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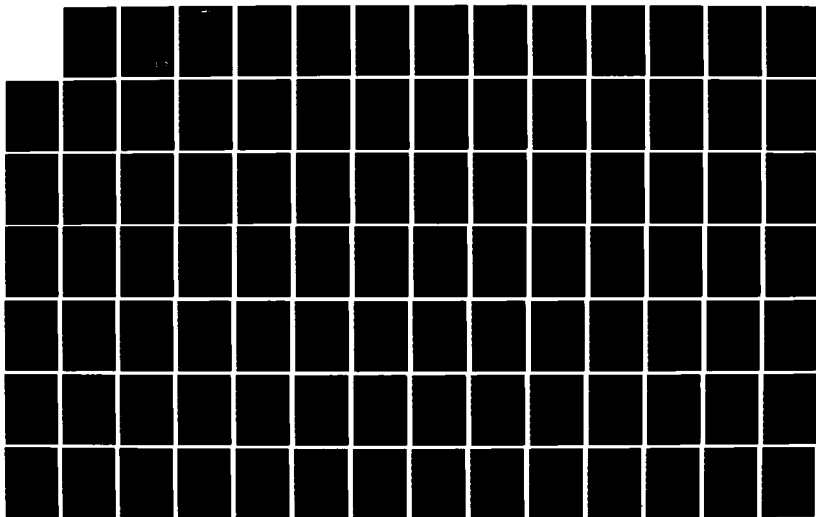
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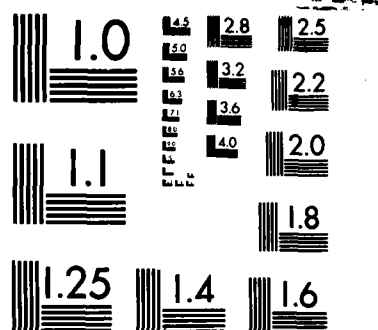
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AN ANALYSIS OF ESTIMATING ERRORS ON GOVERNMENT CONTRACTS

Captain David L. Diedrich
HQDA, MILPERCEN (DAPC-OPA-E)
200 Stovall Street
Alexandria, VA 22332

Final Report 22 March 85

Approved for public release; distribution unlimited.

A thesis submitted to The Ohio State University, Columbus,
Ohio in partial fulfillment of the requirements for the
Degree of Master of Science.

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It is found that there were significant estimating errors in the Corps of Engineer estimates. The variability of these errors is more than expected.

The principal conclusions are:

to retain as a measure of error, the standard percentage form, i.e.,

$$\text{ERROR} = ((\text{OBSERVED} - \text{PREDICTED})/\text{PREDICTED}) * 100; \text{ and}$$

large scale adjustments are not useful.

Baselines were established for further research and study of estimating errors.

THESIS ABSTRACT

THE OHIO STATE UNIVERSITY GRADUATE SCHCCL

(Please type.)

NAME: David L. Diedrich

QUARTER/YEAR: Winter 1985

DEPARTMENT: Civil Engineering

DEGREE: Master of Science

TITLE OF THESIS: An Analysis of Estimating Errors on Government Contracts

Summarize in the space below the purpose
and principal conclusions of your thesis.

This thesis considers what measures should be used to evaluate estimating errors of government estimates on competitively bid construction contracts. A data set from the U.S. Army Corps of Engineers was subjected to analysis using two measures of accuracy.

One objective of this research is to develop mathematical models and find cumulative distributions which may describe estimating practices within the Corps of Engineers. Other objectives are to offer large scale adjustments to compensate for any error present and to give a baseline for future studies and/or attempts to improve estimating accuracy.

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Adviser's Signature

AN ANALYSIS OF ESTIMATING ERRORS
ON GOVERNMENT CONTRACTS

A Thesis

Presented in Partial Fulfillment of the Requirements for
the Degree Master of Science

By

David L. Diedrich, BS

The Ohio State University
1985

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Richard E. Lauen
Adviser
Department of Civil Engineering



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CHAPTER I

INTRODUCTION

1.1 GENERAL BACKGROUND

The United States Army Corps of Engineers is responsible for the management of the construction program for the Department of the Army, for determining the most advantageous bid on each project and awarding the contract to that low responsible bidder. Most contracts for construction are awarded, where it is feasible and practical, on the basis of the competitive bid process.

The U.S. Army Corps of Engineers is also responsible for making an independent estimate of the cost of each project, using the same plans and specifications as the bidders. This estimate is open at the same time the rest of the bids are opened and becomes the basis for screening the rest of the bids.

At the Ohio State University, in the Civil Engineering Department's Construction Engineering and Management Program, there has been recent research conducted by graduate students on the analysis of government estimates and the low bids received on public construction projects. Veselenak (12) performed analysis on data from the Naval

CHAPTER III
PRESENTATION OF RESULTS

3.1 INTRODUCTION

This chapter will present the results of each investigation performed. Some background information on the method will also be provided. The observed findings or apparent trends will be discussed.

3.2 RESULTS OF ERROR MODELING USING ALL OF THE DATA

Descriptive statistics for the initial examination of the two measures of estimating error, DELTA and DELTA1, are given in Table 3.1.

TABLE 3.1

Descriptive Statistics

VAR	MEAN	STD.DEV	MIN	MAX	SKEWNESS	KURTOSIS
DELTA	-14.6%	19.4%	-82.9%	133.3%	.30	8.28
DELTA1	- 9.1%	12.1%	-70.8%	40.0%	-1.30	7.20

Plots of the cumulative density function of DELTA and DELTA1 are shown in Figures 3.1 and 3.2. These plots and statistics show the current estimating error before modeling. The modeling procedure will attempt to account for this variability of the error present.

2.5 TRANSITION

Results of this study presented in Chapter 3 will be presented as cumulative distribution functions (cdfs) of the residuals. Appendix D gives more information on how these curves are constructed. SAS Graph procedures were used in making the cdf plots in this thesis. (9)

In the next chapter, results of grand modeling of the data will be presented, the results of Divisional modeling will be presented and discussed and finally the results of pooling the results of regional compared to grand modeling will be presented and discussed.

subjected to further analysis, entertaining non-linear models or seasonal effects models.

Appendix C covers this sequential model building process in more detail. This second model will be used and a second set of residual error terms will be generated. This second set of error terms will be subjected to further models as appropriate. Following these steps, one final overall model will be arrived at with final coefficients for our parameters and a final set of residuals (error terms). Descriptive statistics of the estimating error before and after modeling for both measures of error, DELTA and DELTA1 will be presented. An approximation of the data will be made using the Ramburg/Schmeiser(R/S) distribution. (3,44-49)

Following this modeling of the estimating error on all the data, the data will be partitioned by Engineer Division, and a separate analysis will be done for each Division. The same methodology will be applied to these data sets as was applied to the complete data set. Descriptive statistics will be presented on the error term, before and after modeling. The residuals from the regional modeling will be pooled and compared with the residual terms from the overall modeling to determine if modeling by Division significantly reduces the variability of estimating error.

Time was used by setting 1 January 1982 as zero time. Thus, a data value of 1.2 represents 14 March 1983.

Two measures of estimating error will be examined in this study:

$$\text{DELTA} = ((\text{LOWBID} - \text{GOVEST}) / \text{GOVEST}) * 100 \quad (1.1)$$

$$\text{DELTA1} = ((\text{LOWBID} - \text{GOVEST}) / (\text{LOWBID} + \text{GOVEST})) * 100 \quad (1.2)$$

Equation 1.1 is the standard form for estimating error in percentage form, and is widely used in industry to measure error. Equation 1.2 was suggested (but not investigated) by Veselenak (12,47) as an alternative measure of estimating error that may be more responsive to the modeling effort. A negative value for either equation 1.1 or equation 1.2 will indicate that the government is overestimating the project cost.

Following the creation of the qualitative variables, the rescaling of DATE in terms of DATE1 and defining the response variables, a general linear model will be introduced to attempt to model the estimating error term with the variables in the data set. SAS Linear Stepwise Procedure will be used, at varying levels of significance to determine the best linear model. (8) A linear regression will then be performed on that model. The difference between the errors before and after modeling will be obtained. The residual error terms from this model

2.4 ANALYSIS TO BE PERFORMED ON ACCEPTED DATA

To meet the research objectives of this study, each data set will be quantitatively analyzed in terms of its estimating error. Once this error is quantitatively described, it will be presented in a manner that will enable grand adjustments to be recommended to compensate for this error. Regression will be used to give a baseline for evaluating future attempts to correct and improve the estimating practice of the Corps of Engineers or any one of its Engineering Divisions.

In the data, there are three qualitative variables--DESCRIP, LOC, and NUMBID. The creation of N-1 levels of qualitative variables is required for the inclusion of these variables into the analysis. NUMBID is a qualitative variable to consider the distinction between negotiated and competitively bid projects. When NUMBID=0, a contract is negotiated, and a 1 level qualitative variable will be used to account for negotiated/bid project effects. An 8 level qualitative variable will be created to account for locational effects. DESCRIP will not be used in this analysis, as there are too many types of work in the data set to classify them into specific type of projects. Also, the full scope of the work cannot be determined from the information given. (It is noted that previous research by Veselenak (12) indicated that type of work did not significantly account for the estimating error.)

TABLE 2.2

Divisional Data Summary

DIV	MEANS				NUMBER OF CASES			
	AMOUNTS IN MILLIONS OF DOLLARS			NUMBER OF BIDDERS				
	PROGAMT	GOVEST	LOWBID		FY82	FY83	FY84	TOTAL
EUR	2.22	1.35	1.14	10.20	175	107	25	307
MRD	3.02	2.34	2.06	7.86	13	21	18	52
NAD	2.39	2.09	1.57	10.10	69	35	14	118
NPD	2.28	1.60	1.25	9.67	9	22	3	34
OHR	2.02	1.48	1.23	7.76	21	9	9	39
POD	2.09	1.64	1.42	4.15	5	12	29	46
SAD	4.30	3.52	2.93	8.48	38	37	18	83
SPD	2.40	1.70	1.69	11.20	22	15	9	46
SWD	4.11	3.50	2.95	8.75	35	43	15	93

the data set. These projects are 20-40 times the magnitude of the mean project size and \$10,000,000 over the next highest value-1/2 the range of the remaining values for project size. The elimination of these two projects on the basis as not representative of the true population reduces the usable data to 818 points.

2.3 DESCRIPTIVE STATISTICS OF THE DATA

Table 2.1 shows the overall range and mean for several variables in the data set. The earliest project recorded occurred on 17 November 1981 and the latest date was 25 June 1984. Table 2.2 shows the data by Division. The mean programmed amount, mean government estimate, mean low bid, and the mean number of bidders are given for each Division. The number of projects per fiscal year for each Division are also given.

TABLE 2.1

Data Summary

	<u>MEAN VALUE</u>	<u>MINIMUM VALUE</u>	<u>MAXIMUM VALUE</u>
PROGAMT	\$2,727,892	\$ 8,000	\$31,000,000
GOVEST	\$2,045,400	\$19,000	\$25,299,000
LOWBID	\$1,707,529	\$ 7,000	\$17,117,000
NUMBID	9.8	0	49

4. NUMBID--The number of bidders that submitted bids for that project. A value of zero indicates that the project was negotiated work, rather than competitively bid upon.
5. PROGAMT--The program amount budgeted for that project, recorded in millions of dollars.
6. GOVEST--The government estimate of the cost of the project, in millions of dollars. This estimate is done internally by the Corps of Engineer Division responsible for the project, or by an architect-engineer design firm. It is prepared using the same detailed plans and specifications as the bidders have at their disposal. This independent estimate is opened and read at the bid opening.
7. LOWBID--The lowest responsible bid received for that project. This figure is recorded in millions of dollars.

In the original data set, there were 7 projects--(Appendix A, line numbers 6, 17, 19, 20, 21, 74, and 541) that did not have government estimates. These projects were eliminated as they had incomplete information. This reduced the usable data to 820 points. Two projects (Appendix A line numbers 161 and 481) are size outliers to

the continental United States, or the world. These Divisions are:

1. European Division (EUR);
2. Missouri River Division (MRD);
3. North Atlantic Division (NAD);
4. North Pacific Division (NPD);
5. Ohio River Division (OHR);
6. Pacific Ocean Division (POD);
7. South Atlantic Division (SAD);
8. South Pacific Division (SPD); and
9. South West Division (SWD).

The projects used in this study represent Military Construction Projects. These projects involve new construction, renovation or remodeling on Army installations located within the jurisdiction of the nine Engineering Divisions.

For each project there were seven variables:

1. LOC-----The Division that the installation was assigned to for project control purposes. For example, the Army installation of Fort Knox, Kentucky is assigned to the Ohio River Division (OHR) for project control purposes.
2. DATE----The date that the bids were opened for that project.
3. DESCRIP-A general description of the nature of the project.

PN	LOCATION	PROJECT DESCRIPTION	BIDS OPENED	NO OF BIDDERS	FULL SCOPE COST EST (\$000)	LOW BID (\$000)	PROG AMT (\$000)	W/5 PERCENT CONTINGENCY COST (\$000)	DESCRIPTION SCOPE REDUCTION & AMT (\$000)	MISCELLANEOUS REMARKS (A) - AWARDED
299E	Ft Riley	Barracks Mod	24Feb82	17	295	215	289	239		(A) 25 Mar 82
185E	Ft Irwin	Tracked Veh Maint Shades	25Mar82	20	297	277	349	307		(A) 10 Mar 82
155E	Ft Monmouth	Correct Fire Code	24Mar81	6	252	223	226	248		(A) 12 Mar 82
227E	Ft Polk	Observe Fire Tower	24Mar82	8	268	225	286	249		(A) 16 Mar 82
319	Ft Eustis	Ship to Shore Waste Coll	24Mar82	8	257	179	350	203		(A) 30 Mar 82
422E	Ft Bragg	Electronic Maint Shop	10Mar82	9	291	320	322	356		(A) 24 Mar 82
431	Ft Hood	Co Admin & Supply	18Mar82	10	410	349	430	388		(A) 15 Jun 82
101E	Amstutz	Misc Elec & Hydr Maint	24Mar82	11	413	357	477	395		(A) 21 Apr 82
452E	Ft Belvoir	Install Ext Sup Postwide	24Mar82	5	178	144	207	161		(A) 6 Apr 82
301	Ft Campbell	Steam Plant Mod	8Apr82	6	177	122	300	137		(A) 21 May 82
153E	Ft Gordon	Tri-Tac Tug Fec	13Apr82	8	464	377	499	418		(A) 22 Apr 82
139E	Ft Greely	Renov Health Cl	13Apr82	6	446	405	443	455		(A) 22 Apr 82
2169E	Cp Reetz, CO	Mini Gym	14Apr82	14	52	53	118	110		(A) 18 Jun 82
2170E	Walsgruen, CO	Mini Gym	14Apr82	14	66	45	118	106		(A) 18 Jun 82
2171E	Regen, CO	Mini Gym	14Apr82	14	59	52	118	109		(A) 18 Jun 82
2172E	Welden, CO	Mini Gym	14Apr82	14	44	49	118	107		(A) 18 Jun 82
2173E	Schneeburg, CO	Mini Gym	14Apr82	14	129	49	129	108		(A) 18 Jun 82

FIGURE 2.1: Recent Bid Experience Reports

CHAPTER II

RESEARCH APPROACH

2.1 INTRODUCTION

Regression analysis is the fitting of a probabilistic model to a data set to describe a response variable, in terms of a predictor variables. (5,62) Regression analysis to model construction data is widely used in the Construction Engineering and Management Program at the Ohio State University. This method will be the general approach used in the analysis of the data set from the U.S. Army Corps of Engineers.

2.2 DATA BASE

The data used in this study came from the Office of the Chief of Engineers, U.S. Army Corps of Engineers, Washington D.C.(11). Figure 2.1 is a copy of one sheet of this report. A list of the 827 contracts contained in this report is given in Appendix A. These 827 projects cover a two and one half fiscal year period, October, 1981 through June, 1984.

The Corps of Engineers has nine Engineering Divisions that are responsible for the management of construction for the Department of the Army. Each Division covers a part of

Chapter 2 discusses the data to be studied and the general research approach to the problem.

Chapter 3 presents the results of the analysis of the data set.

Chapter 4 contains a summary, major conclusions and recommendations on the evaluation of estimates within the U.S. Army Corps of Engineers.

and/or to be awarded. Underestimation of the cost of the project will complicate matters in the form of change orders, cost overruns and request for more funds. Any improvement in the accuracy of estimate prepared by the Corps of Engineers can have a great impact of the fiscal performance of the Corps of Engineers or any one of its Divisions.

1.4 LIMITATION OF THIS STUDY

It is beyond the scope of the thesis to attempt to tell the Corps of Engineers how to proceed to improve their estimates or change their estimating procedure. The data used in this study came from the U.S. Army Corps of Engineers Recent Bid Experience-Military Construction Activities Report. (11) It is assumed the government estimate and the lowbid contained in that report are the final figures on which the contract award was made.

1.5 ORGANIZATION OF THESIS

This thesis contains four chapters. A list of references follows the last chapter. Appendices comprise the last portion of the text.

Chapter 1 outlines the background of the Corps of Engineers functions, the study objectives and significance of the study.

Facilities Engineering Command (NAVFAC) and Selim (10) studied General Services Administration (GSA) data along with NAVFAC Data.

