year period.

With the adoption of the range tests and adjustment process in the Performance Funding System, the use of the latest three years of data no longer seemed appropriate. Trends in the latest three years of LHA expense data when the system was initiated would reflect earlier federal subsidy decisions which were now subject to revision. Furthermore, after the system was initiated, the latest three years of expense data would contain the sudden discontinuity between first and second year expense levels caused by the range tests, the adjustment process, and the application of the new system in general. A decision was made, therefore, to use only the latest year of available data for the prototype equation.

Use of a Single Equation

There are two main functions of the prototype equation within the Performance Funding System. First, as described in this chapter, the equation is used to calculate each LHA's prototype for the initial year as well as the associated upper and lower limits of its prototype range. These values are used in the Funding System to set an Authority's base year allowable expense level.

The second use of the equation is to calculate how much the base amount will be changed each year. Along with the inflation factor, discussed in the next chapter, the base year allowable expense level is modified in the formula by the difference in the estimated prototype expense for next year minus the current year's prototype expense ($P_{y+1} - P_y$). In this context,

the prototype equation is primarily used to project the base amount forward by adjusting it for anticipated changes in LHA operating conditions. If no changes in operating conditions were anticipated for a given LHA, and if there were no anticipated inflation, the base amount would remain the same.

The use of the prototype equation to estimate an amount of change (rather than the absolute level of expenditure) influenced how the equation was finally developed. After several trial runs computing differences between successive yearly prototypes, it became clear that the same equation had to be used to estimate the two successive prototypes (P_{y+1} and P_y) in the calculation. Different equations, each derived from a different data base,[4] often yielded rather different prototypes, as might be expected from the size of the standard errors of estimate involved. The use of a single equation in the calculation of ($P_{y+1} - P_y$) does not mean that the equation will remain the same every year. It is still desirable to recalculate the equation every year to capture the changing relationships among the variables.

4. The first year's prototype was derived with data from 1970-72; the later prototype was derived with data from 1971-73.

Chapter VII
THE INFLATION FACTOR

Under the Performance Funding System, an Authority's current allowable expense level (E_y) is to be adjusted annually by adding to it the changes described by the prototype equation ($P_{y+1} - P_y$) and multiplying this sum by an inflation factor (F).

The data used to derive the inflation factor is from the Bureau of the Census annual survey of Wages of Local Government Employees, described in Chapter V. Because Authorities are forward funded, the inflation factor must anticipate or predict the rate of inflation that will affect each LHA's expenses during its next fiscal year. The inflation factor is defined, therefore, as the ratio of the average monthly wage rate of local government employees next year (W_{y+1}) to their current year's average monthly rate (W_y):

$$F = \frac{W_{y+1}}{W_y}$$

This chapter is concerned primarily with the problem of how to predict next year's wage rate. First, however, a review of the rationale of the inflation factor is in order.

Reasons for Using the Inflation Factor as a Multiplier.

In the original approach to the prototype equation, the local government wage variable was used as an independent or explanatory variable, along with the other variables identified in Chapter V. Three

years of data were used in the calculations, and the weight given the wage variable in the prototype equation was the principal means of accounting for inflation. When one year of data was used, however, the weight of this variable was no longer statistically significant.[1]

This means that the variation among the expenses of High Performance Authorities in any one year could be adequately accounted for by a set of variables that did not include the wage variable. It seemed sensible, therefore, to use the prototype equation derived from only one year's data to measure the impact of noninflationary changes from year to year. The same factors that accounted for the wide variation among Authorities at any given time could be assumed to account for the relatively minor variation, excluding inflation, within an Authority from one year to the next. Hence, the equation element $(P_{y+1} - P_y)$ was developed

It also seemed reasonable to apply the percentage change in wage rate directly to LHA expenses. These considerations entered into that important decision:

(1) As noted, if the local wage rate was employed along with the other independent variables in a multiple regression equation using only one year's data, the weight of the variable would be affected by the variance across LHA's rather than the variance over time, and there was no reason to believe that the result would be realistic in projecting Authority expenses. Even when the initial approach with three years of data was employed, there was a confounding of across - Authority variance and variance over time.

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1. In simulations with 1972 data. With three years of data, the variation in expenses from year to year of any given LHA was apparently accounted for primarily by the wage variable; when one year of data is used, there is no year-to-year variation.

(2) If wage rates were included directly in the equation, the empirically determined weight that reflected the relationship between local government wage rates and Authority expenses over recent years would be suspect because of the restrictions placed on Authority expenses by the Interim formula.

(3) A series of computer simulations projecting formulas based on the latest three years of data indicated that such formulas might lose their ability to adjust Authority expenses for noninflationary changes in local operating conditions in several years if an inflation factor were included in the formula. The wage changes were increasingly dominating the other variables as each successive year's expenses were determined more and more by the differences in wages from year to year. Furthermore, the percentage increases in allowable expenses seemed to be much greater for some LHA's than others, and the amount of the difference did not appear warranted by the amount of difference among areas in inflation rates.

(4) Study of the interrelationships among the independent variables in simulations with 1972 data showed that the wage variable failed to achieve a statistically significant weight in the multiple regression because of its high statistical relationship with the regional variable which was measuring the relative cost of LHA operations across the 10 HUD regions. As the regional variable was, in effect, taking the wage variable out of the prototype equation for a single year, and as the value of the regional variable would not change when the value of $(P_{y+1} - P_y)$ was computed, the prototype equation element $(P_{y+1} - P_y)$ could be considered relatively free of short-term inflationary change. Giving a full weight to the inflation as a multiplier of both the current expense level (E_y) and the change in prototype $(P_{y+1} - P_y)$ seemed justified.

(5) The decision to apply the wage ratio separately was consistent with the Performance Funding System decision to separate out utility expenses and to apply a separate rate of increase to utilities.

(6) Especially with utilities excluded, it also seemed justified to multiply the current year's allowable expense level by the local government wage ratio when these expenses were projected forward. Wages of Authority personnel make up a large portion of LHA operating expenses. Authority personnel wages in turn are frequently keyed to the wages of comparable employees in the local government. As local government wages rise, LHA wages can be expected to remain competitive. Using wage changes as a multiplier would make supportable Authority expense levels more sensitive to these changes.

The Problem of Projecting Next Year's Wage Rate

Use of the inflation factor as a multiplier in the prototype equation raised the problem of how to project wages forward to make estimates for the next fiscal year. As a first step in consideration of a projection method, Urban Institute staff examined the average local government employee wage data for successive years (1970, 1971, 1972, and 1973) in the states and counties. The examination indicated that the ratios W_{y+1}/W_y varied widely from year to year for individual LHA's. The ratio also varied widely among LHA's for any given year. Even the average of the three ratios W_{1971}/W_{1970}, W_{1972}/W_{1971} and W_{1973}/W_{1972} varied considerably among LHA's.

Consequently, it was decided to use a multiple regression equation to update the average earnings figure assigned to the LHA's. The principal advantage of a regression equation is that the equation reflects the change in average earnings of all locales used in derivation of the equation and, at the same time, allows individualized rates of inflation

to be calculated for each Authority. That is, the use of the equation to obtain projected wage levels reduces the wide variation in ratios that would obtain if the wage data from each area were used separately to derive the ratio for the area, but it does not entirely eliminate such variation (as would happen if some overall average ratio were used for all areas). Moreover, the use of the regression equation allows compensation to an Authority for general price and wage inflation even if the specific index (the average earnings of the local government employees) had not risen in its area in the past year.