This thesis reports a study, done on data obtained from the U.S. Army Corps of Engineers, in which the government estimating accuracy was evaluated.

1.2 RESEARCH OBJECTIVES

This study focuses on three main objectives: The first objective is to quantitatively describe the current estimating practice within the U.S. Army Corps of Engineers Military Construction Program, to determine if improvement is needed in this area. The second objective is to offer a few simple adjustments that may be useful to help correct for any error that may exist within the estimating activity. The third objective is to give a baseline for future attempts to improve estimating accuracy by the Corps of Engineers, or any one of its Divisions.

1.3 SIGNIFICANCE OF THIS STUDY

A good accurate estimate of the cost of the project is a critical management tool. Overestimation on a project, saying it will cost more than it will, can cause an overcommitment of funds. This can prevent this fund from being available for other projects, either to be planned

The negative means for DELTA and DELTA1 indicate that the government is overestimating the cost of the project, on average. The range and variability of estimating error are much larger than expected by this author.

The Linear Stepwise Regression Procedure in SAS was used to initially explore the appropriateness of a linear model, for DELTA and DELTA1. Initially, the Stepwise Procedure was run, for both DELTA and DELTA1, with alpha=.15. This yielded the Models 3.1 and 3.2

$$\begin{aligned} \text{DELTA} = & -12.39 - (.002 * \text{GOVEST}) - (.34 * \text{NUMBID}) + (2.25 * \text{DATE1}) \\ & - (6.22 * \text{NAD}) - (5.46 * \text{OHR}) \end{aligned} \quad (3.1)$$

$$\text{DELTA1} = -8.25 - (.21 * \text{NUMBID}) + (1.52 * \text{DATE1}) - (4.05 * \text{NAD}) \quad (3.2)$$

Next, the Stepwise Procedure was run using a smaller alpha level. It was decided to use alpha=.05, as this is a commonly accepted level for alpha. This yielded equations 3.3 and 3.4.

$$\text{DELTA} = -12.92 - (3.66 * \text{NUMBID}) + (2.30 * \text{DATE1}) - (5.82 * \text{NAD}) \quad (3.3)$$

$$\text{DELTA1} = -8.25 - (.21 * \text{NUMBID}) + (1.52 * \text{DATE1}) - (4.05 * \text{NAD}) \quad (3.4)$$

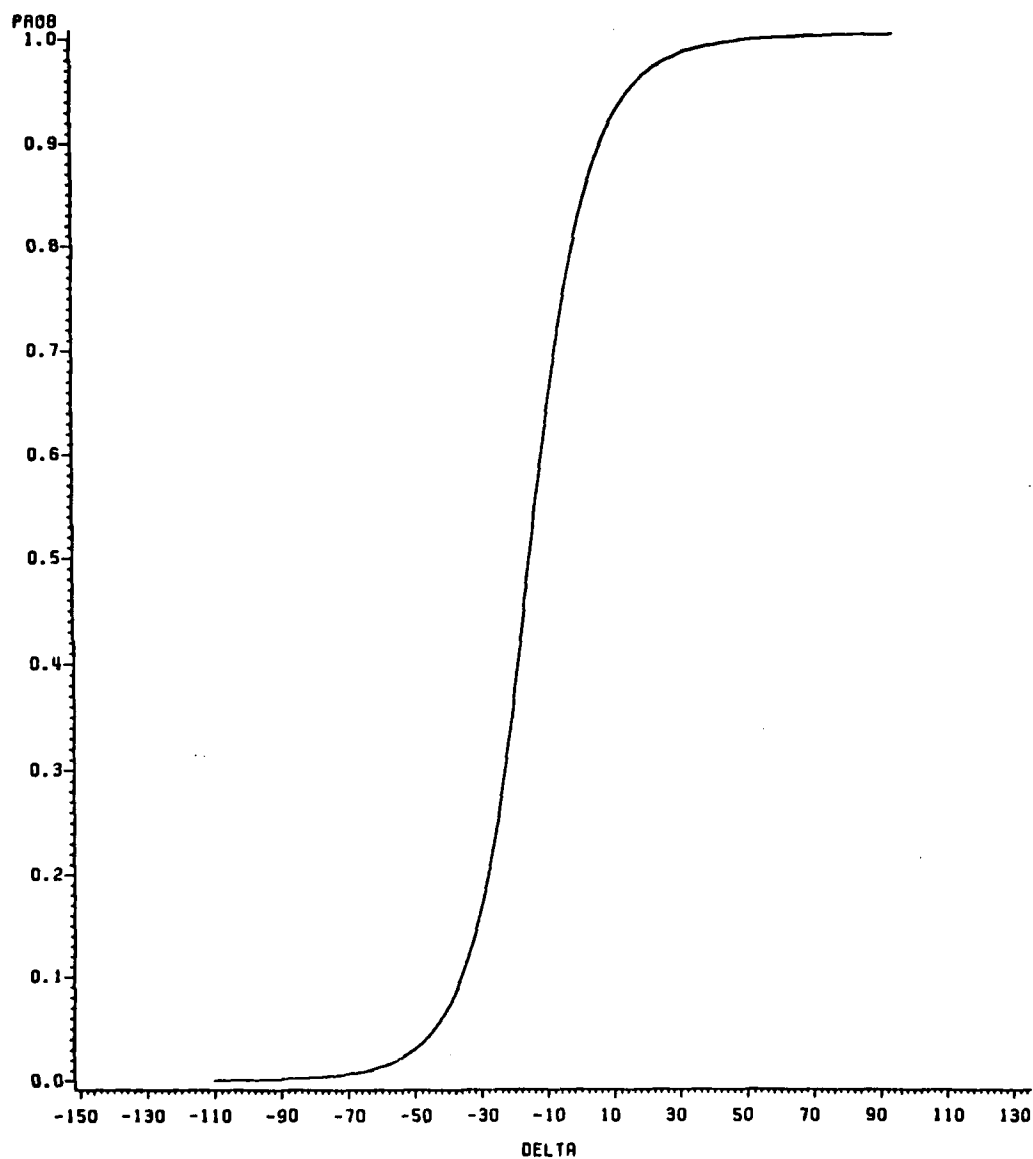


FIGURE 3.1: CDF Of DELTA Before Modeling

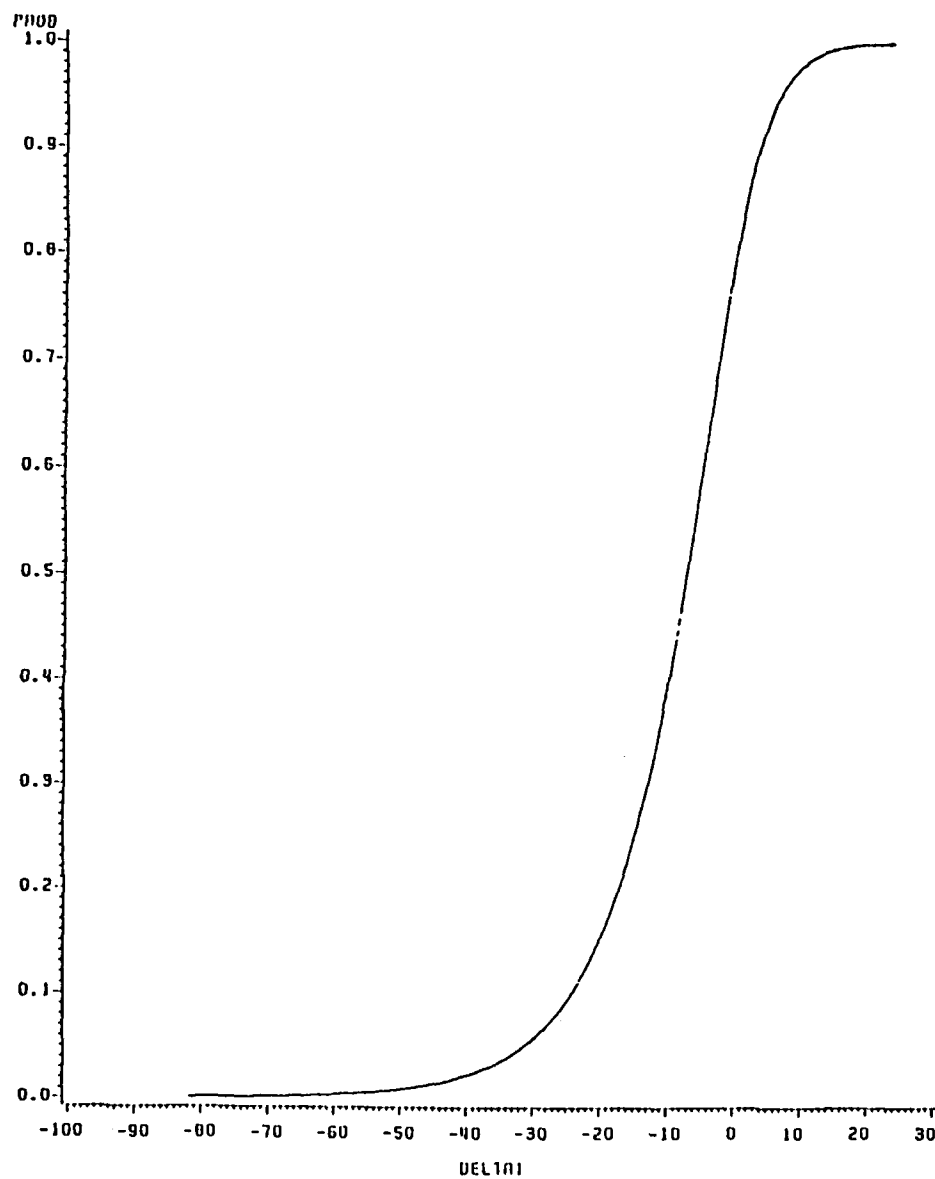


FIGURE 3.2: CDF of DELTA1 Before Modeling

These two equations had a value for the coefficient of determination¹ R^2 of .0449 and .0466 respectively. This model was useful in accounting for a very small proportion of the variance in the data. These two equations were used to find the first generation of residuals for further modeling. Once these residuals were created, they were plotted against all the variables in the model as well as those not in the model. Trends were noted and an appropriate model was decided upon to model this residual error. Figure 3.3 is a plot of the residual error term, RESID, versus DATE1.

The plot of RESID vs DATE1, showed promise of seasonal, or cyclical effects in the data, for both DELTA and DELTA1. This was not unexpected as the research done by Veselenak (12) and Selim (10) at the Ohio State University, also indicated presence of seasonal effects in similar data sets. One procedure to fit a seasonal model is to use a sinusoidal function to model the response variable. Appendix B gives the general approach taken for fitting the data with a sinusoidal function. Previous

1 R^2 , the coefficient of determination, represents the proportion of the sum of squares of deviations of the response variable observations about their mean that can be attributed to a linear relation² between the response and independent variables. R^2 is always between 0 and 1. A value of 1 indicates that the linear model accounts for all variability of the response variable. A value of 0 indicates that the model accounts for none of the variability (5, 83-84).

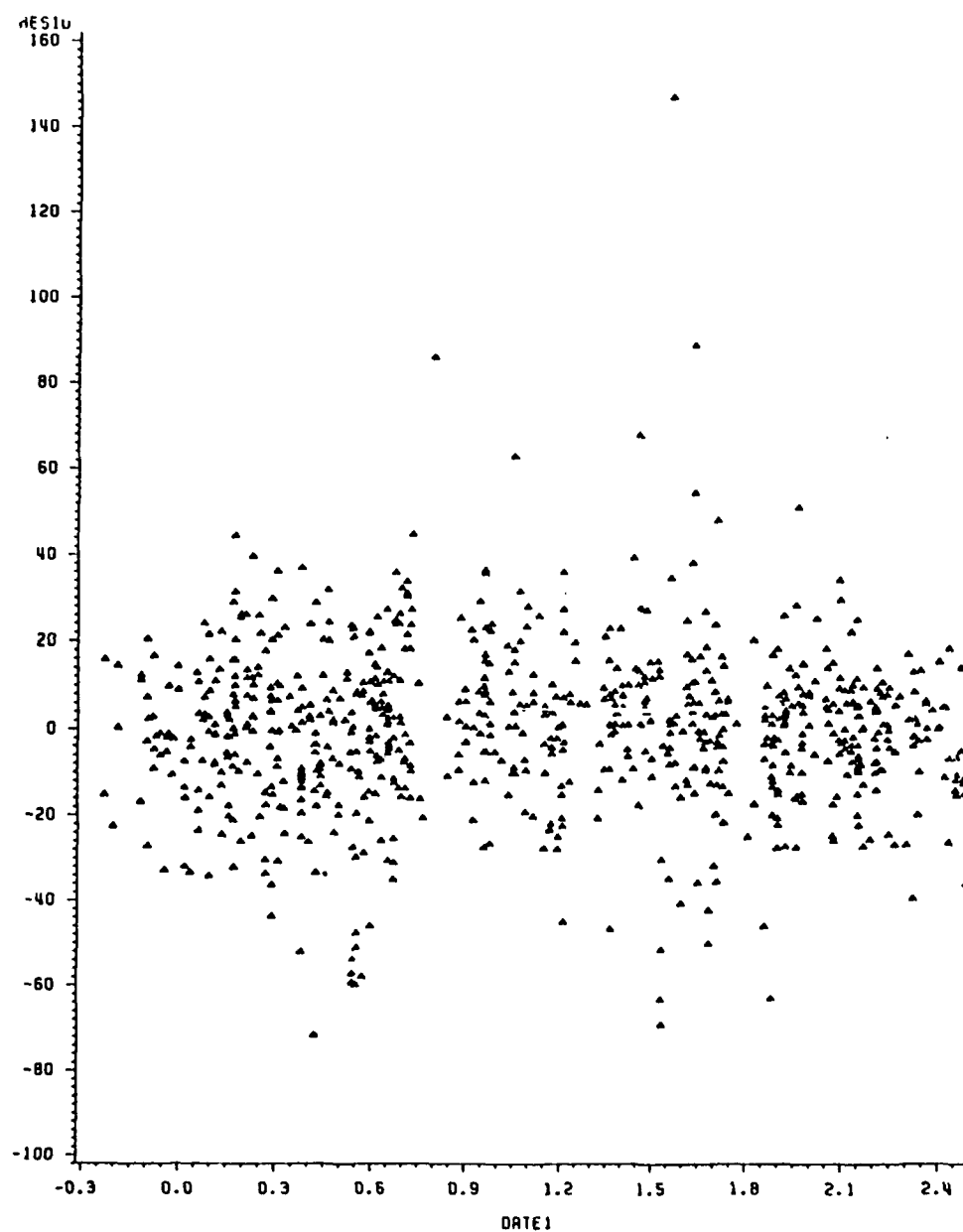


FIGURE 3.3: Residuals vs DATE1

research, as well as the plot of this data set, indicate that a cycle length of one year is an appropriate initial estimate. The general model:

$$\text{RESID 1} = A(+B*\text{SIN}((C*\text{DATE1})+D)) \quad (3.5)$$

was used to initially fit the residual error terms. A range for each parameter was specified and input into PROC NLIN, the SAS Non-Linear Procedure. Equations 3.6 and 3.7 were found.

$$\text{DELTA RESID1} = .11+(1.56*\text{SIN}((2\pi\text{DATE1})+2.1813)) \quad (3.6)$$

$$\text{DELTA1 RESID1} = .05+(1.25*\text{SIN}((2\pi\text{DATE1})+1.7751)) \quad (3.7)$$

The phase shift parameter, D, shifted the wave so that the low point in the wave, where the largest overestimation occurs to April 27 for DELTA and May 20 for DELTA1.

These values correspond to previous studies that indicate early spring as a time where construction jobs are scarce and hence there is more competition for each job, possibly indicating a cheaper price on each project.

The parameter estimates from the above model, indicate that there is evidence of seasonal effect in the data. The models account for 3% to 4% of the estimating error. This seasonal model may be confounded by the data, and Divisional modeling may allow this trend to show more clearly.

The residual errors from these models were plotted against all variables in the model and those not in the model to look for trends that may indicate alternative models that should be considered. Analysis of these plots showed no apparent trends in the data, and it was decided that the best model for both DELTA and DELTA1 is as given in equation 3.8:

$$\text{DELTA} = A + (B \cdot \text{NUMBID}) + (C \cdot \text{DATE1}) + (D \cdot \text{NAD}) + (E \cdot \text{TIME}) \quad (3.8)$$

where $\text{TIME} = \text{SIN}((2\pi \cdot \text{DATE1}) + F)$, and F has the value of 2.1813 for DELTA and 1.7751 for DELTA1. Final regression run results are listed in Tables 3.3 and 3.4.

TABLE 3.2

Post Modeling Statistics

VARIABLE	MEAN	STD DEV	RANGE	SKEWNESS	KURTOSIS
DELTA	0	18.82	218.24	.44	9.44
DELTA1	0	11.78	112.39	-1.25	7.72

Although these models do not account for much of the variability of the data, they may be useful to future attempts in improving the estimating accuracy of the Corps of Engineers. Following modeling, the error could be characterized by the statistics in Table 3.2. The modeling

TABLE 3.3

Final Model for DELTA

MODEL

DEPARTMENT VARIABLE DELTA

$R^2 = .06$

F = 12.60

P $\leq .9999$

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	p
INTERCEP	-10.08	1.87	-5.36	.0001
NUMBID	- .63	.13	-4.95	.0001
DATE1	1.95	.90	-2.15	.0314
NAD	- 5.76	1.89	-3.04	.0024
TIME	1.59	.99	1.61	.1076

TABLE 3.4
Final Model for DELTA1

<u>MODEL</u>		<u>DEPARTMENT VARIABLE DELTA</u>		
		R^2	= .06	
		F	= 13.61	
		P	$\leq$.9999	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-6.29	1.17	-5.35	.0001
NUMBID	- .39	.08	-4.92	.0001
DATE1	1.25	.56	2.22	.0270
NAD	-4.02	1.18	-3.41	.0007
TIME	1.29	.59	2.18	.0294

effort showed a slight decrease in standard deviation, but these models do not significantly reduce the ranges of estimating errors.

Overlays of the cumulative density functions before and after modeling are shown in Figures 3.4 and 3.5. Comparisons of the means and standard deviations of DELTA and DELTA1, indicate that DELTA is equivalent to a factor times DELTA1. Table 3.5 demonstrates this fact. Divisional models were next considered to improve upon what was achieved with modeling the entire data set.

3.3 RESULTS OF DIVISIONAL MODELING

Nine new data sets were created from our original set, one for each Division. The estimating error for each Division was modeled and described quantitatively. The loss of degrees of freedom in each data set, will hopefully be offset by the more accurate models, that will be derived for each Division. These models may be useful to each Division in setting a baseline for future attempts in improving their estimating accuracy.

Initial examination of the estimating error of each Division, as measured by DELTA and DELTA1, yielded the following information. The European Division (EUR) had the largest number of projects, 307, as well as the largest range of estimating error, 216%. The North Atlantic

TABLE 3.5

DELTA and Rescaled DELTA 1 Compared

	<u>DELTA</u>	<u>RESCALED DELTA1</u>	<u>RESCALE FACTOR (F)</u>	<u>DELTA1</u>
MEAN	-14.61	-14.58	1.6	-9.73
STD.DEV	19.39	19.39	1.6	12.12

$$\bar{F} = \frac{\sum_{i=1}^2 F_i}{2} = 1.60$$

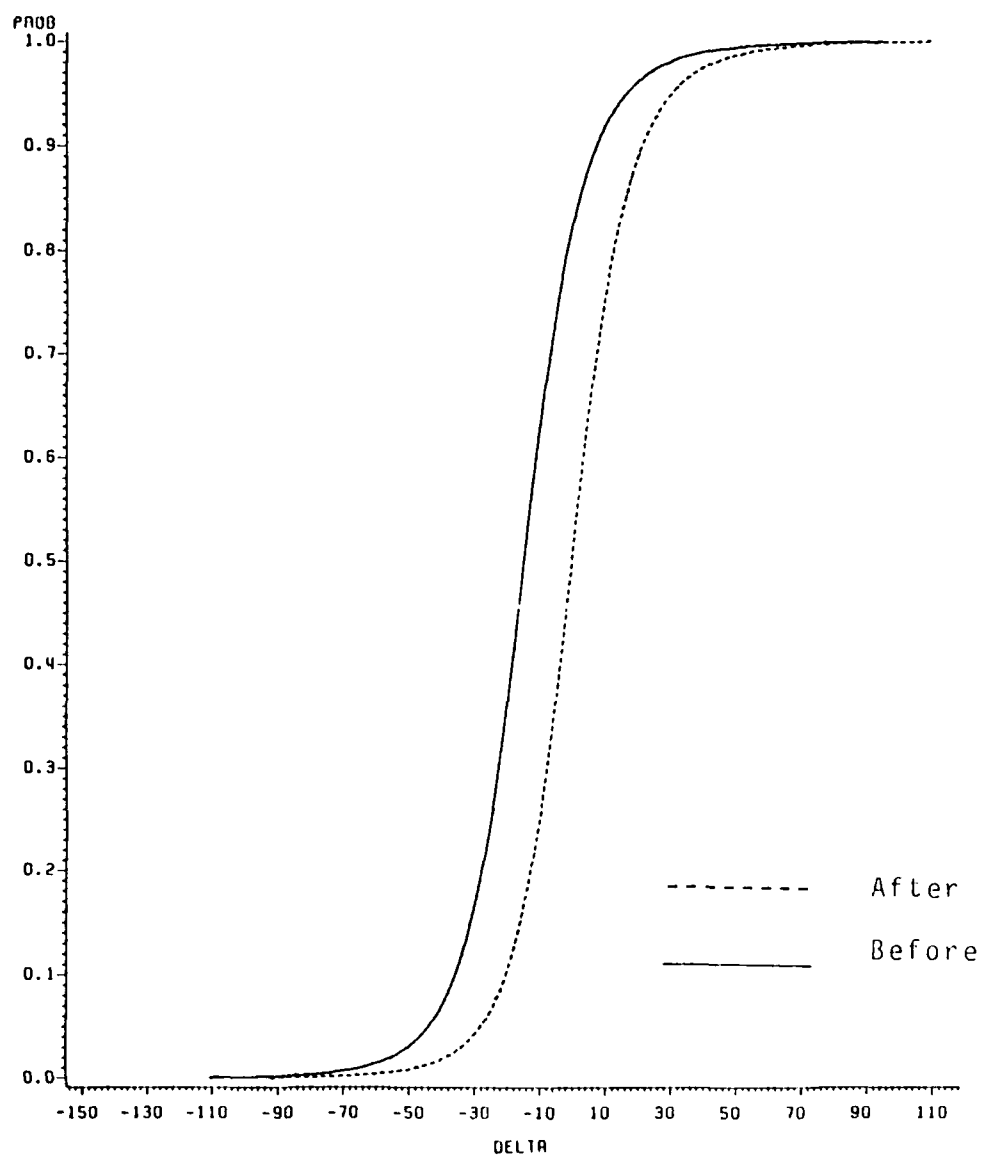


FIGURE 3.4: CDF of DELTA Before and After Modeling

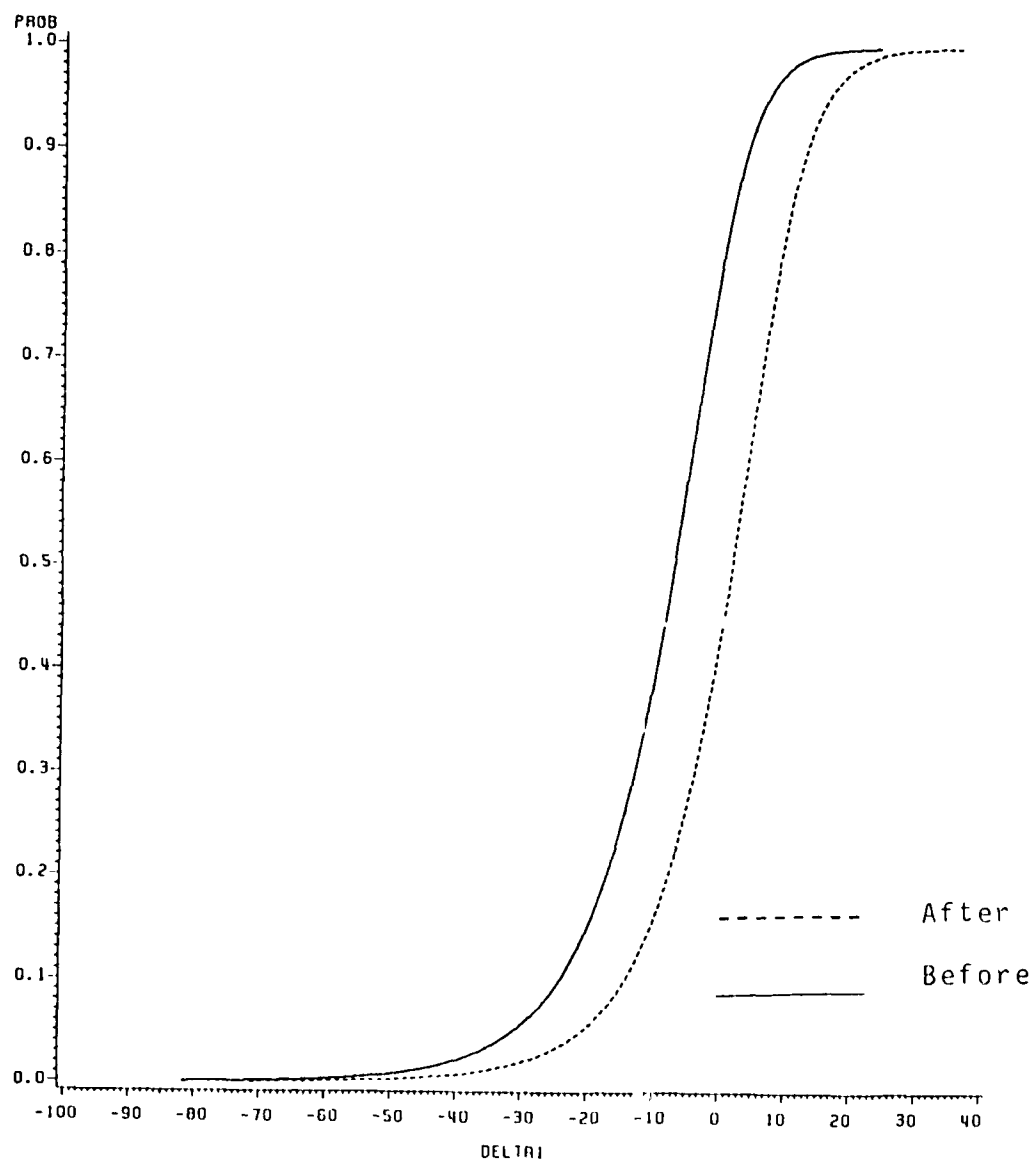


FIGURE 3.5: CDF of DELTA1 Before and After Modeling

Division (NA) had the largest mean estimating error, -20.6%, as well as the largest standard deviation, 22.5%. The North Atlantic Division (NAD) had the largest mean estimating error at -15.4% (using DELTA1). The European Division (EUR) had the largest range of error, 110.8%, as well as the largest standard deviation in the error of 14.2%. Tables 3.6 and 3.7 summarize the statistics of DELTA and DELTA1 for each Division.

Linear stepwise regression was applied to each data set, with the level of significance (alpha) equal to .05. The coefficient of determination (R^2) ranged from .019 to .652 for DELTA and DELTA1. The South Pacific Division (SPD) had no linear model that was significant at alpha=.05 for DELTA or DELTA1. The Missouri River Division (MRD) and the Pacific Ocean Division (POD) had no linear model for DELTA1 which was significant at alpha=.05.

As the results of the overall modeling of the Corps of Engineer data indicated that seasonality was a factor in the explanation of error, this was the next model applied to the first generation residuals from linear modeling. This procedure proceeded as the fitting of of the model did to all the combined data in Section 3.2 of this thesis.

For the modeling DELTA's residuals, some Divisions exhibited a stronger tendency than others toward seasonality. The low point of the sinusoidal function (the

TABLE 3.11

Post Modeling Summary for DELTA1

DIV #	CASES	STANDARD		RANGE(%)	SKEWNESS	KURTOSIS
		MEAN(%)	DEVIATION(%)			
EUR	307	0	14.01	114.52	-1.46	7.66
MRD	52	0	7.28	41.22	.05	4.70
NAD	118	0	13.31	73.09	- .14	3.61
NPD	34	0	7.06	34.23	- .56	3.56
OHR	39	0	8.94	37.47	- .75	3.20
POD	46	0	5.53	27.45	.72	4.36
SAD	93	0	10.31	66.07	-1.65	8.26
SPD	46	0	9.00	38.68	- .31	2.72
SWD	83	0	6.77	38.38	- .55	4.01

TABLE 3.10

Post Modeling Summary for DELTA

DIV #	CASES	MEAN(%)	STANDARD DEVIATION(%)	RANGE(%)	SKEWNESS	KURTOSIS
EUR	307	0	21.96	219.06	.72	11.28
MRD	52	0	12.14	60.65	-.24	3.63
NAD	118	0	21.47	130.57	.82	5.32
NPD	34	0	9.25	44.04	.93	4.43
OHR	39	0	13.98	62.62	-.44	2.97
POD	46	0	13.02	72.86	.05	4.58
SAD	93	0	15.95	86.13	-.81	4.14
SPD	46	0	15.26	68.32	-.09	2.78
SWD	83	0	11.51	62.31	-.02	3.28

TABLE 3.9

Final Model for DELTA1
(Continued)

MODEL SPDDEPARTMENT VARIABLE DELTA1

R^2 = .11
F = 5.81
P $\leq$.9799

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-10.01	1.48	-6.75	.0001
TIME	4.50	1.87	2.41	.0201

MODEL SWDDEPARTMENT VARIABLE DELTA1

R^2 = .22
F = 11.76
P $\leq$.9999

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-1.30	1.81	- .72	.4746
NUMBID	- .67	.19	-3.57	.0006
TIME	-2.61	1.01	-2.58	.0115

TABLE 3.9

Final Model for DELTA1
(Continued)

<u>MODEL OHR</u>		<u>DEPARTMENT VARIABLE DELTA1</u>		
		R ²	= .11	
		F	= 2.48	
		P	≤ .9023	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-5.81	2.89	-2.01	.0519
NUMBID	- .70	.32	-2.19	.0348
<u>MODEL POD</u>		<u>DEPARTMENT VARIABLE DELTA1</u>		
		R ²	= .03	
		F	= 1.60	
		P	≤ .7871	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-4.96	1.55	-3.20	.0025
TIME	-2.57	2.03	1.26	.2128
<u>MODEL SAD</u>		<u>DEPARTMENT VARIABLE DELTA1</u>		
		R ²	= .12	
		F	= 12.74	
		P	≤ .9994	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-1.80	2.09	- .86	.3910
NUMBID	- .74	.21	-3.57	.0006

TABLE 3.9

Final Model for DELTA1
(Continued)

<u>MODEL NAD</u>		<u>DEPARTMENT VARIABLE DELTA1</u>		
		R ²	= .10	
		F	= 13.92	
		P	≤ .9997	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-4.551	2.62	-1.74	.0855
NUMBID	- .851	.23	3.73	.0003

<u>MODEL NPD</u>		<u>DEPARTMENT VARIABLE DELTA1</u>		
		R ²	= .68	
		F	= 12.28	
		P	≤ .9999	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-2.76	3.06	- .90	.3752
NUMBID	- .76	.20	-3.71	.0009
PROGAMT	-3.40	1.32	2.58	.0155
GOVEST	-7.99	2.02	-3.15	.0005
DATE1	5.88	1.66	3.53	.0014
TIME	-2.98	1.90	-1.57	.1286

TABLE 3.9

Final Model for DELTA1

<u>MODEL EUR</u>		<u>DEPARTMENT VARIABLE DELTA1</u>		
		R^2	= .02	
		F	= 3.18	
		P	≤ .9573	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	- 6.13	1.75	-3.51	.0005
NUMBID	- .26	.15	-1.79	.0749
TIME	- 2.44	1.13	-2.15	.0321
<u>MODEL MRD</u>		<u>DEPARTMENT VARIABLE DELTA1</u>		
		R^2	= .08	
		F	= 4.42	
		P	≤ .9595	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-5.73	1.09	-5.25	.0001
NUMBID	3.05	1.45	2.10	.0405

TABLE 3.8

Final Model for DELTA
(Continued)

<u>MODEL SWD</u>		<u>DEPARTMENT VARIABLE DELTA</u>		
		R ²	= .22	
		F	= 11.65	
		P	≤ .9999	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	- 2.27	3.09	- .73	.4645
NUMBID	- 1.16	.32	-3.62	.0005
TIME	4.26	1.72	2.48	.0154

TABLE 3.8

Final Model for DELTA
(Continued)

<u>MODEL POD</u>		<u>DEPARTMENT VARIABLE DELTA</u>		
		R^2	= .09	
		F	= 4.41	
		P	≤ .9584	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-14.01	2.42	-5.78	.0001
NUMBID	- .72	.34	2.10	.0416
<u>MODEL SAD</u>		<u>DEPARTMENT VARIABLE DELTA</u>		
		R^2	= .13	
		F	= 14.90	
		P	.9998	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	- 2.81	3.20	- .88	.3820
NUMBID	- 1.24	.32	-3.86	.0002
<u>MODEL SPD</u>		<u>DEPARTMENT VARIABLE DELTA</u>		
		R^2	= .11	
		F	= 5.60	
		P	.9775	
INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-16.78	2.51	-6.68	.0001
NUMBID	7.49	3.17	2.36	.0225

TABLE 3.8

Final Model for DELTA
(Continued)

MODEL NPDDEPARTMENT VARIABLE DELTA

R^2 = .69
F = 12.42
P $\leq$.9999

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	- 6.85	5.12	-1.34	.1916
NUMBID	- .30	.33	-3.93	.0005
PROGAMT	5.70	2.18	2.61	.0143
GOVEST	-13.45	3.36	-4.00	.0004
DATE1	11.34	2.88	3.93	.0005
TIME	5.41	2.97	1.82	.0788

MODEL OHRDEPARTMENT VARIABLE DELTA

R^2 = .12
F = 5.30
P $\leq$.9730

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-10.06	4.51	-2.23	.0317
NUMBID	- 1.15	.50	-2.30	.0270

TABLE 3.8

Final Model for DELTA

MODEL EURDEPARTMENT VARIABLE DELTA
 $R^2 = .04$
 $F = 6.34$
 $P \leq .9998$

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-7.47	2.70	-2.76	.0061
NUMBID	- .59	.23	-2.57	.0104
TIME	5.44	1.85	2.94	.0354

MODEL MRDDEPARTMENT VARIABLE DELTA
 $R^2 = .12$
 $F = 3.34$
 $P \leq .9562$

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-4.25	4.32	- .98	.3296
NUMBID	- .75	.05	-1.41	.1651
TIME	4.11	2.84	1.45	.1549

MODEL NADDEPARTMENT VARIABLE DELTA
 $R^2 = .08$
 $F = 10.78$
 $P \leq .9986$

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-8.31	4.23	-1.96	.0519
NUMBID	-1.21	.37	-3.28	.0014

rescaled values for the mean and standard deviation are shown in Table 3.12. From this table it is observed that there is no significant difference in the mean and standard deviation of these two measures of error.