Choices in Forming the Regression Equation

In the initial construction of the multiple regression equation, the independent variables were the average earnings figures obtained from the 1970, 1971, and 1972 surveys of the Bureau of Census; the dependent variable was the 1973 average earnings. To project the wage figure forward to 1974, the weights obtained in the regression equation were applied to the following year's data; that is, to estimate 1974 average earnings, the weight for 1970 data was applied to 1971 figures; the weight for 1971 data was applied to 1972 figures; and the weight for 1972 data was applied to 1973 figures. The results of application of the equation to specific Authorities indicated, however, that a few Authorities would receive 1974 inflation factors less than 1.00 and some would receive factors greater than 1.15. The inflation factors ranged from .93 to 1.19. This wide variation was apparently caused by the uneven past rates of change in average monthly wages within some states and counties.

To reduce the problem of very low and very high inflation factors, two steps were taken. First, the equation was rederived with two-year data pairs rather than with three years of data fitted to the fourth year. Three sets of paired data were tried:

(1) The pairs of observations formed with 1972 and 1973 data as the independent and dependent variables, respectively (344 cases).

(2) The preceding pairs plus the pairs with 1971 and 1972 data as the independent and dependent variables, respectively (688 cases).

(3) The preceding pairs and the pairs with 1970 and 1971 data as the independent and dependent variables, respectively (1032 cases).

The regression equation derived with two sets of paired data (688 cases) had the lowest standard error of estimate and therefore was selected.

The selected regression equation was then applied to the 688 cases and the differences (residuals) between the actual and estimated average wages were calculated. Cases in which these differences exceeded 1.96 x the standard error of estimate were eliminated.[2] The 32 pairs eliminated from the 688 cases either had very low (.80 to .96) or very high (1.20 to 1.63) inflation ratios. (Such extreme ratios can reasonably be attributed to sampling and non-sampling errors that enter into the Bureau of Census estimates.) The regression equation was then recomputed without the cases that had large residuals.

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2. With this criterion, one would expect to eliminate approximately 5 percent of the cases. Actually, 32 cases (4.7 percent) were thereby eliminated.

The 1974 Regression Equation and Inflation Factors

Through these steps, the following equation was derived:

$$W_{1974} = 1.02452\ W_{1973} + 30.15054$$

The standard error of estimate for the equation is $30.00. The correlation between the independent and dependent variables is .977; that value indicates that prior year wage levels are highly predictive of current year levels.[3]

To calculate the ratio for a given Authority, its W_{1974} value was first calculated with the derived regression equation. The ratio W_{1974}/W_{1973} was then calculated with the actual Bureau of Census average earnings for W_{1973}. After the computations, the variation in 1974 inflation factors was considered reasonable--the lowest computed ratio for 1974 is 1.0525; the highest is 1.1024. It should be noted that when the above equation is used to calculate W_{1974} estimates and these estimates are divided by the W_{1973}, the inflation factors obtained will become smaller as the value of W_{1973} increases. The equation reflects a strong tendency during the period 1971-73 for areas where average local government wages are relatively high to have smaller annual percentage increases in wages than areas where average wages are relatively low.

The procedure for obtaining the inflation factor assumes that the same relationships found in the preceding year's wage data will hold

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3. The regression equation was based on 656 observation pairs. If the final step had not been taken and all 688 cases had been used, the standard error of estimate for the equation would have been 41.47; the correlation coefficient would have been .955.

during the next year. Under the Performance Funding System the rate of inflation calculated for the forward-funding years 1973-74 is assumed to hold for 1974-75.

The methodology is based on the general premise that the best prediction of what will happen in the next two years is what happened in the last two years. In a sense, that is also the general premise underlying the development of the prototype equation. Just as it will be necessary to annually update the portion of the prototype equation excluding inflation to include the latest available information, it will be necessary to update the equation for calculating the inflation factor as new Bureau of Census wage data become available. Annual updating of these equations should average out, over time, any prediction errors which overcompensate or undercompensate the LHA's.

Chapter VIII
THE PROTOTYPE EXPENSE EQUATION, 1974-75

The part of the analysis that remains to be discussed is the final development of the prototype equation itself. This chapter begins with discussions of the time framework of the analysis and the implementation of the prototype equation in the Performance Funding System. Later, it provides the most recent results of computing the equation. A comparison of the equation results with the actual experience of Authorities in the sample concludes the chapter.

The Time Framework

An understanding of the time framework is essential for the LHA's who will participate in the Funding System as well as for the analyst who is concerned with how the System developed. The time periods covered by the analysis and by the implementation are complicated by various circumstances:

(1) LHA fiscal years are staggered over four quarters--starting on October 1, January 1, April 1, and July 1.

(2) Although the federal Fiscal Year (FY) currently starts on July 1, the Forward Funding Year (FFY) covers the four quarters that start October 1. This lag permits federal funding decisions to be made between July 1 and October 1 (for the first quarter).

(3) The Performance Funding System will begin operation with LHA's whose Fiscal Years commence on April 1, 1975. This means

that approximately half the Authorities will be brought into the system in this FFY and half in the upcoming FFY.

(4) The prototype equation must be derived four or five months before the beginning of a Forward Funding Year so that, in accordance with HUD regulations, Authorities can prepare and submit their budgets three months before their fiscal years begin.

A description of how expense data relevant to these time periods was used in the analyses and in implementing the Performance Funding System is given in Table VI, "Time Periods of the Analysis and System Implementation."

The Final Selection of Variables

We identified three variables--the relative cost of operating Authorities within a HUD region, the square root of the population of the area served, and the average bedroom size--which had a highly significant relationship with operating expenses (less utilities) when combined in a multiple regression equation. These three variables met all criteria for variable selection. The multiple correlation coefficient with operating expenses less utilities for these three variables alone was .77 for the High Performance Authorities.

With these three variables as a base, the computations indicated that it might be worthwhile to add two more variables: the average height of Authority buildings and the square root of the average age of the buildings. Both met all criteria for inclusion, except that the F test of significance of their weights in the equation for the High Performance Authorities was at about the 10 percent level. The two variables were added to the equation because previous computer analyses with 1972

TABLE VI

Time Periods of the Analysis
and System Implementation

Authority Fiscal Year Beginning Date	HUD Forward Funding Year	Use and Application of Expense Data
Oct. 1, 1972	1973	The actual expenses* of the Authorities for Forward Funding Year 1973 were used to derive the Prototype Expense Equation, 1974-75.
Jan. 1, 1973	1973	
April 1, 1973	1973	
July 1, 1973	1973	
Oct. 1, 1973	1974	Authorities whose Fiscal Year began on April 1 or July 1, 1974 will calculate their prototypes for FFY 1974 and apply the Range Test to their 1974 operating budgets. The actual expenses* of the Authorities for FFY 1974 will be used in June 1975 to derive the Prototype Expense Equation, 1975-76.
Jan. 1, 1974	1974	
April 1, 1974	1974	
July 1, 1974	1974	
Oct. 1, 1974	1975	Authorities whose Fiscal Year began on Oct. 1, 1974 or Jan. 1, 1975 will calculate their prototype for FFY 1975 and apply the Range Test to their 1975 operating budgets. The actual expenses* of the Authorities for FFY 1975 will be used in June 1976 to derive the Prototype Expense Equation, 1976-77.
Jan. 1, 1975	1975	
April 1, 1975	1975	
July 1, 1975	1975	

* Since the year-end actual expenses of Authorities whose fiscal year begins on July 1 are not available in May, when the prototype equation is derived, the approved operating expense budgets of these Authorities are used in lieu of actual expenses.

expense data had indicated that both building height and age were useful predictors of Authority expense, and we believed the two variables would add to the ability of the equation to consider differences in operating conditions. Their inclusion raised the multiple correlation coefficient to .80 for the High Performance Authorities and reduced the standard error of estimate from $6.18 to $5.95 in the High Performance Group equation.