3.4 POOLED RESULTS OF REGIONAL MODELS

Once the final models for each Division were determined, the residual errors from these models were pooled. These pooled results were compared with the results from the single models. These statistics are summarized and presented in Table 3.13 and 3.14.

There is a slight reduction in variability of the error, standard deviation, for both DELTA and DELTA1, with the Divisional model. The mean of the estimating error is the same for both models. The plots of the cumulative density function of the pooled results and the overall model for both DELTA and DELTA1 are presented in Appendix F. The reduction of variability for both DELTA and DELTA1 is so slight that it is almost non-existent. The difference in reduction in variability for DELTA compared to DELTA1 is likewise insignificant.

Figures 3.6 and 3.7 show the cdf curves of DELTA before modeling for all Divisions overlaid on one another. These plots indicate that approximately 85% to 90% of the bids received are less than 10% over the government

point of maximum government overestimation) varies from Division. No real pattern can be determined. For DELTA1's residuals, the same was found to exist.

The residual error terms from this seasonal modeling were examined and plotted against all variables in the model and those not yet included in the model. No further trends could be deduced from these plots and "best" models were decided on for the final models for each Division. These final models are presented in Tables 3.8 and 3.9.

Following the acceptance of the final models, final regressions were run on these models. Final estimates of the parameters were found, and descriptive statistics were calculated. These statistics are summarized and presented in Tables 3.10 and 3.11. In most cases, 13 of 18, the range of the estimating error reduced after modeling. There appears to be no significant difference between DELTA1 and DELTA models.

Appendix E contains plots of the cumulative density functions of the before and after modeling errors for each Division. For each Division there are two plots, one for DELTA and one for DELTA1. On each plot there are two functions, before modeling error and after modeling error. To compare the mean and standard deviation of DELTA and DELTA1 there is a need to rescale one or the other. This author choose to rescale DELTA1 (equation 1.2). The

TABLE 3.7

DELTA1 Summary by Division

DIV #	CASES	MEAN(%)	STD. DEV(%)	RANGE(%)	SKEWNESS	KURTOSIS
EUR	307	- 9.11	14.15	110.84	-1.51	7.57
MRD	52	- 6.69	7.37	32.11	- .27	2.99
NAD	118	-13.19	14.10	80.64	- .39	3.42
NPD	34	- 8.41	9.89	35.29	- .42	2.31
OHR	39	-11.28	9.54	41.05	- .62	2.75
POD	46	- 6.35	7.41	40.31	.32	4.69
SAD	93	- 8.17	11.11	69.16	- .61	7.89
SPD	46	- 8.49	9.57	40.71	- .37	2.87
SWD	83	- 7.05	7.69	46.33	- .71	4.75

TABLE 3.6
DELTA Summary by Division

DIV #	CASES	MEAN(%)	STD DEV(%)	RANGE(%)	SKEWNESS	KURTOSIS
EUR	307	-13.92	22.41	216.10	.54	10.04
MRD	52	-11.67	12.94	56.80	.09	2.87
NAD	118	-20.58	22.48	136.71	.54	4.42
NPD	34	-14.05	16.58	60.18	- .10	2.29
OHR	39	-19.03	14.96	66.23	- .27	2.65
POD	46	-11.02	13.79	75.06	1.04	5.73
SAD	93	-13.39	17.22	92.17	- .74	3.82
SPD	46	-14.26	16.20	70.61	.10	3.05
SWD	83	-12.24	13.13	76.77	- .10	3.77

TABLE 3.12

DELTA and Rescaled DELTA1 Compared for Each Division

MEAN

	<u>DELTA</u>	<u>RESCALED DELTA1</u>	<u>DELTA1</u>	<u>RESCALE FACTOR (F)</u>
EUR	-13.92	-15.13	- 9.12	1.53
MRD	-11.67	-11.11	- 6.69	1.74
NAD	-20.58	-21.70	-13.19	1.56
NPD	-14.05	-13.96	- 8.41	1.67
OHR	-19.03	-18.72	-11.28	1.63
POD	-11.02	-10.55	- 6.36	1.73
SAD	-13.39	-13.57	- 8.17	1.63
SPD	-14.26	-14.08	- 8.49	1.68
SWD	-12.24	-11.70	- 7.05	1.73

$$\bar{F} = \frac{\sum_{i=1}^9 F_i}{9} = 1.66$$

STANDARD DEVIATION

	<u>DELTA</u>	<u>RESCALED DELTA1</u>	<u>DELTA1</u>	<u>RESCALE FACTOR (F)</u>
EUR	22.41	23.50	14.15	1.58
MRD	12.94	12.23	7.37	1.75
NAD	22.48	23.40	14.10	1.59
NPD	16.58	16.42	9.89	1.67
OHR	14.96	15.84	9.54	1.56
POD	13.79	12.30	7.41	1.86
SAD	17.22	18.45	11.11	1.55
SPD	16.20	15.90	9.57	1.61
SWD	13.13	12.78	7.69	1.71

$$\bar{F} = \frac{\sum_{i=1}^9 F_i}{9} = 1.66$$

estimate. If the government were to reject bids that are 10% or more above their estimate, this would mean that they would reject approximately 10% to 15% of the bids. This is an area that Larew's theory of socially acceptable biasing could apply (4). With the type of analysis performed, it would be possible for the Corps of Engineers or any of its Divisions to formulate their objectives, in terms of a socially acceptable percentage of bids to be rejected (for being too high). This could be done by the use of a factor applied to the government estimate, without a change in estimating procedure.

3.5 TRANSITION

In the next chapter the results will be summarized and conclusions drawn on those results. Recommendations will be presented for consideration for future research.

TABLE 3.13

Pooled VS Single Model Results for DELTA

MODEL	MEAN(%)	STD(%)	RANGE(%)	SKEWNESS	KURTOSIS
Single	0	18.78	218.24	.44	9.43
Pooled	0	18.23	219.06	.58	10.75

TABLE 3.14

Pooled VS Single Model Results for DELTA1

MODEL	MEAN(%)	STD(%)	RANGE(%)	SKEWNESS	KURTOSIS
Single	0	11.73	112.39	- 1.2	7.72
Pooled	0	11.44	114.52	-1.20	8.12

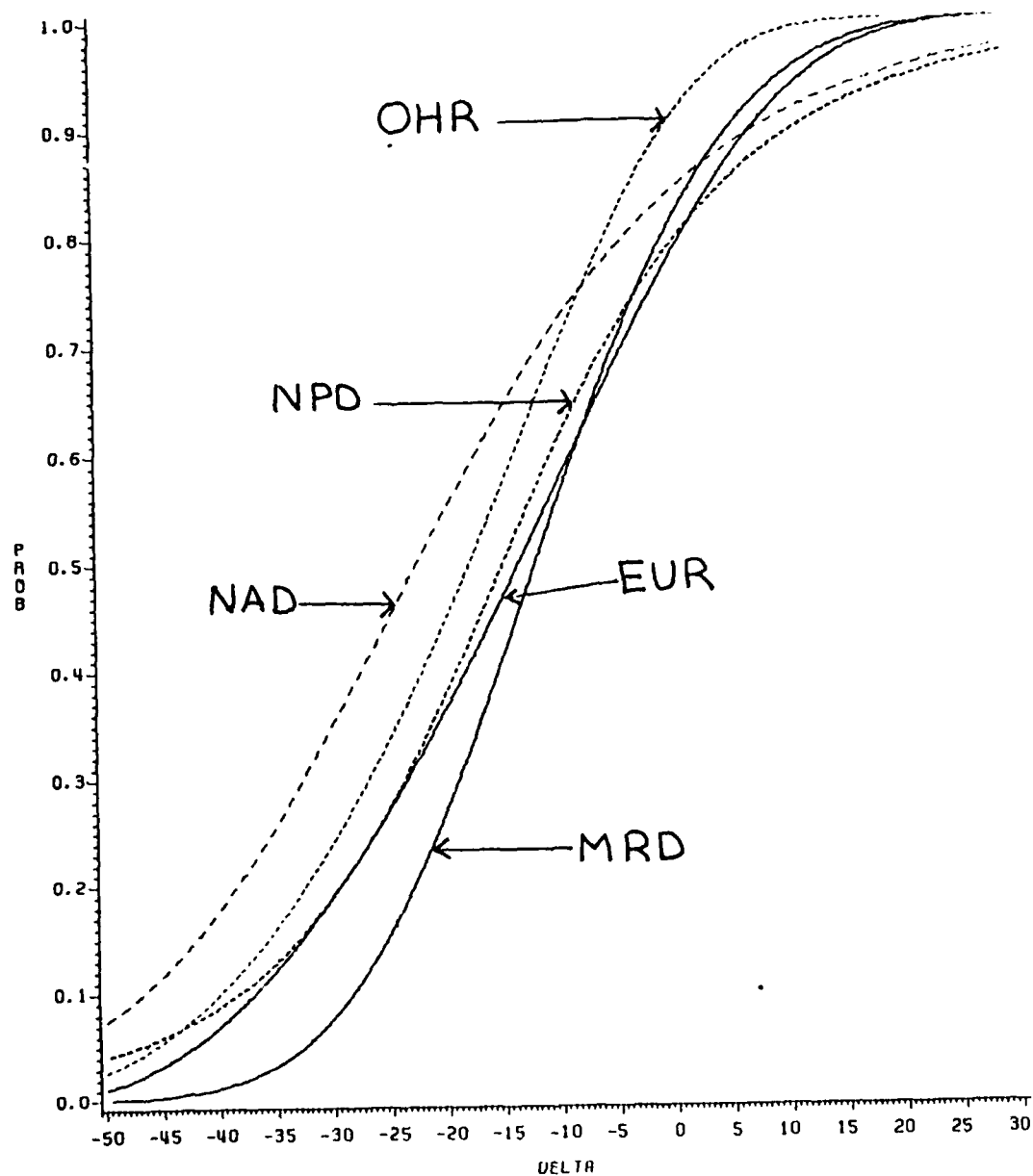


FIGURE 3.6: CDF OF DELTA OVERLAID

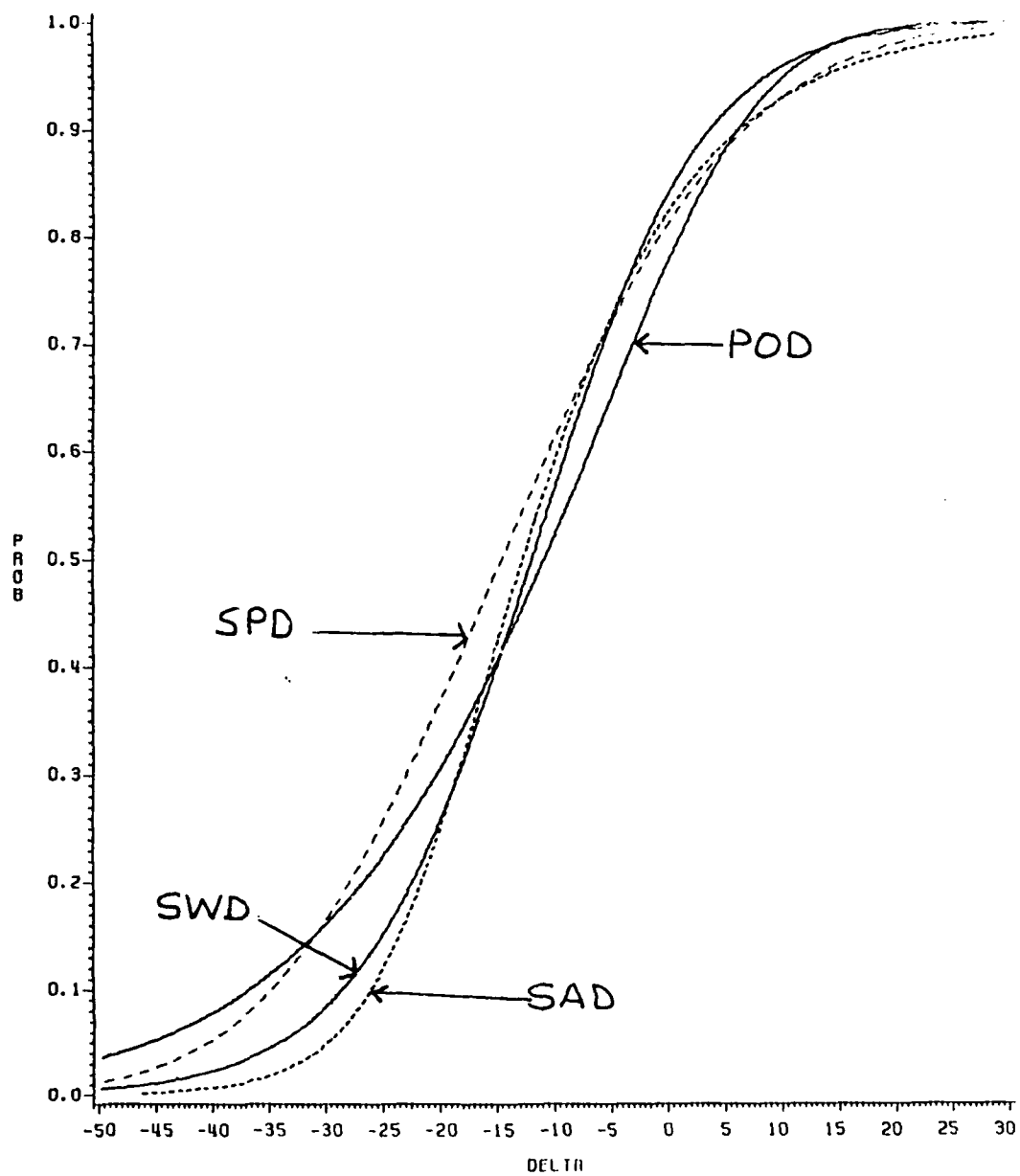


FIGURE 3.7: CDF OF DELTA OVERLAID

CHAPTER IV

SUMMARY AND CONCLUSIONS

4.1 SUMMARY OF ANALYSIS

As reported in Section 3.2 and 3.3, descriptive statistics for DELTA and DELTA1 were calculated and compared for all the data combined, and for each Engineer Division. The error was characterized before and after modeling with descriptive statistics. The plots of the cumulative density functions of the estimating error before and after modeling support the notion of slight improvement. Divisional Modeling also supported the notion of slight improvement in the variation of the estimating error. Pooling the residuals of Divisional Modeling and comparing them with the residuals of grand modeling, indicate a slight reduction in the variance of estimating error as measured by DELTA and DELTA1.

4.2 MAJOR CONCLUSIONS WITH REGARDS TO RESEARCH OBJECTIVES

The major conclusions on each research objective will be presented in this section.

4.2.1 QUANTITATIVE DESCRIPTION OF CURRENT ESTIMATING PRACTICE

There appears to be more variation in the estimating error of the Corps of Engineers than originally expected by this author. Prior to this study, any variation in excess of plus or minus 30% would have been thought to be excessive. The range of the error in the data set, 216%, before modeling, is extremely large and indicates a problem area that needs to be researched and improved upon. Of great concern is the inconsistency of the error, as there appears to be no pattern of consistent under or overestimating. The estimating error present in each Division is also excessive. Some of the Engineer Divisions have smaller variations of error than others, but all would benefit from study of current *methods and practice* to reduce this severe variability of estimating error.

Comparison of both DELTA and DELTA1, before and after modeling, indicate that there is a difference in the mean error before and after modeling, as would be expected. Comparison of the mean and standard deviation of DELTA and DELTA1, fail to indicate a change in the mean error of these two measures of error, either before or after modeling. This author concludes that there is no significant benefit in the use of DELTA1 as a measure of estimating error as compared to the more

conventional measure DELTA. Use of DELTA as a measure of estimating error should not be abandoned in favor of DELTA1.

4.2.2 LARGE SCALE ADJUSTMENTS TO COMPENSATE FOR ERROR

The overall mean error in each Engineer Division and Corps-wide is measure of the bias of the estimating effort. In all cases, the bias was overestimation bias. If this bias had a small variability associated with it (and this was consistently over or under the final estimate) a large scale adjustment could be used to correct the estimate. However, in the Corps of Engineer Data, such consistency of error is not found. With a range of error that is present, any large scale adjustment would help our estimating error average to zero error, but would not help much with individual projects. A significant reduction in the range or spread of estimating error is needed. Consistency in estimating is needed, regardless of direction. Once a consistent pattern is developed and the range of error reduced, then large scale adjustments and unbiasing techniques can be applied. At this point, there is too much variance in the data even after our modeling effort, to effect much change by unbiasing the estimating error.