The weights of the selected variables and the equation constant are given in Table VII. The equation (rounded to three decimal points) is:

$$\text{Prototype}_{1973} = .373C + .430N + 7.706R + 1.953A + 1.215H - 25.202,$$

where the letters stand for the five variables identified in the following table:

Table VII

Independent Variables and Regression Weights for Use in Calculating 1974-75 Prototypes

Variable Name and Equation Symbol	Units	Variable Transformation	Weight
Regional relative cost of LHA operation (C)	100 = Average		.37271
Population of area served by LHA (N)	In Thousands	Square root	.42955
Average number of bedrooms per unit (R)	Bedrooms		7.70579
Average age of project buildings (A)	Years	Square root	1.95297
Average height of project buildings (H)	Stories		1.21486
Equation Constant			- 25.20178

Comparison of 1974 Prototypes and Budgets for the Sampled Authorities

As a test of the prototype expense equation, 1974 prototypes were calculated for each of the 119 Authorities in The Urban Institute sample. (Table VIII gives two examples of how these calculations were performed.)

Table IX supplies the average 1974 prototypes for the Large, Medium, and Small Authorities within the High and Low Performance Groups, along with their average 1974 approved operating budgets. Several important trends in the Authority expense data are shown. First, as expected from earlier studies of LHA expenses, the Large, Medium, and Small Authorities differ significantly[1] in their average 1974 budgeted expenses; the Large Authorities have considerably higher approved expenses. As was also expected, the Low Performance Authorities had higher approved expense levels, on the average, than did the High Performance Authorities. The prototypes for the Authorities in general follow the same pattern--Large Authorities and Low Performance Authorities have higher prototypes. These higher prototypes reflect the more difficult operating conditions of the Large and Low Performance Authorities.

The average prototype values are close to average budgets in all groups except the Large Authorities. The relatively large discrepancy ($8.65 PUM) between average prototype and average budgets in the Large Low Performance Authorities seems to reflect their relatively poor

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1. Analyses of variance were used to compare Large, Medium, and Small Authorities and High and Low Performance Groups on average 1974 prototypes, budgets, and the difference between prototypes and budgets.

TABLE VIII

CALCULATIONS OF 1974 PROTOTYPE
FOR TWO HYPOTHETICAL LHA'S (EXAMPLE A AND B)

Example A

The Forward Funding Year of Authority A ended December 31, 1974. It serves a hypothetical county in Virginia (Region III) which is not in an SMSA. The population of the county, according to the 1970 Census, was 82,394. The average bedroom size of the Authority units is 1.327 (it has 254 units with a total of 337 bedrooms). The average age of the Authority buildings at the end of 1974 was 6.32 years; the average height of its project buildings was 1.89.

Operations/Calculations/Transformations	Variable Value	Variable Weight	Product (Value X Weight)
The Relative cost for Region III is 97.	97	.37271	36.15287
Multiply 1970 population by 1.059, the multiplier for Virginia for 12/31/74. (82,394 x 1.059 = 87,255). Round to nearest thousand (87) and take square root.	9.32737	.42955	4.00657
Average the number of bedrooms	1.327	7.70579	10.22558
Take square root of 6.32 (Years)	2.51396	1.95297	4.90969
Average the height of tallest project buildings	1.89	1.21486	2.29609
	Obtain Sum of Products		57.59080
	Add Constant		-25.20178
	Total		32.38902
Inflation Factor for Virginia is 1.0830	Inflation Factor		x 1.0830
	1974 Authority Prototype		35.07731

TABLE VIII (Continued)

Example B

The Forward Funding Year of hypothetical Authority B ended March 31, 1975. It serves Placer County, California (Region IX) which is in an SMSA. The population of the county, according to the 1970 Census, was 77,306. The average number of bedrooms of the Authority units is 2.152. The average age of the Authority buildings was 14.57 years on March 31, 1975; the average height of project buildings was 3.02.

Operations/Calculations/Transformations	Variable Value	Variable Weight	Product (Value X Weight)
The Relative Cost for Region IX is 132.	132	.37271	49.19772
Multiply 1970 population by 1.104, the multiplier for California for 3/31/75. (77,306 x 1.104 = 85,346). Round to nearest thousand (85) and take square root.	9.21954	.42955	3.96025
Average the number of bedrooms	2.152	7.70579	16.58286
Take square root of 14.57 (Years)	3.81706	1.95297	7.45460
Average the height of tallest project buildings.	3.02	1.21486	3.66887
		Obtain Sum of Products	80.86430
		Add Constant	-25.20178
		Total	55.66252
Inflation Factor for Placer Co. is 1.0622.		Inflation Factor	x 1.0622
		1974 Authority Prototype	59.12473

Table IX

Average 1974 Prototypes and Approved
Operating Budgets for Authorities in Institute Sample
(Total Operating Expenses Less Utilities)

Authority Size	High Performance Group		Low Performance Group		Total Sample	
	Proto.	Budget	Proto.	Budget	Proto.	Budget
Large	50.53	53.70	55.99	64.64	53.33	59.31
Medium	41.29	40.64	47.69	46.26	44.65	43.59
Small	35.21	36.54	41.86	40.39	38.87	38.66
Total Sample	42.47	43.76	48.29	50.04	45.55	47.08

management practices. In previous research,[2] the authors have pointed to the significant relationships between higher operating expenses and low management responsiveness to tenant needs, lack of management firmness in rule enforcement, and low tenant satisfaction with management. These relationships were particularly pronounced in the Large Housing Authorities.

The fairly sizeable difference ($3.17) between average prototypes and average budgets obtained for Large High Performance Authorities is mostly attributable to three High Performance Authorities whose approved 1974 budgets were between 32 and 66 percent greater per unit per month than their 1973 actual expenses. (No Large Low Performance Authorities had percentage increases greater than 28 percent.)

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2. Robert Sadacca, Suzanne B. Loux, Morton L. Isler, and Margaret J. Drury, Management Performance in Public Housing, op. cit. Morton L. Isler, Robert Sadacca and Margaret J. Drury, Keys to Successful Housing Management, op. cit.

Tests of Application of the Range Test on 1974 Prototypes

As noted earlier, the standard error of estimate of the prototype equation was $5.95. Statistical tests of the errors of estimate[3] were made to see if the means and variances of the errors (residuals) were significantly different in the Large, Medium and Small High Performance Groups. The tests indicated that the errors of estimate were not significantly different across the three groups. A chi-square test was then run to determine if the errors of estimate across the 56 Authorities in the High Performance Group could be considered to have come from a normal distribution with a zero mean and a standard deviation of $5.95. The test indicated that the errors could be considered to come from a normal distribution with these parameters. Those tests, however, were run with 1973 predicted and actual expenses. The standard error of estimate, $5.95, was derived from 1973 data. As explained in Chapter IV, the range test is applied to 1974 approved budgets under the Performance Funding System. In the absence of 1974 actual expense data, an error term was approximated from the multiple regression equation that related the five selected independent variables[4] to 1974 budget expenses. The standard error of estimate was calculated as $6.27, a value consistent with an expected increase in Authority operating expenses (less utilities) of

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3. The predicted 1973 cost of each High Performance Authority (obtained from application of the prototype equation) was subtracted from its actual 1973 expense level to arrive at an error of estimate for each Authority.

4. The 1974 values of square root of population, average bedroom size, and so forth, were used. The regional cost values were the same ones used for 1973.

about 5.5 percent from 1973 to 1974 as allowed under the Interim Formula.[5] A chi-square test was run to determine whether the differences between 1974 approved budgets and the 1974 prototypes in the High Performance Group could be considered to come from a normal distribution with a mean of zero and a standard deviation of $6.27. This test, like the previous one using actual expenses and 1973 prototypes, indicated that the differences could be considered to come from a normal distribution with the indicated parmeters.

Determination was made of the upper and lower limits within which the actual 1974 expenses of the High Performance LHA's should be expected to fall 90 percent of the time.[6] These limits came to $10.31 above and below the 1974 prototype calculated for each Low Performance Authority in the Institute sample. The 1974 approved budget of each Authority was then examined to see if it fell within the prototype range for the Authority. The results are shown in Table X.

Approximately 90 percent of the High Performance Medium and Small Authorities do have 1974 approved budgets that fall within their prototype range. The three High Performance Large LHA's with greatly increased budgets were above the upper limit of their prototype range. If not for these three cases, about 90 percent of the High Performance Large Authority budgets also would have fallen within their prototype range.

A test was performed to determine whether the differences between 1974 approved budgets and 1974 prototypes of the 56 LHA's in the High

5. When each value of a dependent variable is multiplied by a constant (in this case 1.055) the standard error of estimate is also multiplied by that constant ($5.95 x 1.055 is approximately equal to $6.27).

6. The standard error of estimate ($6.27) was multiplied by the abscissa values of the unit normal curve that delineate 90 percent of the area ($\pm$ 1.645) to obtain $\pm$ $10.31.

Table X
Number of Authorities Whose 1974 Approved Budgets
Fell Below, Within, and Above their Prototype Ranges

Authority Size	Performance Group	Results of Range Test		
		Below	Within	Above
Large	High	1	14	4
	Low	0	13	7
Medium	High	1	16	2
	Low	2	17	2
Small	High	0	17	1
	Low	2	18	2
Total	High	2	47	7
	Low	4	48	11

Performance Group were related to the size of the 1974 prototypes (as might happen if the prototype equation was systematically yielding relatively low prototypes to high cost large High Performance LHA's). The correlation of the 1974 prototype levels with the differences (1974 approved budgets minus 1974 prototypes) was obtained and found to be not significantly different from zero. The correlation of 1974 prototype levels with the squares of these differences was also obtained and found to be not significantly different from zero.[7] These results indicate the size of the 1974 prototypes of High Performance Authorities is unrelated to the size of the difference between their 1974 prototypes and 1974 approved operating budgets.

7. The correlation of the squares of the 1974 prototype levels with the differences was also not significant. See Chapter 3, Applied Regression Analysis, by N. R. Draper and H. Smith, John Wiley & Sons, Inc., New York, 1966, for a discussion of tests used to determine whether prediction errors are unrelated to the predicted values.

As could have been expected from the large difference between their 1974 prototype and budget averages (see Table IX), a substantial number of Low Performance Large Authorities (7) had budgets above the upper limit of their prototype range. However, of these seven Authorities, only one had a budget so far above the upper limit that one would not expect that its allowable expense level under the Performance Funding System would exceed its 1974 budget in four years if the current rate of inflation continues. Similarly, only one of the seven above-range Medium and Small Authorities had a budget so far above the upper limit that its allowable expense level will probably not exceed its 1974 budget in the next four years.

Chapter IX
LOOKING AHEAD

The Performance Funding System was designed with four principal criteria in mind:

(1) To provide a level of subsidy that would permit LHA's to provide sufficient housing services to residents and adequately maintain the housing stock.

(2) To afford equity among the Housing Authorities by varying the subsidized expense levels according to local conditions.

(3) To allow LHA's the flexibility to allocate their financial resources to meet changing operating conditions.

(4) To allow greater certainty and ease of budget preparation for HUD and Local Housing Authorities.

How well the System will meet these criteria can only be determined through study of the results of applying the System over the next several years.

However, the results of the simulations of how the Performance Funding System would operate for the 119 Authorities in the Institute sample have been quite encouraging. Under the System, almost all of these Authorities would receive federal subsidy levels more in line with their changing operating circumstances than those received under the Interim formula.[1] Moreover, the current wide diversity of expense levels among Authorities operating under similar circumstances would be narrowed.

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1. Even Authorities whose current year budgets are above the upper limit of their prototype range would benefit through receiving greater federal support for their utility expenses.

Most Authorities would also benefit administratively. Authorities would find it easier to anticipate their allowable expense levels. They could allocate budgeted funds more flexibly. Less time and expense would be used for budget reviews.

Some serious questions remain unanswered, however. Three major questions about the future of operating subsidies are addressed in this final chapter.

Will the Subsidies Be Adequate?

When in operation, the Performance Funding System will determine how much LHA operating expenses will be expected to change each year. The new expense levels will ultimately enter the data base and in turn influence the size of subsequent allowable expense levels. Note that the System is essentially self-contained--once the system is initiated, allowable LHA expense levels are determined from previously allowable expense levels.

What assurances are there that a self-contained system will assign Housing Authorities sufficient funds for necessary housing services to their tenants and adequate maintenance of their buildings and grounds? What assurances are there that the funding levels will not be too high? These questions go to the heart of the rationale of the approach taken to develop prototype expenses. The prototype equation was based on the expenses of "High Performance" Authorities. But if the Performance Funding System is self-contained, what mechanism assures that even the High Performance Authorities will be adequately funded in the future?

To meet this need, the authors recommend strongly that the Performance Funding System be closely monitored to assure that the housing service levels provided by Authorities do not decrease over time and that Authorities can meet their obligations to their tenants and their communities.

The basic mechanism for evaluation should be the periodic reassessment of the sampled Authorities. We recommend that the performance of the Authorities be measured every two or three years to reestablish which Authorities should be placed in the High Performance Group. The data collected can be compared with earlier data from the same Authorities and it can be determined whether average Authority performance is increasing, decreasing or remaining relatively constant over time. A decrease in performance levels could be indicative of insufficient funding if the decreases in performance were not related to ineffective management practices.