4.2.3 BASELINE FOR FUTURE STUDY

The models presented in this thesis, for both individual Engineer Division and Corps-wide, give a starting position to analyze any improvement techniques implemented to correct the variation and bias of estimating error. This can be linked with the quantitative description of error, to form a "before improvement" picture of estimating practice. This characterization of the estimation effort can be compared to an "after improvement implemented" to see if results were significant. Ideally, information would be collected and analyzed up until the time of implementation of the new techniques. This information would be compared with the post-improvement information, to see if the estimating accuracy improved. The techniques and methodology of quantitatively describing the data and modeling would be useful to the Corps of Engineers or any of its Divisions, attempting to improve in this area.

4.3 MAJOR RECOMMENDATIONS FOR FUTURE RESEARCH

1. Examine and explore methods to aid in the standardization of estimating procedure, to improve estimating accuracy.
2. Explore changes of error over time, as in Kossuth (2) and Baswari (1).
3. Consider and explore statistical packages available for use on a microcomputer, so as to enable this methodology to be useful to industry.
4. Gather more specific data on each project.
5. Develop a specific coding scheme to classify projects into type of work, for entrance of that variable into the model.
6. Obtain similar data from private industry to validate both the methodology and the models in this study, for use with private industry needs.
7. Explore Larew's theory of social biasing of estimates with this and other data sets more fully.

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APPENDIX A
LIST OF ORIGINAL DATA

Table A.1 gives the original data used in this study.

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM	GOV-	LOW-	PRO-
			BID	EST	BID	GAMF
638	EUR ALTER BLDG	29NOV83	6	0.237	0.215	0.49
639	SAD PHYSICAL FITNESS CN	30NOV83	5	1.975	1.818	2.80
640	SWD TRNG SUPPORT WHSE	01DEC83	9	0.536	0.443	0.60
641	NAD SATELLITE TERM FAC	01DEC83	12	1.230	1.075	1.25
642	EUR BARRACKS W/DINING	01DEC83	10	1.414	1.279	2.37
643	EUR FACS MOD	01DEC83	15	1.549	1.366	2.30
644	EUR DINING BKS CONV	01DEC83	9	2.561	2.364	4.35
645	EUR TACT EQUIP SHOP	06DEC83	19	9.354	8.941	13.80
646	EUR AUTO CTRLS-ECIP	08DEC83	9	0.438	0.349	0.76
647	OHR REARM CONSOL MAN	08DEC83	9	13.598	12.711	22.00
648	NAD WEAPONS MAINT FAC	13DEC83	21	8.168	4.792	8.90
649	NPD BRIGADE HQ	13DEC83	15	0.805	0.906	1.50
650	EUR RECREATION CENTER	13DEC83	15	0.923	0.893	1.15
651	SAD MISSILE SYS SOFTWARE	14DEC83	8	11.262	6.894	16.00
652	POD PUL TANK RELOCATION	15DEC83	17	0.844	1.132	1.40
653	NPD BARRACKS-MLRS	16DEC83	13	1.402	1.283	1.74
654	EUR FAC MODERNIZATION	16DEC83	14	3.742	3.539	5.40
655	NAD COMM CTR ADD/ALT	20DEC83	6	1.512	1.122	1.65
656	NAD FOOD SERVICE TRNG	20DEC83	13	4.190	3.576	5.30
657	NPD BN HQ & CLASSROOM	20DEC83	15	1.159	0.965	1.45
658	SAD CHILD CARE CENTER	21DEC83	5	3.049	3.009	4.40
659	NPD TACT EQUIP SHOP	21DEC83	9	3.101	3.199	7.80
660	NAD MAINT FAC	21DEC83	5	6.754	5.999	7.20
661	SAD METROLOGY/CALIB LAB	21DEC83	6	1.630	1.194	2.60
662	POD TACT EQUIP SHOP	22DEC83	16	2.525	2.489	5.10
663	MRD PHYSICAL FITNESS CN	28DEC83	10	3.128	3.000	3.55
664	SAD PINK WATER SYS	04JAN84	8	3.661	3.651	4.25
665	EUR PHYSICAL FITNESS CN	16JAN84	5	1.687	1.650	2.65
666	POD TACT EQUIP SHOP	17JAN84	2	4.384	4.290	6.20
667	NAD RENOVATE BLDG	18JAN84	10	0.958	0.918	0.91
668	MRD UTILITIES-MUSAAF	19JAN84	7	5.122	4.652	5.40
669	EUR BN HQ W/CLASSROOM	19JAN84	14	1.010	0.786	1.75
670	EUR ATTIC INSUL	19JAN84	5	0.589	0.562	0.92
671	OHR FLIGHT SIMULATOR	24JAN84	8	2.786	1.790	5.50
672	NAD STEAM DIST SYS	24JAN84	12	5.025	4.344	3.95
673	MRD SEWAGE TRMT PLANT	25JAN84	11	1.243	1.072	1.15
674	SPD COMMUNICATIONS ADP	30JAN84	7	1.453	1.074	1.90
675	EUR PHYS FITNESS CTR	31JAN84	10	1.630	1.500	2.45
676	EUR PHYS FITNESS CTR	31JAN84	7	0.405	0.353	0.76
677	EUR PHYS FITNESS CTR	01FEB84	8	0.989	0.973	1.55
678	SPD COMMUNICATIONS CTR	01FEB84	11	0.897	1.087	1.75
679	NPD CORRECT OSHA DLF	02FEB84	10	0.883	1.035	2.65
680	NAD BARRACKS MOD	03FEB84	12	7.042	5.468	8.10
681	EUR FACS MOD	07FEB84	14	3.823	3.163	4.55
682	SWD BRADLEY VEH SPT FAC	07FEB84	12	1.713	1.484	1.25
683	EUR PHYS FITNESS CTR	14FEB84	19	1.386	1.264	2.55
684	EUR ATC EQUIP SHOP	16FEB84	10	1.177	1.153	1.60
685	EUR BARRACKS	16FEB84	13	2.366	1.992	3.25
686	NPD RANGE & TRNG FAC IP	21FEB84	10	0.831	0.938	0.94

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMT
589	SPD BDS GROUND SIMUL FC	28JUL83	6	0.350	0.323	0.290
590	NAD CEILING INSUL	04AUG83	21	0.177	0.059	0.212
591	EUR RIPPLE CONTROL	16AUG83	9	0.335	0.421	0.292
592	EUR HTG BLDG 4172	31AUG83	2	0.314	0.373	0.303
593	EUR HELIPADS	06SEP83	11	0.411	0.344	0.403
594	SPD E BLOCK DRAINAGE	12SEP83	3	1.026	0.612	0.726
595	OHR AMHE FACILITY	13SEP83	13	0.326	0.213	0.354
596	NAD COMPUTER FAC	16SEP83	8	0.370	0.270	0.337
597	EUR GDAAC BLDG	19SEP83	4	0.155	0.146	0.258
598	NAD CHEM CHANGEHOUSE	02NOV82	7	0.676	0.568	0.703
599	EUR WASTE BURNING FAC	16DEC82	2	0.130	0.165	0.120
600	EUR CHANGEHOUSE	17DEC82	9	0.496	0.401	0.481
601	EUR TOXIC CHEM FAC	27DEC82	9	0.560	0.453	0.555
602	NRD CHEM CHANGEHOUSE	08MAR83	8	0.565	0.535	0.629
603	EUR ENGINE TEST CELLS	23MAY83	6	0.273	0.305	0.370
604	SAD EMCS EXTENSION	23JUN83	5	0.048	0.044	0.053
605	EUR GEN INST BLDG	30JUN83	6	0.328	0.270	0.429
606	EUR INDOOR FIRING RANGE	02SEP83	3	0.190	0.209	0.327
607	NAD PACK SHIP REC FAC	12SEP83	4	0.298	0.324	0.390
608	NAD TOXIC MUN CHG HOUSE	19SEP83	5	0.394	0.397	0.481
609	SAD CO ADMIN & SUPPLY	02SEP83	3	0.607	0.550	1.500
610	NRD FLIGHT SIMULATOR	20OCT83	14	5.011	2.984	8.000
611	SWD WEAPONS TRAINING FC	27OCT83	11	2.095	1.450	2.150
612	EUR ADMIN BLDG MLRS	08NOV83	11	0.453	0.361	0.750
613	EUR BARRACKS	08NOV83	13	1.282	1.161	2.350
614	EUR BARRACKS	08NOV83	13	3.036	3.394	6.800
615	EUR TACT EQUIP SHOP	08NOV83	10	1.385	1.161	2.150
616	NAD WEATHERSTRIPPING	08NOV83	10	0.335	0.119	0.450
617	EUR TACT EQUIP SHOP	10NOV83	9	2.847	2.781	3.100
618	EUR FACILITIES MOD	10NOV83	16	3.951	3.222	5.700
619	SWD TBNG FAC-JSTARS	15NOV83	12	0.474	0.392	0.650
620	NAD RECREATION CTR	17NOV83	12	1.489	1.447	1.500
621	SAD FLIGHT SIMULATOR	17NOV83	3	1.773	1.352	3.050
622	SAD ELEC DIST SYS	17NOV83	11	2.063	0.486	3.000
623	EUR AMMO STORAGE-DIVAD	17NOV83	11	1.183	0.865	2.550
624	EUR PIN/PERSONNEL CTR	18NOV83	12	1.014	0.833	1.800
625	EUR ATC EQUIP SHOP	18NOV83	15	6.844	5.626	11.800
626	EUR TACT EQUIP SHOP MOD	22NOV83	17	2.614	2.105	2.550
627	EUR HARDSTAND	22NOV83	18	0.226	0.227	0.340
628	POD UPGRADE POL STORAGE	22NOV83	11	0.999	0.590	2.000
629	NAD ENERGY EFFICIENT LT	22NOV83	10	0.200	0.119	0.360
630	NRD CO ADMIN & SUPPLY	23NOV83	13	2.993	2.133	4.250
631	NRD BN HQ & CLASSROOM	23NOV83	13	2.449	1.722	2.800
632	EUR BARRACKS MOD	24NOV83	17	6.849	5.842	6.600
633	EUR BARRACKS W/DINING	25NOV83	16	4.245	3.801	7.100
634	SWD CO ADMIN & SUPPLY	29NOV83	10	1.804	1.633	2.200
635	SWD BN CLASSROOM	29NOV83	10	0.474	0.426	0.530
636	SAD DINING PACS MOD	29NOV83	6	1.271	1.471	1.800
637	SAD STAM DIST SYS	29NOV83	16	4.686	4.313	6.500

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAM
540	EUR WADS	30AUG83	13	2.852	2.299	5.000
541	MRD EMCS	01SEP83	6	.	1.902	1.372
542	EUR FAC MOD	09SEP83	10	3.962	3.557	6.000
543	NAD EMCS	15SEP83	9	1.213	0.560	1.035
544	POD A/C FUEL STG	23SEP82	14	0.470	0.598	0.492
545	NAD ADDN TO MAIN GATE	18OCT82	11	0.088	0.145	0.168
546	SAD WEAPONS TRNG FAC	03NOV82	7	0.348	0.265	0.321
547	SWD MOVING TGT	30NOV82	11	0.439	0.471	0.391
548	POD STANDBY GEN	03DEC82	2	0.187	0.146	0.187
549	SWD CONSEC SPT DET FAC	08DEC82	9	0.360	0.340	0.387
550	SWD VET FACILITY	16DEC82	4	0.399	0.448	0.266
551	MRD NEO-NATAL ICU	20DEC82	7	0.456	0.467	0.485
552	EUR HANGAR EXPANSION	21DEC82	6	0.278	0.262	0.351
553	EUR EQUIP MAINT CTR	23DEC82	3	0.478	0.544	0.819
554	NAD RANGE IMPROVEMENT	18JAN83	16	0.388	0.261	0.393
555	MPD TACT EQUIP SHOP	04JAN83	21	0.326	0.233	0.300
556	EUR READY BUILDING	19JAN83	12	0.160	0.164	0.323
557	MPD LINEAR ACCELERATION	01FEB83	15	0.382	0.334	0.495
558	SPD TSFO CLASSROOM	02FEB83	9	0.246	0.270	0.301
559	EUR READY BUILDING	16MAR83	12	0.117	0.131	0.271
560	EUR READY BUILDING	16MAR83	12	0.092	0.111	0.281
561	EUR EP MESS FACILITY	17MAR83	7	0.373	0.160	0.260
562	MRD ADD TO ADP BLDG 30	30MAR83	15	0.461	0.473	0.543
563	SWD ALT VET CLINIC	12APR83	9	0.303	0.280	0.357
564	NAD SIT PREP FOR EQ IN	26APR83	7	0.279	0.172	0.313
565	POD TSFO FAC	29APR83	3	0.423	0.369	0.598
566	NAD COM SUPPORT CTR	03MAY83	12	0.585	0.518	0.646
567	SAD VEHICLE MECH COURSE	10MAY83	14	0.691	0.736	0.734
568	SWD ENT CLINIC ALT	11MAY83	8	0.201	0.192	0.288
569	NAD INITIAL OPS FAC	12MAY83	19	0.613	0.172	0.565
570	POD MILES WAREHOUSE	12MAY83	17	0.438	0.389	0.607
571	NAD AD FUNCTIONAL FIRE	17MAY83	11	0.756	0.614	0.834
572	SPD AD ASARS FAC	17MAY83	14	0.526	0.438	0.383
573	SWD WATER PUMP STATION	19MAY83	7	0.575	0.535	0.760
574	SWD BULK STORAGE	25MAY83	14	0.467	0.419	0.413
575	SPD FIRING RANGE	26MAY83	7	0.455	0.436	0.989
576	MRD BKS IMPROVEMENT	01JUN83	8	0.429	0.419	0.561
577	SWD PARACHUTE RIGGING	02JUN83	13	0.401	0.379	0.496
578	NAD SUPPLY & EQUIP ADDN	02JUN83	13	0.276	0.200	0.298
579	EUR APPLIED INSTRUCT AD	08JUN83	6	0.117	0.150	0.214
580	MRD CARDIAC CATHETER LB	10JUN83	2	0.368	0.387	0.425
581	NAD LAUNDRY BOILER PLNT	15JUN83	13	0.249	0.365	0.279
582	NAD HOT METAL FAC	21JUN83	9	0.478	0.413	0.500
583	MRD USDA SEC	23JUN83	6	0.770	0.894	0.992
584	SWD RANGE	30JUN83	9	0.623	0.475	0.796
585	SWD WATER TREAT FAC	07JUL83	8	0.445	0.460	0.425
586	EUR COMMUNICATIONS CTR	12JUL83	5	0.455	0.174	0.579
587	SAD BFSS-IESS SPT FAC	19JUL83	17	0.326	0.250	0.480
588	NAD MAINT TRAIN FAC	22JUL83	7	0.547	0.642	0.867

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM	GOV- BID	LOW- EST	PRO- BID	PRO- GAML
491	SWD TACT EQUIP SHOP	01SEP83	4	2.333	2.040	2.950	
492	OHR TANK DRIVING COUISE	01SEP83	8	2.475	1.948	2.900	
493	SWD TRAINEE BKS	02SEP83	16	17.678	15.298	20.000	
494	SAD EM BKS	02SEP83	3	4.600	4.900	5.800	
495	EUR BOQ	06SEP83	6	1.490	0.701	2.300	
496	EUR GYM	06SEP83	6	1.375	0.540	2.200	
497	EUR WATER SUPPLY	07SEP83	5	0.240	0.186	0.610	
498	OHR SANITARY LANDFILL	08SEP83	12	1.711	1.656	3.000	
499	MRD RADIO THERAPY	12SEP83	6	0.567	0.526	0.595	
500	MRD ALTER BLDG 500	12SEP83	4	0.529	0.525	0.534	
501	EUR TRAINING AREA	14SEP83	5	0.564	0.779	0.722	
502	SWD ELECTRIC SHOP	14SEP83	6	0.457	0.350	0.390	
503	EUR MAINT FAC & HARDSTD	14SEP83	11	0.754	0.629	0.871	
504	OHR COMPUTER FAC	15SEP83	4	0.553	0.479	0.658	
505	EUR TACT EQUIP SHOP	16SEP83	9	1.408	1.325	2.100	
506	SWD DIVISION HQ	16SEP83	8	10.226	8.879	13.500	
507	OHR TACT EQUIP SHOP	21SEP83	6	2.383	2.130	3.200	
508	SPD OSHA DEFICIENCIES	21SEP83	3	1.940	1.515	2.100	
509	MRD RANGE & FAC IMPRV	21SEP83	3	1.361	1.189	1.350	
510	EUR BARRACKS	22SEP83	12	1.498	1.498	3.650	
511	SPD TACT EQUIP SHOP	23SEP83	7	2.300	2.125	3.200	
512	OHR EXT STEAM DIST SEP	05OCT82	12	0.869	0.549	0.710	
513	EUR HEALTH CLINIC	18NOV82	10	0.035	0.094	0.150	
514	EUR HW CONVERSION	02DEC82	5	0.102	0.111	0.410	
515	EUR AUTO HTG SYS	15DEC82	8	1.813	1.475	2.400	
516	EUR HEATING PLANT	12JAN83	17	4.228	3.985	4.342	
517	EUR STEAM CONVERSION	20JAN83	7	0.119	0.092	0.102	
518	EUR ACRPT MAINT HANGAR	20JAN83	22	2.205	1.741	2.372	
519	EUR RANGE UPGRADE	25JAN83	9	0.430	0.457	1.211	
520	EUR REHAB DEQ	28JAN83	18	2.330	1.935	1.331	
521	EUR AMMO IGLOOS	02FEB83	14	0.317	0.281	0.300	
522	EUR TACT EQUIP SHOP	24FEB83	19	2.441	1.710	5.100	
523	EUR ECIP CONTROLS	15MAR83	10	0.126	0.089	0.717	
524	NAD UPGRD SCTY SYS	15MAR83	2	3.116	2.689	4.300	
525	NAD PHYSICAL DVLPMNT CT	16MAR83	16	16.014	15.763	17.960	
526	SPD MOD SEWAGE TR PLANT	05APR83	13	1.941	1.749	2.100	
527	EUR ACCESS ROAD	05MAY83	6	0.153	0.168	0.500	
528	NAD EMISSION CNTRL BOIL	11MAY83	14	2.012	1.382	1.900	
529	EUR MAINT SHOP	17MAY83	6	0.906	0.855	4.370	
530	EUR AUTO CONTROLS	25MAY83	4	0.061	0.061	1.036	
531	EUR TACT EQUIP SHOP	26MAY83	15	4.659	4.116	7.100	
532	MRD HYDROLOGICAL BARR	22JUN83	6	3.146	2.642	5.100	
533	SAD REGIONAL SEWER	30JUN83	17	6.942	6.505	5.503	
534	EUR DRAIN & SEWER	20JUL83	16	0.450	0.183	0.800	
535	EUR INCINERATOR	28JUL83	6	0.468	0.356	0.500	
536	NAD PK, SHIP REC FAC	09AUG83	6	0.912	0.654	0.540	
537	EUR WATER PUR PLT	15AUG83	7	1.805	1.889	2.550	
538	EUR FAC MOD	19AUG83	7	7.227	5.784	6.767	
539	EUR WADS	30AUG83	13	3.954	3.340	5.000	