Based on the evaluation, and possibly even preceding it, there are a number of places in the System where improvements are at least potentially feasible. For example, there can be more than one inflation factor. If future research indicates that other expense components rise at predictably different rates, LHA total operating expenses could readily be broken down into more than two components, and a separate inflation factor applied to each expense component, e.g., wages, material and supplies, and all other expenses. In addition, new predictive measures for utilities and for rental income may be developed to improve those aspects of the Performance Funding System. Improvements in the prototype equation should also be sought through testing out additional independent variables.

Note, however, that some aspects of LHA expenses lie entirely beyond the System. Of special concern is whether Authorities will be able to adequately upgrade existing stock under the Performance Funding System. The expense levels on which the prototype formula is based do not include modernization funds or monies to make up for deferred maintenance. Supplemental funds most probably will be needed for this purpose and for other historical conditions of inadequacy.

What Will Happen to the Low Performance Authorities?

Another unresolved question is whether the Low Performance Authorities whose current approved budgets are substantially above the upper limit of their prototype range can make up the future loss in subsidy dollars through increased management efficiency. Although being "held harmless" at their current budget levels, these Authorities may actually receive less "real" funds as time goes on because of wage and price inflation and the aging of their stock. What will happen if some of these Authorities cannot absorb cost increases through increased efficiency and are forced to lower housing service levels?

Institute analyses indicate that above-range Authorities tend to have lower levels of services than do other Authorities. They also tend to use poorer management practices. However, they also must contend with more difficult operating circumstances. It may be necessary to provide these Authorities with "catch-up" funds (in the mode of HUD's recently initiated Target Projects Program) and/or technical assistance from outside agencies to help them streamline their managements, improve their

operating circumstances, and gain the confidence and the cooperation of their tenants and staff. The Performance Funding System, by itself, will not assure that conditions in these low-performing LHA's will improve.

Can Standards Be Defined for Housing Services?

At the root of the problem of evaluating and improving the Performance Funding System is the difficulty of establishing what is "sufficient" or "adequate" in the way of housing services. Ultimately, consideration must be given to the questions of what kinds and levels of housing services should be available to low-income families in the United States, in and out of public housing, and who should pay for these services. The development of the prototype equation avoided the question of how much it should cost Housing Authorities to perform their service obligations, primarily because there was no commonly accepted or official definition of what those obligations were. In the Introduction to this paper we pointed out the difficulties of establishing housing service standards. For example, standards differ from place to place. Moreover, standards can shift over time; a service level that is adequate today may not be adequate tomorrow. Such definition is rooted in the values, ethics and resources of our society, and could be expected to change as these factors themselves change over time.

The Performance Funding System must ultimately be based upon equity, especially in the distribution of resources to provide housing services to the nation's poor. In the long run, there is a need for detailed analysis of the level of housing services that should be provided in public housing and the cost of providing those services. The 119

representative Public Housing Authorities are a convenient sample for such analysis. The next major step toward achieving the goals of public housing should be the consideration of a common set of objectives for all Housing Authorities and the development of procedures for determining whether the Authorities are meeting these objectives adequately. In the meantime, the authors believe that the prototype equation and the Performance Funding System can improve public housing operations for the federal government, for the Housing Authorities, and for the people whom public housing serves.

APPENDIX A

CRITERION, CONTROL, MANAGEMENT, AND SWING VARIABLES

Table A-1

DEFINITION, SOURCE, UNITS, MEANS AND RANGES OF THE 24 CRITERION VARIABLES AND THE RESULTS OF SIGNIFICANCE TESTS OF MEAN DIFFERENCES

NOTES

SOURCE: Abbreviations refer to questionnaire:

BC--Board Chairman
ED--Executive Chairman
CO--Central Office Staff
PM--Project Manager
PS--Project Staff
HH--Household

UNITS: The highest and lowest units of measure only are indicated; intermediate scores are omitted (e.g., Variable #010: the complete scale is: 3 = very good; 2 = good; 1 = poor; 0 = very poor).

RANGE: The lowest and highest scores actually obtained for individual Authorities are given. This is not the possible range of responses.

RESULTS OF SIGNIFICANCE TESTS: The means of the High and Low Performance Groups or Large, Medium and Small samples are "significantly" different if the differences among the means are so large that it is reasonable to infer that the differences did not arise by chance. The probability values in this report give the probability that differences as large as those obtained could have resulted by chance.

The following abbreviations are used:

P. G. = Performance
Size = Size Group
P. G. x S. = Interaction between Performance and Size Groups
n. s. = not significant (i.e., no significant difference in means between the applicable groups).

Example: The Results of Significance Test for Variable 010 means that there was a significant difference (at the 5% level) between the High and Low Performance Groups in the average manager rating of unit condition; that the differences in averages were more pronounced (significant at the 1% level) between the three Size Groups; and that there was no significant interaction between Performance and Size Groups.

Table A-1 (Continued)

CRITERION VARIABLES

001--Residents' satisfaction with project

Source: HH--52,55,274,275,291
Units: 1 = satisfied; 0 = dissatisfied Range: .50 - .94

	Large	Medium	Small	Total	Results of Significance Tests	
High	.71	.77	.83	.77	P.G.	1%
Low	.62	.68	.78	.70	Size	1%
Total	.67	.72	.80	.73	P.G. x S.	n.s.

002--Residents' satisfaction with neighbors

Source: HH--142,145,197,199
Units: 1 = satisfied; 0 = dissatisfied Range: .49 - .99

	Large	Medium	Small	Total	Results of Significance Tests	
High	.77	.83	.91	.83	P.G.	1%
Low	.70	.75	.83	.76	Size	1%
Total	.74	.78	.86	.80	P.G. x S.	n.s.

003--Residents' satisfaction with safety and security

Source: HH--78,254,255,261
Units: 1 = satisfied; 0 = dissatisfied Range: .39 - 1.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	.72	.82	.92	.82	P.G.	1%
Low	.61	.73	.85	.73	Size	1%
Total	.67	.77	.88	.77	P.G. x S.	n.s.

004--Residents' evaluation of cleanliness of buildings and grounds

Source: HH--126,127,129,131
Units: 1 = satisfied; 0 = dissatisfied Range: .24 - 1.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	.66	.76	.87	.76	P.G.	1%
Low	.50	.57	.73	.60	Size	1%
Total	.58	.66	.80	.68	P.G. x S.	n.s.

Table A-1 (Continued)

005--Residents' satisfaction with maintenance

Source: HH--95,96,98,100
Units: 1 = satisfied; 0 = dissatisfied
Range: .33 - 1.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	.79	.88	.91	.86	P.G.	1%
Low	.68	.78	.83	.77	Size	1%
Total	.73	.83	.87	.81	P.G. x S.	n.s.

006--Residents' satisfaction with management

Source: HH--110-112,232,233,239
Units: 1 = satisfied; 0 = dissatisfied
Range: .36 - .99

	Large	Medium	Small	Total	Results of Significance Tests	
High	.80	.84	.88	.84	P.G.	1%
Low	.69	.73	.81	.75	Size	1%
Total	.74	.78	.84	.79	P.G. x S.	n.s.

007--Residents' perception of their present and future quality of life

Source: HH--267,268
Units: 12 = best life; 0 = worst life
Range: 5.92 - 10.66

	Large	Medium	Small	Total	Results of Significance Tests	
High	8.06	8.46	8.90	8.47	P.G.	1%
Low	7.29	7.84	8.17	7.78	Size	1%
Total	7.67	8.13	8.50	8.10	P.G. x S.	n.s.

008--Residents' evaluation of condition of unit

Source: HH--81-86,101-105
Units: 1 = good; 0 = poor
Range: .56 - .97

	Large	Medium	Small	Total	Results of Significance Tests	
High	.85	.87	.90	.87	P.G.	1%
Low	.80	.82	.84	.82	Size	1%
Total	.82	.84	.87	.84	P.G. x S.	n.s.

009--Residents' evaluation of neighborhood acceptance of project

Source: HH--195,196
Units: 1 = good; 0 = poor
Range: .45 - 1.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	.75	.81	.88	.81	P.G.	1%
Low	.70	.70	.79	.73	Size	1%
Total	.73	.75	.83	.77	P.G. x S.	n.s.

Table A-1 (Continued)

010--Manager's evaluation of condition of building systems

Source: PM--72,74,76,78,80,82,84,86
Units: 3 = very good; 0 = very poor Range: .65 - 3.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	1.90	2.24	2.47	2.20	P.G.	5%
Low	1.86	2.12	2.07	2.02	Size	1%
Total	1.88	2.17	2.25	2.10	P.G. x S.	n.s.

011-- Manager's evaluation of condition of units

Source: PM--153,155,157,159,161,163,165,167,169
Units: 3 = very good; 0 = very poor Range: .75 - 3.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	2.01	2.21	2.39	2.20	P.G.	1%
Low	1.83	2.04	1.91	1.93	Size	5%
Total	1.92	2.12	2.13	2.05	P.G. x S.	n.s.

012--Manager's evaluation that resident failure to maintain unit is no problem

Source: PM--187
Units: 3 = no problem; 0 = big problem Range: 0.00 - 3.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	1.63	1.89	2.22	1.91	P.G.	1%
Low	1.22	1.50	2.02	1.59	Size	1%
Total	1.42	1.68	2.11	1.74	P.G. x S.	n.s.

013--Manager's evaluation of seriousness of effects of deferred maintenance

Source: PM--40-45,69
Units: 7 = very serious; 0 = no deferred maint. Range: 0.00 - 5.31

	Large	Medium	Small	Total	Results of Significance Tests	
High	1.78	.45	.45	.90	P.G.	5%
Low	2.63	.41	.98	1.32	Size	1%
Total	2.22	.43	.74	1.12	P.G. x S.	n.s.

014--Authority's evaluation of Authority Staff

Source: ED--191-193;PM--35,37,102,103;CO--15-18;PS--30-32
Units: 3 = very good; 0 = very poor Range: 1.84 - 3.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	2.41	2.65	2.71	2.59	P.G.	1%
Low	2.24	2.54	2.51	2.43	Size	1%
Total	2.32	2.59	2.60	2.51	P.G. x S.	n.s.

Table A-1 (Continued)

015--Job satisfaction of Authority employees

Source: ED--88,177-180;PM--104-106,108,324;CO--34a-34d;PS--36-38
Units: 3 = very satisfied; 0 = very dissat. Range: 1.95 - 3.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	2.44	2.69	2.76	2.62	P.G.	5%
Low	2.34	2.65	2.61	2.54	Size	1%
Total	2.39	2.67	2.68	2.58	P.G. x S.	n.s.

016--Authority employees' evaluation of how well Authority is meeting its objectives

Source: BC--2,3,4;ED--24,25,26;PM--99,100,101
Units: 3 = very well; 0 = very poorly Range: .97 - 3.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	2.27	2.58	2.56	2.47	P.G.	1%
Low	2.01	2.25	2.22	2.17	Size	1%
Total	2.14	2.41	2.38	2.31	P.G. x S.	n.s.

017--Authority employees' evaluation of community acceptance

Source: BC--96;ED--146;PM--325
Units: 3 = very good; 0 = very poor Range: .67 - 3.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	2.15	2.49	2.69	2.44	P.G.	1%
Low	1.78	1.85	2.14	1.93	Size	1%
Total	1.96	2.15	2.39	2.17	P.G. x S.	n.s.

018--Occupancy rate

Source: HUD Records
Units: Percentage Range: 89.72 - 100

	Large	Medium	Small	Total	Results of Significance Tests	
High	97	99	99	99	P.G.	5%
Low	98	97	98	98	Size	n.s.
Total	98	98	99	98	P.G. x S.	n.s.

019--Proportion of rent delinquent units

Source: ED--255
Units: Percentage Range: 0.00 - 67.0

	Large	Medium	Small	Total	Results of Significance Tests	
High	12	10	4	9	P.G.	1%
Low	21	10	15	15	Size	5%
Total	16	10	10	12	P.G. x S.	n.s.

Table A-1 (Continued)

020--Ratio of delinquent rents to dwelling rent schedule

Source: HUD Records
Units: Percentage
Range: 0.00 - 11.07

	Large	Medium	Small	Total	Results of Significance Tests	
High	1	0	1	1	P.G.	n.s.
Low	1	0	1	1	Size	n.s.
Total	1	0	1	1	P.G. x S.	n.s.

021--Average vandalism cost per unit

Source: ED--199;PM--312
Units: Dollars per unit last year
Range: 0.00 - $115.87

	Large	Medium	Small	Total	Results of Significance Tests	
High	$ 7.59	$3.93	$1.38	$ 4.35	P.G.	1%
Low	26.66	9.22	3.80	12.86	Size	1%
Total	17.37	6.71	2.71	8.86	P.G. x S.	5%

022--Estimate of burglaries and personal victimization per unit

Source: PM--310,311
Units: Number per unit last year
Range: 0.00 - .85

	Large	Medium	Small	Total	Results of Significance Tests	
High	.06	.02	.01	.03	P.G.	1%
Low	.20	.06	.01	.09	Size	1%
Total	.13	.04	.01	.06	P.G. x S.	1%

023--Area Office evaluation of how well Authority is meeting its objectives

Source: Area Office--01,02,03
Units: 3 = very well; 0 = very poorly
Range: 0.00 - 3.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	1.96	2.37	2.20	2.18	P.G.	1%
Low	1.35	2.05	1.86	1.76	Size	1%
Total	1.65	2.20	2.02	1.96	P.G. x S.	n.s.

024--Area Office evaluation of how effectively Authority cooperates with other agencies

Source: Area Office--04,05,06
Units: 3 = very well; 0 = very poorly
Range: 0.00 - 3.00

	Large	Medium	Small	Total	Results of Significance Tests	
High	2.53	2.47	2.07	2.36	P.G.	1%
Low	1.74	2.07	2.16	2.00	Size	n.s.
Total	2.12	2.26	2.12	2.17	P.G. x S.	1%

Table A-2

CONTROL, MANAGEMENT, AND SWING VARIABLES[1]

CONTROL VARIABLES

043	Number of projects in Authority
045	Average size of projects
046	Weighted average age of oldest project building
049	Number of elevators in average project
050	Proportion of units having own outdoor yard space
051	Average number of bedrooms per unit
054	Management problems attributed to design of project
055	Manager satisfaction with the quality of materials, equipment and workmanship used in construction of project
057	Manager evaluation that the surrounding neighborhood does not cause management problems
058	Number of abandoned cars moved off site by management last year
059	Resident perception that junk and abandoned cars are a problem
060	Resident evaluation that neighborhood has recently gotten better or worse
063	Resident evaluation of neighborhood municipal services
064	Manager evaluation of neighborhood municipal services
067	Civil service laws and political pressure are not a problem in controlling Authority staff
069	Central city or suburb
070	SMSA or Non-SMSA
072	HUD Region
073	Average January temperature

[1]For information on the sources, units, means, ranges, and results of significance tests for these variables, refer to Appendix II of Management Performance in Public Housing, op. cit.