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMI
442	SAD SIGNAL SCHOOL	16JUN83	14	5.699	4.859	9.200
443	EUR POWER UPGRADE	16JUN83	7	0.470	0.544	0.800
444	NAD INSTALL ECONOMIZER	21JUN83	12	0.270	0.244	0.300
445	EUR HEATING SYSTEM CONV	21JUN83	2	0.417	0.432	0.440
446	EUR BKS W/ADMIN	21JUN83	10	1.045	0.972	2.200
447	SAD BARRACKS	23JUN83	15	11.554	10.454	15.470
448	SAD CO ADMIN & SUPPLY	23JUN83	15	1.143	1.000	2.050
449	NRD TACT EQUIP SHOP	28JUN83	5	1.189	1.248	1.550
450	SWD TACT EQUIP SHOP	08JUL83	4	1.617	1.600	1.640
451	SWD TACT EQUIP SHOP	08JUL83	4	3.502	3.588	5.500
452	EUR UPGRD CUSTODIAL FAC	12JUL83	9	0.348	0.124	0.570
453	EUR UPGRD CUSTODIAL FAC	12JUL83	9	0.266	0.048	0.350
454	EUR BKS & BOQ	12JUL83	9	0.999	0.568	1.450
455	EUR ADMIN BLDG	12JUL83	9	0.995	0.238	1.100
456	NRD HOSPITAL UPGRADE	13JUL83	6	9.314	7.947	13.600
457	EUR MAINT SHOP	21JUL83	11	0.208	0.485	0.593
458	SWD TACT EQUIP SHOP	21JUL83	17	6.894	5.761	8.400
459	SWD TACT EQUIP SHOP	21JUL83	17	4.732	3.514	6.200
460	EUR BARRACKS	21JUL83	16	4.020	3.311	7.600
461	SAD SEWAGE TRMT EXT	21JUL83	6	0.940	0.511	1.250
462	SAD WATER DIST SYSTEM	21JUL83	6	0.978	0.831	1.000
463	SAD ROAD NET & DRAIN	21JUL83	6	6.419	5.858	8.300
464	EUR COAL FIRED HTG PLNT	21JUL83	11	1.045	0.315	0.601
465	SWD TACT EQUIP SHOP	26JUL83	10	3.189	2.809	4.100
466	NRD COMBINED RANGE	27JUL83	6	2.399	1.955	2.500
467	SAD DECON TRNG FAC	03AUG83	17	13.561	9.029	7.500
468	EUR TACT EQUIP SHOP	05AUG83	9	1.162	1.011	2.300
469	POD CONS COM CTR	09AUG83	7	3.021	3.426	4.100
470	EUR MAINT FAC	09AUG83	9	0.687	0.680	1.200
471	SAD RANGE UPGRADE	10AUG83	4	1.520	1.636	1.950
472	SWD CONTAIN HAZ CHEM	11AUG83	9	0.596	0.444	0.500
473	SPD CO ADMIN & SUPPLY	11AUG83	7	0.527	0.497	0.550
474	SAD GORGAS HOSPITAL	12AUG83	2	2.211	2.199	2.650
475	EUR HTG PLANT	16AUG83	8	0.160	0.143	1.015
476	EUR HTG PLANT	16AUG83	6	0.026	0.026	0.203
477	EUR ELECTRIC SUBSTA	16AUG83	6	0.060	0.056	0.232
478	EUR SECURE PARKING	18AUG83	13	0.287	0.499	0.613
479	EUR SECURE PARKING	18AUG83	13	0.287	0.400	0.648
480	SAD TRAINEL BKS W/DININ	18AUG83	5	7.396	7.115	9.700
481	SAD COMMAND & CTRL HQ	18AUG83	11	34.100	29.212	41.000
482	EUR MOTOR REPAIR SHOP	18AUG83	6	0.349	0.201	0.830
483	EUR BARRACKS	19AUG83	6	5.482	5.490	12.200
484	EUR PATRIOT IRP	19AUG83	7	0.524	0.307	0.460
485	OHF TACT EQUIP SHOP	23AUG83	7	3.097	2.736	3.200
486	SAD POST OFFICE	24AUG83	4	0.213	0.117	0.270
487	SAD HEALTH CLINIC	24AUG83	4	0.667	0.644	1.050
488	SAD IPV RANGES	25AUG83	9	12.567	13.067	15.500
489	SAD TACT EQUIP SHOP	25AUG83	7	3.984	3.509	5.700
490	SWD DINING FAC MOD	25AUG83	8	0.799	0.687	0.980

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMI
393	OHR FLIGHT SIMULATOR	15MAR83	11	2.234	1.925	2.85
394	SAD BARRACKS	15MAR83	14	9.287	6.523	11.70
395	SAD CO ADMIN & SUPPLY	15MAR83	14	1.331	0.811	2.10
396	SAD DINING FAC	15MAR83	14	1.316	0.826	1.65
397	SWD MAINT MOD	16MAR83	15	23.634	18.430	29.00
398	SPD SATELLITE CTRL FAC	18JAN83	11	2.052	1.826	2.05
399	NAD OBS FIRE TR FAC	18JAN83	16	0.295	0.410	0.32
400	NAD GYM ADDITION	19JAN83	18	0.444	0.400	0.49
401	EUR BARRACKS	19JAN83	12	2.800	2.380	5.10
402	EUR SQUAD QUAL RANGE	25JAN83	9	0.101	0.093	0.50
403	EUR PLT QUAL RANGE	25JAN83	9	0.135	0.159	1.50
404	POD AIRCRAFT HANGAR	01FEB83	8	18.903	12.802	20.00
405	EUR HOSPITAL RENOVATE	02FEB83	12	13.486	10.110	29.00
406	SPD BARRACKS	03FEB83	13	1.770	1.978	2.20
407	NAD COMM SYS FAC	10FEB83	12	1.580	0.926	1.70
408	EUR BARRACKS	10FEB83	21	1.130	1.032	2.05
409	SWD CO ADMIN & SUPPLY	10FEB83	10	4.005	3.684	4.30
410	SWD BN HQ & CLASSROOM	10FEB83	10	2.322	2.183	2.45
411	EUR DEP COM SYS	16FEB83	10	1.444	1.610	3.95
412	NRD ENERGY CONS	23FEB83	3	0.488	0.305	0.85
413	EUR TACT EQUIP SHOP	23FEB83	9	1.922	1.764	3.35
414	OHR ADDN ELEC PWR BLDG	23FEB83	8	0.544	0.492	0.63
415	EUR BARRACKS	23FEB83	9	5.146	4.272	10.40
416	SAD BARRACKS MOD	16MAR83	5	1.937	1.863	2.80
417	SAD BARRACKS MOD	17MAR83	3	1.134	0.989	1.35
418	SWD ELECTROMAG TEST FAC	24MAR83	15	3.393	2.395	4.95
419	MPD BN AC PARK APRON	24MAR83	9	1.400	1.324	2.80
420	NRD GENERAL INST BLDG	31MAR83	8	4.701	4.830	4.20
421	EUR FAC MOD	27APR83	8	3.462	2.537	5.80
422	EUR AUTO CTRLS-ECIP	04MAY83	6	0.909	0.869	1.25
423	SPD TRAINING RANGES	05MAY83	20	1.137	0.803	1.54
424	SPD TACT EQUIP SHOP	10MAY83	8	0.411	0.424	0.99
425	EUR AUTO CONTROLS-ECIP	10MAY83	15	1.059	0.891	1.85
426	NRD RR LOADING AREA	12MAY83	7	2.850	2.533	2.80
427	NRD ACCESS ROAD	12MAY83	7	0.768	0.668	1.85
428	MPD COBRA FIRING RANGE	17MAY83	11	1.024	0.965	1.25
429	SWD CHILD CARE CENTER	19MAY83	12	2.132	2.110	2.60
430	POD TACT EQUIP SHOP	19MAY83	19	1.836	1.549	2.93
431	MPD CONTROL TOWER	26MAY83	6	1.381	1.334	1.67
432	NRD MAINT DIV COMPLEX	26MAY83	8	8.660	6.577	11.00
433	EUR DINING FAC-ECIP	26MAY83	3	0.383	0.351	0.44
434	EUR TACT EQUIP SHOP	01JUN83	25	2.929	2.286	5.00
435	EUR TACT EQUIP SHOP	01JUN83	25	3.950	2.857	4.84
436	NAD INSULATE 300/400 AR	08JUN83	19	1.178	0.775	1.55
437	EUR BARRACKS	14JUN83	9	6.307	6.326	14.60
438	EUR TACT EQUIP SHOP	14JUN83	9	0.242	0.243	1.25
439	EUR AMMO STGE ISLOOS	14JUN83	13	0.668	0.632	0.68
440	POD CONTROL ELEC SUBSTA	15JUN83	8	0.574	0.402	0.63
441	EUR HVAC UPGRADE	16JUN83	7	0.283	0.328	0.95

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMT
344	EUR NBC DECON TNG CTR	02OCT82	17	0.991	0.639	1.65
345	EUR BARRACKS	16NOV82	17	1.456	1.268	3.45
346	EUR TRAINING FAC	16NOV82	7	3.482	2.828	8.70
347	EUR BARRACKS-DIVAD	16NOV82	17	1.942	1.605	3.95
348	EUR STGE MAINT	16NOV82	22	1.041	0.711	1.10
349	EUR TACT EQUIP SHOP	23NOV82	9	4.039	3.841	7.10
350	EUR MAINT SPT FAC	24NOV82	10	3.191	2.631	6.30
351	EUR TACT EQUIP SHOP	24NOV82	15	0.652	0.577	0.92
352	EUR BARRACKS	24NOV82	19	0.973	0.745	2.10
353	EUR BARRACKS	24NOV82	21	2.368	1.872	5.80
354	MRD INSULATE BLDGS	02DEC82	6	0.387	0.341	0.55
355	EUR ATTIC INSULATION	02DEC82	9	1.139	0.739	1.85
356	SPD VEH MAINT FAC	09DEC82	16	1.349	1.151	2.10
357	EUR FLT SIM BLDG	10DEC82	11	3.224	2.700	7.30
358	EUR BARRACKS W/DINING	10DEC82	10	0.597	0.684	1.10
359	EUR AMMO STORAGE	14DEC82	24	1.113	0.962	2.15
360	NAD M1 TRNG FAC	15DEC82	16	7.831	3.795	9.40
361	NAD AVIATION TNG FAC	15DEC82	17	3.639	3.024	6.40
362	SWD BN HQ W/CLASSROOM	15DEC82	9	1.176	1.150	1.50
363	SWD CO ADMIN SUPPLY	15DEC82	9	1.733	1.547	2.35
364	EUR AUTO TEMP CTRLS	16DEC82	4	0.344	0.365	0.72
365	EUR WASTE OIL BURN FAC	16DEC82	2	0.130	0.164	0.12
366	NAD BARRACKS W/DINING	16DEC82	15	9.948	8.479	13.80
367	SWD HANGAR W/SHOPS	16DEC82	9	13.722	10.154	15.50
368	SPD TROOP MED CLINIC	16DEC82	14	3.384	3.333	5.80
369	EUR UPGRADE RANGE	21DEC82	4	0.241	0.218	0.26
370	EUR BARRACKS	21DEC82	26	1.574	1.153	4.05
371	SAD TACT EQUIP SHOP	21DEC82	5	0.290	0.322	0.57
372	NAD SATELLITE CTRL FAC	21DEC82	20	2.282	1.070	2.50
373	SAD TACTICAL EQUIP SHP	11JAN83	3	0.280	0.305	0.72
374	EUR VEHICLE HARDSTAND	12JAN83	11	0.405	0.267	0.52
375	MRD CO ADMIN & SUPPLY	12JAN83	17	0.319	0.261	0.44
376	SAD DINING FAC MOD	17JAN83	7	0.265	0.205	0.36
377	EUR NITE GETBACK CTRL	17JAN83	2	0.109	0.108	0.16
378	NAD TRAINING AREA	24FEB83	15	2.875	2.343	3.20
379	MPD HELICOPTER HANGAR	01MAR83	10	5.111	3.201	7.40
380	MPD UNIT MAINT HANGAR	01MAR83	10	5.193	3.244	7.50
381	MPD TACT EQUIP SHOP	02MAR83	21	2.348	1.339	2.90
382	MPD TACT EQUIP SHOP	02MAR83	21	0.890	0.508	1.10
383	MRD BN HQ W/CLASSROOM	02MAR83	12	1.256	1.039	1.45
384	MRD CO ADMIN & SUPPLY	02MAR83	12	1.236	1.023	1.75
385	MPD GYMNASIUM	03MAR83	8	0.974	0.886	1.70
386	SPD ROAD IMPROVEMENTS	03MAR83	20	9.830	8.828	13.00
387	SWD MAINT MOD	03MAR83	25	10.145	7.192	10.00
388	EUR ENERGY CONSERVATION	03MAR83	9	0.604	0.497	1.15
389	MRD BARRACKS	09MAR83	14	3.047	2.479	3.60
390	NAD RENOV HVAC SYS	10MAR83	7	5.712	3.097	9.80
391	SAD ELECT DIST REHAB	10MAR83	11	3.980	2.403	2.67
392	EUR FACILITY MOD	10MAR83	23	1.319	1.031	2.45

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAM
295	SWD SCIT	11AUG82	6	0.477	0.409	0.483
296	EUR NSL MAINT FAC	20AUG82	4	0.195	0.194	0.251
297	OHR MECH VENT-SAFETY DV	24AUG82	4	0.019	0.022	0.015
298	OHR MECH VENT-SAFETY DV	25AUG82	6	0.192	0.170	0.161
299	OHR ALT OIL FIRED HEAT	25AUG82	5	0.301	0.248	0.306
300	EUR ALT SAN SEWER SYS	26AUG82	10	0.210	0.201	0.482
301	OHR MECH VENT-SAFETY DV	31AUG82	6	0.099	0.089	0.063
302	HRD CQNT ABOVE GND TKS	01SEP82	6	0.255	0.158	0.290
303	OHR MECH VENT-SAFETY DV	01SEP82	3	0.059	0.032	0.049
304	NAD INSUL/STORM WINDOW	08SEP82	8	0.135	0.144	0.360
305	OHR OPERATIONS CENTER	09SEP82	2	0.198	0.181	0.200
306	NAD COLLECTION METHANE	20SEP82	2	0.210	0.170	0.269
307	EUR HARDSTAND	10SEP82	3	0.271	0.329	0.357
308	EUR HARDSTAND	14SEP82	6	0.166	0.143	0.321
309	OHR AC ENG TEST FAC	14SEP82	5	0.459	0.373	0.463
310	EUR BORDER OBS POST	16SEP82	4	0.095	0.113	0.121
311	EUR BORDER OBS POST	16SEP82	4	0.088	0.105	0.113
312	EUR BORDER OBS POST	16SEP82	4	0.098	0.120	0.184
313	EUR BORDER OBS POST	16SEP82	4	0.198	0.218	0.246
314	SAD OBS FIRE TRAINER	20SEP82	5	0.202	0.300	0.469
315	NAD ALT FOR EDPC SYS	21SEP82	3	0.447	0.302	0.379
316	EUR TNG SPT BLDG	21SEP82	13	0.249	0.266	0.462
317	NAD WTR RECYCLE & VEH	22SEP82	6	0.134	0.146	0.161
318	NAD CONV BLDG 320	17NOV81	9	0.138	0.125	0.158
319	HRD ALTER MED INT CARE	30NOV81	6	0.368	0.327	0.464
320	POD CONV BLDG 104	22DEC81	3	0.375	0.290	0.465
321	SAD K.D. SNIPER RANGE	23DEC81	18	0.169	0.129	0.196
322	SAD REN COSCOM FAM FAC	29DEC81	11	0.145	0.141	0.191
323	SWD WASTE WATER TMNT	12JAN82	2	0.369	0.318	0.369
324	OHR ADJ FRESH AIR QUANT	21JAN82	4	0.150	0.096	0.200
325	NAD TEMP LACV FAC	28JAN82	12	0.443	0.372	0.462
326	SPD FIRE STATION ADDN	17FEB82	15	0.187	0.132	0.204
327	NAD CHURCHVILLE TEST C	18FEB82	16	0.361	0.180	0.361
328	OHR TMDE FAC	23FEB82	9	0.258	0.226	0.207
329	OHR WATER MONITORING ST	25MAR82	7	0.171	0.159	0.220
330	EUR MAINT FAC	04MAY82	9	0.296	0.273	0.381
331	EUR GEN PURPOSE WHSE	12MAY82	12	0.400	0.380	0.475
332	SWD ADDN WASHER/DRYER	18MAY82	8	0.315	0.274	0.341
333	HRD ADDN/ALT LAB	03AUG82	3	0.278	0.309	0.265
334	NAD BEL MIL CLOTH STORE	03AUG82	9	0.149	0.097	0.200
335	OHR ALT OIL FIRED HEAT	25AUG82	5	0.301	0.248	0.306
336	NAD TROOP TEST MODULES	26AUG82	8	0.267	0.227	0.322
337	SAD ROADWAY IMP	01SEP82	3	0.397	0.402	0.485
338	SWD INTERIM A/C REFUEL	03SEP82	4	0.045	0.056	0.056
339	EUR TRAILER PARKING	07SEP82	16	0.256	0.195	0.491
340	EUR INSTALL HEAT CTRL	08SEP82	3	0.331	0.332	0.487
341	EUR PARKING OP M-1	14SEP82	6	0.166	0.143	0.321
342	EUR WATER SUPPLY SYS	16SEP82	3	0.290	0.349	0.413
343	SWD MOD SHIP & REC BLDG	21SEP82	4	0.424	0.340	0.467