Table A-2 (Continued)

MANAGEMENT VARIABLES

127	Executive Director has attended training courses in last two years
128	Executive Director's annual salary
140	Evaluation of Executive Director's effectiveness by Board Chairman
151	The organizational structure of the Authority needs to be modified to make it more efficient
161	Tenants should be trained and encouraged to do minor repairs
169	Eviction rate for rent delinquency
177	Response time to emergency request for maintenance
178	Response time to routine requests for maintenance
182	Proportion of occupants who have been charged for repairs
184	Proportion of occupants who have made repairs themselves
190	Residents have added or changed locks on their apartment doors
191	Residents' perception of strictness of management
194	Residents' perception of their treatment by management
196	Management contact's name known by residents
201	Tenants want more say in how project is managed
206	Number of hours per week Board Chairman spends in Authority business
211	Central Office Staff's involvement in investigating complaints
213	On-site staff's involvement in making policy decisions
222	Tenant involvement in setting rules

Table A-2 (Continued)

SWING VARIABLES

026	Number of people per unit
027	Number of children per unit
033	Proportion of families with personal problems making managing more difficult
035	Proportion of families with no adult who speaks English well enough to express needs
037	Average income of Authority households
042	Number of social services which tenants either have used or say that they would use if made available
052	Resident perception of having enough bedrooms
053	Resident perception of having enough plumbing for personal hygiene
091	Helpfulness of HUD Area Office in solving problems
109	Support given by local newspapers and other media
113	Number of unions involved with Authority
122	Proportion of Authority staff who are members of a union
174	Tenants perceive they are similar to their neighbors in regard to housekeeping standards and rules about raising children
179	Manager's perception of repair frequency for building systems
180	Manager's perception of repair frequency for units

APPENDIX B

PROCEDURE USED IN ESTIMATING RELIABILITY OF ASSIGNMENT OF AUTHORITIES INTO PERFORMANCE GROUPS

Procedure Used in Estimating the Reliability of the Assignment of Authorities into Performance Groups

1. Division of Criterion Variables into Two Subsets. The purpose of this step was to obtain two similar subsets of variables to allow for unreliability attributable to the selection of the particular criterion variables used in the study. The 24 criterion variables were divided into 12 pairs of similar variables; the pairing was accomplished on the basis of similarity of content, and source (questionnaire) and correlation with other criterion variables within the Large Housing Authority sample. One variable in each pair was then randomly assigned to Subset A and the other to Subset B. A few pair-wise assignments were then switched in order to equalize the average data usage in each subset (see Step 6 and last column of Table I). The 12 variables assigned to Subset A were 001, 002, 006, 008, 009, 011, 012, 014, 017, 018, 019, and 024. Subset B was composed of Variables 003, 004, 005, 007, 010, 013, 015, 016, 020, 021, 022 and 023.

2. Redefinition of the Variables on the Basis of a Reduced Number of Items.

The purpose of this step was to allow for unreliability attributable to the particular questionnaire items that comprised the criterion variables used in the study. Where the variable was a composite score based on responses to two or more items, the items were paired on the basis of content and one item was randomly selected from each pair to form a new reduced composite. Where pairs of items could not be readily formed on the basis of content, items were selected randomly. Table B-1 indicates the original and reduced numbers of items comprising each variable.

3. Selection of Respondent Subsamples. The purpose of this step was to allow for unreliability attributable to the particular samples of Authority project staff, Central office staff and households selected in each Authority. The indicated samples were randomly split into two subsamples with half the respondents in each subsample. One project staff, household and Central office subsample was then randomly selected to use in obtaining Authority scores for Variable Subset A. The other subsamples were used in obtaining Authority scores for Variable Subset B. Table B-1 indicates which variables were based on the responses of these split samples.

4. Assignment of Authorities into High and Low Groups. After the scores of the Authorities had been obtained on the 24 variables from the reduced data (items, respondents), the iterative discriminant analysis procedure described in Chapter III was carried out on the variables in Subset A. The procedure resulted in 18 Authorities being placed in the High Performance Group and 21 in the Low Group. When the procedure was applied to the 12 criterion variables in Subset B, 19 Authorities were placed in the High Group and 20 in the Low Group. The Table below shows the overlap in the two assignments.

		With Subset A	
		High	Low
With Subset B	High	12	7
	Low	6	14

5. Correlation Between Assignments. Assuming that the 12 variables taken together in the discriminant analysis procedure are measuring overall Authority performance and that overall Authority performance is a normally

distributed, continuous variable, the tetrachoric correlation between the results of the first and second application of the discriminant analysis procedure was computed with the formula:

$$r_t = \text{Cos} \left\{ 180^{\circ} \cdot \frac{\sqrt{BC}}{\sqrt{AD} + \sqrt{BC}} \right\}$$

where A = 12, B = 7, C = 6 and D = 14. The correlation was .500.

6. Estimating the Reliability of the Assignment Procedure. The full procedure actually used by the Institute in assigning Authorities involved variables measured more reliably (through using more items and respondents) than the variables used in Step 5 above. To estimate the reliability of the procedure actually used by the Institute, the Spearman-Brown Prophecy Formula was adopted from psychometrics. This formula gives the reliability of a full length test when the correlation between two equivalent parts of the test are known. The formula assumes only that the variances and covariance of the two parts are equal to the average variance and covariances for all other equal-length parts of the test. The formula has been applied successfully to rating scales and judgments and has been used to predict the reliability to be expected by increasing the number of judges or ratings.[1] The procedures employed in splitting the variables and selecting the items and respondents in the current application were designed to make the assumption concerning variance and covariance reasonable in generalizing the formula from total test length to total information used in arriving at an overall score, i.e., placement in the High or Low Performance Group.

[1] Gulliksen, H., Theory of Mental Tests (New York, John Wiley & Sons, Inc., 1950), p. 66.

Table I gives the ratio of the amount of information used in deriving each criterion score in the current application to the amount of information used in deriving the criterion scores where the actual assignments were made using all 24 variables and full information. Averaging of the ratios indicated for variable Subsets A and B gives an average information use ratio of .5707. As only half the 24 variables were used in each Subset, the amount of information used in each of the current applications of the assignment procedure was approximately 28.5% of the amount of information used in the actual assignments based on full information. The full amount of information was then calculated as the reciprocal of .2853 or 3.505 (that is, the actual assignment procedure used about three and one-half times the information that either of the current assignments did).

The Spearman-Brown Formula is:

$$R_{KK} = \frac{Kr_{II}}{1 + (K - 1)r_{II}} \text{ ; where}$$

r_{II} is the correlation between the two subparts, K is the number of items in the full test divided by the number of items in each of the subparts and R_{KK} is reliability of the full length test. Substituting 3.505 for K and .500 for r_{II} gives .78 as the estimate of the reliability for the assignment procedure when all information is used.