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAM
246	NAD BOQ FIRE ALARM SYS	15APR82	10	0.069	0.027	0.139
247	SAD FENCING HAWK-1	16APR82	3	0.030	0.022	0.400
248	NAD VEHICLE STORAGE BLD	20APR82	7	0.317	0.322	0.350
249	NAD AC VENT BLDG	20APR82	16	0.269	0.298	0.310
250	NAD INSTALL EXT LGHTNG	22APR82	13	0.271	0.124	0.260
251	NAD HEATED RNG CLASSRM	29APR82	15	0.292	0.149	0.422
252	NAD FIRING RANGE MOD	06MAY82	6	0.109	0.089	0.134
253	EUR READY BLDG	13MAY82	5	0.215	0.197	0.464
254	NAD PERIMETER SCTY FNC	26MAY82	7	0.265	0.221	0.243
255	NAD CSH STG & MNT FAC	27MAY82	6	0.447	0.469	0.487
256	NAD COURTS & FIELDS	01JUN82	2	0.304	0.243	0.420
257	NAD SAB TERM ADDN	03JUN82	13	0.342	0.250	0.435
258	NRD CO ADMIN & SUPP	07JUN82	7	0.392	0.302	0.450
259	NAD TACT EQUIP SHOPS	07JUN82	6	0.399	0.336	0.330
260	SWD ALTER BLDG 421	10JUN82	8	0.202	0.214	0.251
261	NAD AMMO SURV BLDG	15JUN82	15	0.270	0.222	0.283
262	SPD TR VEH ROUGH WASHER	08DEC81	22	0.448	0.336	0.460
263	SPD RANGE CONTROL BLDG	29DEC81	10	0.199	0.184	0.220
264	SWD FIRE TRNG CLASSROOM	05JAN82	8	0.467	0.361	0.485
265	SWD LASER ENGAGEMENT WH	05JAN82	8	0.498	0.355	0.473
266	OHR SLUDGE DRYING FAC	06JAN82	13	0.368	0.242	0.340
267	SAD NIGHT FIRE RANGE	06JAN82	9	0.251	0.131	0.227
268	NAD ALT TO 4 BLDG	12JAN82	6	0.223	0.170	0.152
269	OHR FIRE SAFETY IMPR	12JAN82	11	0.222	0.110	0.189
270	OHR OMNI DIR APP LTG SY	19JAN82	13	0.092	0.087	0.103
271	SPD EXT FNCNG UTIL PAV	28JAN82	13	0.336	0.286	0.371
272	SPD NBD FAC UPGD	26JAN82	16	0.383	0.314	0.400
273	SWD BOILER CONTROL	03FEB82	13	0.193	0.092	0.290
274	NAD OSHA DEFICIENCIES	03FEB82	4	0.127	0.124	0.220
275	NAD EVAL COOLING	09FEB82	24	0.231	0.142	0.200
276	MPD PHYSICAL SECURITY	09FEB82	3	0.249	0.199	0.368
277	EUR EUD OFC ANNEX	10FEB82	14	0.410	0.378	0.499
278	NAD BLDG 814 TO DENTAL	17FEB82	14	0.444	0.277	0.477
279	NRD MOD DINING FAC	16JUN82	6	0.298	0.354	0.360
280	EUR PATRIOT FAC	16JUN82	9	0.330	0.267	0.471
281	NAD SEWAGE PUMPING FAC	17JUN82	4	0.140	0.121	0.125
282	MPD RANGE BN INF HQ	22JUN82	12	0.113	0.104	0.133
283	NAD IMPR SEWAGE TRMT PL	24JUN82	9	0.340	0.188	0.302
284	EUR INSTALL LOOP LINE	22JUN82	3	0.132	0.120	0.222
285	OHR HQ MEPCON ALT	29JUN82	4	0.451	0.309	0.195
286	EUR V CORPS BATTLE CTR	08JUL82	5	0.369	0.366	0.412
287	EUR HEAVY DROP RIG FAC	14JUL82	5	0.257	0.202	0.432
288	MPD VOLTAGE REGULATOR	15JUL82	2	0.192	0.173	0.130
289	SWD ADDN HEALTH CLINIC	20JUL82	5	0.403	0.388	0.456
290	SWD TARGET LAUNCH CAMP	27JUL82	10	0.407	0.380	0.480
291	NAD ALTER BLDG 59	29JUL82	7	0.140	0.091	0.212
292	EUR SECURITY FENCE	03AUG82	2	0.182	0.203	0.353
293	MPD RELOC YUCON RFL RNG	06AUG82	5	0.447	0.422	0.426
294	NAD ADD/ALT BLDG 665	06AUG82	9	0.133	0.120	0.188

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM	GOV-	LOW-	PRO-
			BID	EST	BID	GAMI
197	EUR INSTRUCTIONAL BLDG	16FEB82	12	0.339	0.355	0.415
198	NAD GUIDED MSL MAINT	23FEB82	24	8.588	5.487	9.250
199	SAD HOSPITAL ADD/ALT	25FEB82	6	20.220	17.117	27.500
200	SWD DS/GS MAINT FAC	04MAR82	12	0.698	0.613	0.970
201	EUR POL POLLUTION CTRL	25MAR82	15	0.775	0.648	0.997
202	SAD ABERDEEN TNG FAC	13APR82	10	4.819	4.240	6.130
203	SAD SUPPORT & MAINT	13APR82	10	3.510	3.286	5.188
204	NAD MOD IND FAC III	20APR82	7	11.096	8.819	10.800
205	EUR IMP POL HANDLING	20APR82	10	0.726	0.686	1.500
206	EUR RANGE UPGRADE	20APR82	8	0.961	0.884	1.300
207	EUR POL POLLUTION CTRL	18MAY82	11	0.607	0.389	0.500
208	SAD INS, SIM WNDW WEATH	29JUN82	16	0.516	0.326	0.676
209	EUR POL POLLUTION CTRL	08JUN82	13	1.413	1.012	0.752
210	EUR HOSPITAL PHASE III	20JUL82	6	5.901	5.611	5.401
211	SAD ELEC/MECH UPGD HOSP	03AUG82	9	14.850	12.387	16.500
212	EUR TACT EQUIP SHOP	10AUG82	14	1.650	1.546	2.600
213	EUR ECIP TEMP HEAT REC	10AUG82	4	1.211	1.140	2.270
214	SAD UPGRD SEWAGE PLANT	12AUG82	7	0.268	0.270	0.300
215	EUR AMMO IGLOOS	12AUG82	16	1.379	1.468	1.800
216	EUR BN HQ & CLASSROOM	13AUG82	18	0.527	0.381	1.050
217	EUR BARRACKS	17AUG82	13	2.407	2.144	5.550
218	EUR TEMP HEAT RCVR	18AUG82	6	1.149	0.874	2.300
219	EUR AUTO HEATING SYSTEM	24AUG82	13	3.003	2.875	5.500
220	SPD REC CENTER	25AUG82	13	1.730	1.660	2.250
221	SPD WATER SUP IMP	26AUG82	10	0.623	0.338	0.397
222	EUR BKS. WASH/POL POINT	31AUG82	8	0.761	0.639	0.800
223	SAD ADMIN AREA IMP	03SEP82	11	1.412	1.539	1.800
224	EUR AUTO HTG SYSTEM	02SEP82	4	3.576	2.062	2.500
225	EUR IMPR POL-MAINT FAC	07SEP82	10	1.577	1.121	1.360
226	SAD STORAGE TANK	15SEP82	8	0.443	0.321	0.563
227	EUR AUTO HEATING SYSTEM	22SEP82	12	0.984	0.728	2.400
228	MRD EHCS COMPUTER RM	30SEP82	5	0.067	0.066	0.080
229	MRD BARRACKS MOD	24FEB82	17	0.295	0.215	0.289
230	SPD TRACKED VEH MAINT	02MAR82	20	0.297	0.277	0.349
231	NAD CORRECT FIRE CODE	02MAR82	6	0.252	0.223	0.226
232	SWD OBSERVE FIRE TOWER	03MAR82	8	0.268	0.225	0.286
233	NAD SHIP TO SHORE WASTE	09MAR82	8	0.257	0.179	0.350
234	SAD ELECTRONIC MAINT SH	10MAR82	9	0.291	0.320	0.322
235	SWD CO ADMIN & SUPPLY	18MAR82	10	0.410	0.349	0.430
236	SAD MSL ELEC & HYDR MN	24MAR82	11	0.413	0.357	0.477
237	NAD INSTALL EXT SUP PW	24MAR82	5	0.178	0.144	0.207
238	OHV STEAM PLANT MOD	08APR82	6	0.177	0.122	0.300
239	SAD TRI-TAC TNG FAC	13APR82	8	0.464	0.377	0.499
240	MPD RENOV HEALTH CLIN	13APR82	6	0.446	0.405	0.443
241	EUR MINI GYM	14APR82	14	0.052	0.053	0.118
242	EUR MINI GYM	14APR82	14	0.066	0.045	0.118
243	EUR MINIGYM	14APR82	14	0.059	0.052	0.118
244	EUR MINIGYM	14APR82	14	0.044	0.049	0.118
245	EUR MINI GYM	15APR82	14	0.129	0.049	0.129

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMT
148	EUR CHILD CARE CENTER	23JUL82	10	1.277	0.941	1.407
149	EUR ADMIN BLDG	27JUL82	8	0.619	0.173	1.150
150	EUR ECIP	27JUL82	4	0.205	0.203	0.410
151	EUR ECIP	29JUL82	6	0.197	0.115	0.305
152	EUR AUTO HEAT PLANT	03AUG82	4	0.228	0.241	0.264
153	EUR BARRACKS SEWER LINE	03AUG82	7	1.024	0.886	0.455
154	SAD BOILERS	03AUG82	5	22.500	14.980	19.000
155	NAD GP MAGAZINES	04AUG82	10	0.689	0.524	0.760
156	EUR TACT EQUIP SHOP	05AUG82	5	0.165	0.155	1.286
157	EUR AMMO IGLOOS	05AUG82	5	0.156	0.129	0.280
158	EUR AMMO IGLOOS	05AUG82	3	0.142	0.061	0.154
159	EUR AMMO IGLOOS	02SEP82	14	0.176	0.123	0.265
160	EUR BARRACKS W/ DINING	05AUG82	5	7.092	7.008	13.668
161	SWD HOSPITAL PHASE II	05AUG82	13	66.285	59.787	81.000
162	EUR MISSLE MNT FAC	10AUG82	15	3.120	2.697	5.500
163	EUR BARRACKS	10AUG82	16	2.092	2.003	4.800
164	NAD BARRACKS MOD	11AUG82	7	13.492	8.889	18.600
165	EUR TACT EQUIP SHOP	12AUG82	10	2.679	2.392	3.940
166	EUR HARDSTAND TACT FAC	12AUG82	11	0.475	0.370	0.800
167	EUR AMMO SURV BLDG	13AUG82	11	0.736	0.694	0.965
168	EUR BARRACKS MLRS	17AUG82	10	1.377	1.253	3.485
169	EUR TACT EQUIP SHOP	17AUG82	6	1.786	1.433	2.050
170	SPD INSULATION	18AUG82	8	0.502	0.302	0.520
171	EUR UTILITIES SUP-MLRS	18AUG82	49	8.070	6.351	7.400
172	EUR UTILITIES-PX CMMSRY	18AUG82	8	2.641	2.399	2.573
173	SWD CHILD CARE CENTER	19AUG82	5	2.141	2.055	2.050
174	EUR MIS & TAC EQUIP SHP	19AUG82	14	4.031	3.451	5.100
175	SAD RECEPT & PROCESS CM	24AUG82	7	3.023	2.649	3.800
176	EUR RELOC BARRACKS	25AUG82	6	0.967	0.860	1.175
177	EUR BEQ	25AUG82	7	1.535	1.370	2.340
178	EUR AMMO IGLOOS	25AUG82	9	0.634	0.568	0.965
179	EUR MAINT HARDSTAND	26AUG82	14	5.058	4.013	7.100
180	SWD TRAINING FAC-ROLAND	27AUG82	6	3.020	2.523	3.700
181	EUR FAC MOD II	27AUG82	4	3.579	3.008	5.226
182	NAD WINDOW TRMT INSUL	01SEP82	6	3.345	2.343	3.600
183	SAD ADMIN AREA IMP	02SEP82	11	1.412	1.537	1.850
184	SWD OSHA DEFICIENCIES	03SEP82	7	0.670	0.741	0.770
185	EUR HEATING PLANT-BEQ	07SEP82	6	1.054	1.173	1.266
186	MRD INCINERATOR PLANT	08SEP82	12	3.515	3.035	3.750
187	SAD EXP TRUCK ACCESSROAD	10SEP82	6	0.627	0.450	0.880
188	SAD BRIGADE MAINT FAC	13SEP82	11	2.694	2.063	2.929
189	EUR AMMO IGLOOS	14SEP82	6	0.920	0.973	0.884
190	EUR VEH MAINT BLDG	07OCT81	12	0.850	0.831	0.960
191	NAD CHEM SEC UPGRADE	07OCT81	2	0.348	0.234	0.375
192	SPD LIQUID WASTE DISP	16OCT81	10	2.215	1.341	1.800
193	SAD CONDENSATE WET LN	21OCT81	12	0.864	0.711	1.450
194	SWD BATTERY REPAIR-OSHA	21OCT81	4	0.527	0.534	0.609
195	MRD INSULATE BLDG	01DEC81	12	0.998	0.986	1.550
196	MRD PERSHING II	02FEB82	12	1.850	1.529	3.900