In order to test whether the reliability could be raised through changing the criterion variables used in the assignment process, the two matched criterion variables (V 19 and V 20) which had the least relationship to one another and to the other 22 variables were dropped from Subsets A and B, respectively. (The low relationships indicated that inclusion of these two variables probably contributed to unreliability.) The analyses

described above were then rerun with 11 variables in each subset. The correlation between the first and second applications was .70 which resulted in a reliability coefficient of .90 when information usage was taken into account.

Table B-1

Information Used in Arriving at Authority Scores in Determining Reliability

Var. Number	Data Subset	No. of Items Available	No. of Items Used	Respondents[1] Used	Approximate Ratio of Data Used to Total Available
001	A	5	3	½ households	.300
002	A	4	2	½ households	.250
003	B	4	2	½ households	.250
004	B	4	2	½ households	.250
005	B	4	2	½ households	.250
006	A	6	3	½ households	.250
007	B	2	2	½ households	.500
008	A	11	5	½ households	.227
009	A	2	1	½ households	.250
010	B	8	4	All project managers	.500
011	A	9	5	All project managers	.455
012	A	1	1	All project managers	1.00
013	B	7	3	All project managers	.429
014	A	3,4	2	All PM, ½ PS, ½ CO, ED	.438
015	B	3,4,5	2	All PM, ½ PS, ½ CO, ED	.346
016	B	3	2	All PM, ED, BC	.667
017	A	1	1	All PM, ED, BC	1.000
018	A	Records		Full data usage	1.000
019	A	1	1	ED	1.000
020	B	Records		Full data usage	1.000

Table B-1 (Continued)

021	B	1	1	All PM, ED	1.000
022	B	2	2	All PM	1.000
023	B	3	2	AO	.667
024	A	3	2	AO	.667
				Average Subset A	.570
				Average Subset B	.572

[1]CODE: PM = Project managers; PS = Project Staff;
CO = Central Office Staff; ED = Executive Director;
BC = Chairman of the Board; AO = HUD Area Office

APPENDIX C

POPULATION GROWTH FACTORS BY STATE

Table C-1
POPULATION GROWTH FACTORS BY STATE

For Population at end of Authority Fiscal Year, Multiply 1970 Census Population by Number Below

	Sept. 73	Dec. 73	March 74	June 74	Sept. 74	Dec. 74	March 75	June 75
Alabama	1.013	1.014	1.014	1.015	1.016	1.017	1.018	1.019
Alaska	1.060	1.064	1.068	1.073	1.077	1.081	1.085	1.089
Arizona	1.076	1.081	1.087	1.092	1.097	1.103	1.108	1.114
Arkansas	1.024	1.026	1.027	1.029	1.031	1.032	1.034	1.035
California	1.074	1.079	1.084	1.089	1.094	1.099	1.104	1.110
Colorado	1.067	1.072	1.076	1.081	1.086	1.090	1.095	1.100
Connecticut	1.059	1.064	1.068	1.072	1.076	1.080	1.084	1.088
Delaware	1.067	1.072	1.077	1.081	1.086	1.091	1.096	1.100
District of Columbia	1.065	1.070	1.074	1.079	1.083	1.088	1.092	1.097
Florida	1.075	1.081	1.086	1.091	1.097	1.102	1.107	1.113
Georgia	1.046	1.049	1.052	1.056	1.059	1.062	1.065	1.068
Hawaii	1.048	1.051	1.055	1.058	1.061	1.065	1.068	1.071
Idaho	1.024	1.026	1.027	1.029	1.031	1.032	1.034	1.035
Illinois	1.037	1.039	1.041	1.044	1.046	1.049	1.051	1.054
Indiana	1.040	1.043	1.045	1.048	1.051	1.054	1.056	1.059
Iowa	1.011	1.012	1.012	1.013	1.014	1.015	1.015	1.016
Kansas	1.014	1.015	1.016	1.017	1.018	1.019	1.020	1.021
Kentucky	1.017	1.018	1.020	1.021	1.022	1.023	1.024	1.025
Louisiana	1.033	1.035	1.037	1.039	1.042	1.044	1.046	1.048
Maine	1.009	1.009	1.010	1.010	1.011	1.012	1.012	1.013
Maryland	1.075	1.080	1.086	1.091	1.096	1.101	1.107	1.112
Massachusetts	1.037	1.039	1.041	1.044	1.046	1.049	1.051	1.054
Michigan	1.046	1.049	1.052	1.055	1.058	1.061	1.065	1.068
Minnesota	1.041	1.044	1.047	1.049	1.052	1.055	1.058	1.061
Mississippi	1.005	1.005	1.005	1.006	1.006	1.006	1.007	1.007
Missouri	1.030	1.032	1.034	1.036	1.038	1.040	1.042	1.044
Montana	1.014	1.015	1.016	1.017	1.018	1.019	1.020	1.021
Nebraska	1.021	1.023	1.024	1.025	1.027	1.028	1.030	1.031
Nevada	1.124	1.133	1.142	1.150	1.159	1.168	1.178	1.187
New Hampshire	1.066	1.070	1.075	1.079	1.084	1.089	1.093	1.098
New Jersey	1.055	1.059	1.063	1.067	1.070	1.074	1.078	1.082
New Mexico	1.025	1.027	1.029	1.031	1.032	1.034	1.036	1.037
New York	1.031	1.033	1.036	1.038	1.040	1.042	1.044	1.046
North Carolina	1.028	1.030	1.032	1.034	1.036	1.038	1.040	1.042
North Dakota	.989	.989	.988	.987	.986	.986	.985	.984
Ohio	1.034	1.036	1.039	1.041	1.043	1.046	1.048	1.050
Oklahoma	1.032	1.034	1.036	1.038	1.040	1.042	1.045	1.047
Oregon	1.055	1.059	1.063	1.067	1.070	1.074	1.078	1.082
Pennsylvania	1.011	1.012	1.013	1.013	1.014	1.015	1.016	1.017
Rhode Island	1.030	1.032	1.034	1.036	1.038	1.040	1.042	1.044
South Carolina	1.019	1.021	1.022	1.023	1.025	1.026	1.027	1.029
South Dakota	.996	.995	.995	.995	.994	.994	.994	.994
Tennessee	1.030	1.032	1.034	1.036	1.039	1.041	1.043	1.045
Texas	1.050	1.054	1.057	1.061	1.064	1.068	1.071	1.075
Utah	1.057	1.061	1.065	1.069	1.073	1.077	1.081	1.085
Vermont	1.047	1.051	1.054	1.057	1.060	1.064	1.067	1.070
Virginia	1.044	1.047	1.050	1.053	1.056	1.059	1.062	1.065
Washington	1.056	1.060	1.064	1.068	1.072	1.076	1.079	1.083
West Virginia	.976	.975	.973	.972	.970	.969	.967	.966
Wisconsin	1.041	1.044	1.047	1.049	1.052	1.055	1.058	1.061
Wyoming	1.011	1.012	1.012	1.013	1.014	1.015	1.015	1.016

The estimated 1970-80 statewide growth rates were obtained from U.S. Bureau of Census, "Projected Percent Change in Population for States: April 1, 1970 to July 1, 1980", Current Population Reports: Population Estimates and Projections, Series P-25, No. 477, March 1972, p. 6, Series I-E.

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