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMT
99	EUR AMMO STORAGE	18MAY82	8	0.169	0.153	0.245
100	EUR IGLOO STORAGE	18MAY82	8	0.039	0.028	0.055
101	EUR IGLOO STORAGE	18MAY82	8	0.045	0.033	0.068
102	EUR IGLOO STORAGE	18MAY82	8	0.056	0.042	0.082
103	EUR IGLOO STORAGE	18MAY82	8	0.117	0.039	0.049
104	NAD UTILITIES EXPANSION	25MAY82	8	4.533	2.427	3.550
105	NAD GEN INST BLDG	27MAY82	11	2.487	1.989	3.250
106	OHF ALTER HQ FAC-PK II	27MAY82	10	2.747	2.467	4.000
107	EUR IGLOO STORAGE	01JUN82	3	0.041	0.007	0.008
108	EUR TACT EQUIP SHOP	01JUN82	6	0.732	0.531	1.809
109	EUR BARRACKS MODERN	02JUN82	16	1.691	1.347	1.568
110	EUR BARRACKS	02JUN82	8	3.132	2.511	5.708
111	EUR IGLOO STORAGE	02JUN82	3	0.068	0.080	0.055
112	NAD BED BLDG MOD	03JUN82	6	25.299	16.010	26.000
113	EUR FACILITIES MODERN	03JUN82	11	5.396	3.994	6.432
114	SAD STEAM LINE INC	03JUN82	19	3.019	1.368	4.750
115	NAU BN HQ AND CLASSROOM	08JUN82	8	1.178	0.843	1.300
116	EUR ALT HOSPITAL	08JUN82	7	10.687	7.828	26.532
117	EUR ECIP HEAT PLANT	08JUN82	12	0.525	0.395	0.630
118	SAD TRAINEE BARRACKS	10JUN82	15	14.225	13.304	19.850
119	EUR PAVE ROADS	15JUN82	21	0.401	0.249	0.635
120	SWD BARRACKS COMPLEX 2	16JUN82	7	0.633	0.453	0.633
121	SWD EMCS	17JUN82	8	0.745	0.820	0.840
122	NAD REFUSE FIRED INCIN	17JUN82	10	2.170	2.146	2.150
123	EUR TEMP HEAT RECOVERY	22JUN82	10	1.467	1.261	2.500
124	NAD PHYSICAL FITNESS	22JUN82	7	3.882	2.864	5.200
125	EUR CHAPEL/REL ED CTR	30JUN82	11	1.925	1.462	2.050
126	EUR BASIC LOAD SITE	30JUN82	5	1.598	1.513	2.090
127	EUR TACT EQUIP SHOP	06JUL82	12	0.638	0.545	1.166
128	SAD OSHA DEFICIENCIES	08JUL82	14	0.470	0.447	0.700
129	SAD MISC FLO ABATMENT	13JUL82	7	0.917	0.744	0.790
130	EUR AMMO IGLOO	13JUL82	5	0.149	0.166	0.210
131	EUR HEAVY EQUIP MNT PAC	13JUL82	8	5.042	4.296	5.754
132	NAD EMCS	14JUL82	11	1.400	1.148	2.800
133	NAD HEAT RECOVERY	15JUL82	13	5.398	5.387	4.100
134	EUR PACS MOD, SEWER UGD	16JUL82	10	1.927	2.033	2.806
135	EUR BKS W/ DINING	16JUL82	10	2.772	1.586	6.550
136	EUR ADMIN BLDG	16JUL82	10	1.417	0.434	3.150
137	EUR SUPPLY OFC AND WHSE	16JUL82	10	0.839	0.213	1.300
138	EUR CMNTY ACT PAC	16JUL82	10	0.320	0.088	0.590
139	EUR BARRACKS PACS	16JUL82	8	1.898	1.110	2.900
140	EUR COMMTY ACTS PAC	20JUL82	8	0.384	0.147	0.650
141	EUR BARRACKS	20JUL82	8	1.888	1.061	2.500
142	EUR ADMIN BLDG	20JUL82	8	0.519	0.135	1.050
143	EUR CMNTY BLDG	20JUL82	8	0.496	0.172	0.960
144	EUR FLT SIM BLDG	20JUL82	7	4.892	3.281	8.000
145	NAD WINDOW TRMT INSUL	20JUL82	12	0.510	0.369	0.620
146	EUR ECIP	22JUL82	5	0.582	0.453	0.699
147	SWD BARRACKS	26JUL82	7	2.800	2.640	3.142

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM	GOV- BID	LOW- EST	PRO- BID	GAMT
50	EUR RANGE UPGRD IFV	04MAR82	18	0.091	0.086	0.241	
51	SPD UPGRADE PWR LINE	04MAR82	19	0.586	0.496	1.500	
52	EUR MAJOR TNG AREA UPGD	04MAR82	10	0.175	0.216	0.400	
53	EUR BARRACKS-SOTAS	04MAR82	20	1.067	0.934	2.211	
54	SPD CO ADMIN AND SUPPLY	11MAR82	11	2.166	1.238	2.400	
55	SND ADV PWR TNG TEST FC	11MAR82	5	2.203	2.495	2.350	
56	SPD EMERGENCY GENERATOR	16MAR82	13	1.012	1.094	0.810	
57	SAD INCIN W/HEAT RECVRY	16MAR82	17	3.347	2.673	3.700	
58	EUR FAC MODERN MAINT FC	18MAR82	13	2.929	2.178	4.800	
59	SPD BARRACKS	18MAR82	14	7.788	7.257	9.000	
60	SPD CO ADMIN AND SUPPLY	18MAR82	14	3.223	2.875	3.600	
61	SPD BN HQ AND CLASSROOM	18MAR82	14	2.417	2.293	2.600	
62	NAD MED ADMIN AND SPT	23MAR82	12	5.856	3.056	6.250	
63	SPD DINING FAC	24MAR82	8	2.956	3.691	3.850	
64	SAD BN HQ AND CLASSROOM	25MAR82	14	0.901	0.825	1.200	
65	POD AMMO STORAGE	31MAR82	5	1.826	2.065	1.950	
66	EUR TANK MAINT FAC	23MAR82	14	3.551	3.311	5.869	
67	EUR AMMO STRG-MLRS	30MAR82	12	0.401	0.290	0.501	
68	POD DENTAL CLINIC	30MAR82	10	2.988	2.877	3.800	
69	EUR IGLOO STORAGE	30MAR82	7	0.063	0.063	0.080	
70	NAD IMPRVE UTIL SYS	01APR82	13	2.809	1.575	3.100	
71	EUR TACT EQUIP SHOP	01APR82	9	0.538	0.573	0.925	
72	NRD CORRECT OSHA DEF	07APR82	4	0.772	0.565	0.670	
73	EUR BARRACKS W/ DINING	07APR82	13	6.896	6.893	12.804	
74	EUR IGLOO STORAGE	08APR82	4	.	0.045	0.096	
75	EUR IGLOO STORAGE	08APR82	4	0.059	0.032	0.068	
76	EUR IGLOO STORAGE	08APR82	4	0.061	0.035	0.068	
77	NAD BARRACKS MODERN	13APR82	22	1.354	1.060	1.450	
78	OHF CONTAM WASTE PROCES	14APR82	7	0.603	0.517	1.450	
79	NPD PHYSICAL FITNESS CN	20APR82	5	3.815	4.462	6.700	
80	EUR RANGE UPGRADE	20APR82	8	0.961	0.884	1.300	
81	SAD CONV BLDG C1 LAB	21APR82	12	2.863	2.177	2.600	
82	SPD CONTAM WASTE PROCES	22APR82	13	0.493	0.404	1.500	
83	EUR IGLOO STORAGE	23APR82	8	0.042	0.040	0.055	
84	EUR IGLOO STORAGE	24APR82	7	0.050	0.034	0.055	
85	NAD TACT EQUIP SHOP	27APR82	10	4.474	2.968	5.100	
86	SPD SECURITY IMPRVMT	28APR82	4	0.530	0.369	1.150	
87	NAD OSHA DEFICIECCIES	28APR82	6	0.305	0.317	0.820	
88	EUR AMMO IGLOOS	11MAY82	9	0.169	0.143	0.245	
89	NAD WINDOW TRMT INSUL	10MAY82	11	2.671	3.069	3.550	
90	EUR TACT EQUIP SHOP	18MAY82	10	1.942	1.818	4.520	
91	EUR IGLOO STORAGE	18MAY82	8	0.053	0.032	0.058	
92	EUR IGLOO STORAGE	18MAY82	8	0.042	0.029	0.047	
93	EUR IGLOO STORAGE	18MAY82	10	0.042	0.031	0.051	
94	EUR IGLOO STORAGE	18MAY82	8	0.058	0.043	0.082	
95	EUR IGLOO STORAGE	18MAY82	8	0.094	0.071	0.123	
96	EUR IGLOO STORAGE	18MAY82	8	0.051	0.039	0.082	
97	EUR IGLOO STORAGE	18MAY82	8	0.055	0.041	0.068	
98	EUR IGLOO STORAGE	18MAY82	8	0.043	0.031	0.055	

TABLE A.1 - ORIGINAL DATA

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMT
1	EUR FORKLIFT CHARGING	17NOV81	4	0.543	0.534	0.501
2	EUR TACTICAL EQUIPMT SH	17NOV81	8	1.937	1.313	1.970
3	NAD SPRINKLER SYS OSHA	24NOV81	3	0.472	0.484	0.510
4	EUR BARRACKS	24NOV81	23	1.523	1.104	2.332
5	EUR STINGER TGT SIMUL	24NOV81	11	0.611	0.551	1.126
6	EUR BARRACKS	24NOV81	23	-	3.972	8.522
7	NAD LANDHILL CLOSURE	25NOV81	12	1.671	0.821	1.800
8	NAD ADV HK ENER LAUNCH	25NOV81	20	2.135	1.513	2.800
9	EUR BATTALION HQ	01DEC81	16	1.261	0.890	1.688
10	EUR BARRACKS	02DEC81	18	2.787	2.056	4.824
11	EUR STINGER TGT SIMUL	04DEC81	9	0.551	0.454	1.126
12	EUR TACTICAL EQUIP SHOP	09DEC81	13	2.266	1.712	3.940
13	EUR HELIPADS	14DEC81	27	0.759	0.304	0.711
14	SAD WASHRACK UPGRADE	16DEC81	16	0.584	0.435	0.760
15	SAD AMMO SUPPLY POINT	16DEC81	30	7.753	5.356	11.600
16	NAD SURVEILLANCE WKSHP	17DEC81	13	1.921	1.438	2.200
17	SAD FIRE STATION	17DEC81	2	-	0.868	1.350
18	EUR OPER BLDG	18DEC81	20	0.828	0.720	1.566
19	SPD TACTICAL EQUIP SHOP	14JAN82	18	-	3.867	11.600
20	SPD SUPPORT MAINT FAC	14JAN82	18	-	4.176	6.300
21	SPD GEN SPT MAINT FAC	14JAN82	18	-	6.808	7.000
22	NPD VEH EXHAUST SYS	21JAN82	7	1.557	1.111	1.200
23	SWD BN HQ AND CLASSROOM	21JAN82	10	1.985	1.874	2.200
24	SWD CO ADMIN AND SUPPLY	21JAN82	10	3.161	2.757	3.900
25	NPD VEH EXHAUST SYS	21JAN82	7	1.296	0.864	1.150
26	SWD DIV SUP-SI FAC	26JAN82	8	0.497	0.386	0.630
27	NAD WINDOW TRMT INSUL	27JAN82	7	2.095	2.176	2.750
28	SWD TACT EQUIP SHOP	02FEB82	15	5.438	4.350	8.000
29	NAD ENERGY IMPROVEMENT	02FEB82	8	1.165	1.172	1.500
30	SAD WASTE PROCESS INCIN	03FEB82	8	0.959	0.898	0.959
31	SAD NON-DIV MAINT FAC	03FEB82	9	0.245	0.168	1.100
32	EUR MAINT FAC	09FEB82	8	1.834	1.578	3.136
33	SPD ELECT TGT MAINT FAC	09FEB82	10	0.594	0.489	0.600
34	EUR BARRACKS MODERNIZA	09FEB82	9	0.683	0.569	1.246
35	EUR FACILITIES MOD	15FEB82	23	2.415	2.151	4.663
36	NAD GUID MSL MYN FAC AD	23FEB82	24	8.588	5.487	9.250
37	SWD TACT EQUIP SHOP	23FEB82	11	0.519	0.452	0.660
38	SWD TACT EQUIP SHOP	23FEB82	7	3.820	3.215	4.250
39	NAD OSHA DEFICIENCIES	25FEB82	19	0.409	0.214	0.640
40	EUR BKS W/ ADMIN	25FEB82	26	1.121	0.853	2.090
41	NAD UPGRADE A/C	25FEB82	13	1.469	0.860	1.600
42	EUR SCHAEBISCH HALL	02MAR82	5	0.429	0.336	0.881
43	OHR GYM W/ 50 MTR POOL	02MAR82	6	3.900	2.547	3.900
44	EUR IGLOO STORAGE	02MAR82	4	0.036	0.042	0.053
45	NAD EMCS	03MAR82	6	0.535	0.259	1.200
46	SAD BARRACKS	04MAR82	8	6.054	5.884	9.000
47	OHR CIDC FIELD OPS BLDG	04MAR82	15	1.194	0.893	1.500
48	EUR XM1 RANGE 4,10,20	04MAR82	18	1.223	1.348	2.000
49	SAD CO ADMIN AND SUPPLY	04MAR82	8	1.340	1.413	0.950

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMT
687	EUR PHYS FITNESS CTR	21FEB84	10	0.156	0.145	0.410
688	EUR MAINT HANGAR ADD	22FEB84	8	0.487	0.418	1.200
689	SWD MULTI-PUMP TRNG RNG	23FEB84	6	8.501	5.790	9.600
690	HRD CO ADMIN & SUPPLY	23FEB84	10	1.412	1.101	1.700
691	HRD CO ADMIN & SUPPLY	23FEB84	10	1.725	1.354	2.150
692	HRD CO ADMIN & SUPPLY	23FEB84	10	1.412	1.122	1.500
693	HRD BRIGADE HQ	23FEB84	10	1.098	0.865	1.400
694	HRD BN HQ & CLASSROOM	23FEB84	10	1.098	0.890	1.200
695	HRD BN HQ & CLASSROOM	23FEB84	10	1.098	0.897	1.200
696	HRD MAINT HANGAR W/OPS	29FEB84	11	7.745	5.776	8.100
697	EUR FIRE PROTECTION SYS	29FEB84	4	2.054	1.325	2.550
698	SPD WATER WELLS	08MAR84	13	5.769	3.490	3.200
699	EUR BARRACKS-CEWI	08MAR84	8	1.890	1.807	3.100
700	POD MULTI-PPOSE REC CN	15MAR84	6	2.642	2.192	2.500
701	POD MISSLE ASSY FAC	15MAR84	6	0.640	0.487	0.830
702	POD EXPLOSIVE STGE FAC	15MAR84	6	0.573	0.494	0.710
703	POD PHOTO LAB WASTE WTR	15MAR84	6	0.216	0.205	0.530
704	POD TACT EQUIP SHOP	15MAR84	11	1.529	1.478	2.200
705	SAD DINING FAC MOD	19MAR84	5	0.898	0.894	0.700
706	HRD SEWAGE TRMT PLNT	21MAR84	5	0.416	0.424	0.490
707	POD BARRACKS W/DINING	21MAR84	14	12.903	11.997	16.400
708	EUR TACT EQUIP SHOP	22MAR84	10	1.443	1.288	1.700
709	HRD MAINT COMPLEX PH2	27MAR84	8	9.378	9.117	12.600
710	SWD MAINT HANGAR/CEWI	28MAR84	12	9.987	8.645	13.200
711	NAD CSM MEDICAL RESEARCH	29MAR84	13	3.243	2.918	3.650
712	SAD MG GUN TRNG RANGE	29MAR84	8	1.151	0.747	0.440
713	EUR FAC MOD SHOP	30MAR84	14	1.526	1.241	2.200
714	EUR COAL STG RUNOFF	05APR84	11	0.851	0.516	0.550
715	SAD ELEC DIST SYS	09APR84	6	0.898	0.880	0.760
716	HRD RANGE ROADS	01MAY84	8	6.583	4.590	7.200
717	SPD PHYS FITNESS CTR	01MAY84	11	2.056	1.747	3.400
718	HRD MUTI-PPOSE TRNG RG	02MAY84	7	15.184	12.173	31.000
719	SAD BARRACKS	03MAY84	8	6.969	7.162	12.000
720	HRD TACT EQUIP SHOP	09MAY84	7	4.691	4.504	5.000
721	HRD UPGRADE WATER SUPP	10MAY84	14	2.223	1.913	2.850
722	SWD MULTI-PPOSE TRNG RG	24MAY84	7	2.778	2.518	2.800
723	SWD MULTI-PPOSE TRNG RG	24MAY84	7	3.427	3.616	5.200
724	SPD OUTDOOR COURTS & PD	05JUN84	3	1.227	0.815	1.000
725	SAD WPNS MAINT TRNG FAC	12JUN84	10	5.331	3.960	5.700
726	SAD CHEM AGENT DISP FAC	14JUN84	6	7.856	5.938	10.200
727	SWD DINING FAC MOD	19JUN84	7	4.105	3.500	4.350
728	SAD ATC EQUIP SHOP	21JUN84	6	4.527	3.549	6.300
729	HRD TANK INST FAC-M1	21JUN84	12	3.516	2.660	4.200
730	HRD ENERGY MONITOR CTRL	25JUN84	10	2.218	1.161	3.600
731	SAD EDUCATION CTR	27MAR84	11	3.914	3.463	5.200
732	SWD TRAINEE BARRACKS	05APR84	12	21.919	17.091	23.000
733	HRD ELEC SUBSTATION	18APR84	9	1.066	0.860	1.400
734	SPD BRIGADE HQ	25APR84	11	0.938	0.786	1.500
735	SWD VEHICLE/TEAM CBT RG	24MAY84	7	2.524	2.663	3.350

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM	GOV-	LOW-	PRO-
			BID	EST	BID	GAMT
736	NAD PHYS FITNESS CTR	05JUN84	5	1.545	1.607	1.500
737	OHR RENOV BRIDGE	14JUN84	6	3.000	2.527	4.500
738	NAD ALTER BLDG #1	22SEP83	12	0.804	0.469	0.532
739	EUR TEST EQUIP PWR SPLY	22SEP83	5	0.145	0.120	0.219
740	MPD RANGE SUPPORT BLDG	26SEP83	9	0.420	0.397	0.473
741	MPD MACHINEGUN RANGE	26SEP83	2	0.890	0.872	0.842
742	SPD AVIATION LAB FAC	28SEP83	2	0.551	0.425	0.460
743	MPD SOCOM BARRACKS/AD	06OCT83	5	0.445	0.407	0.495
744	MPD UPGRD HOSPITAL	25OCT83	4	0.475	0.528	0.510
745	EUR UPGRD ELEC DIST SYS	08NOV83	10	0.235	0.210	0.477
746	SWD ELEC MAINT SHOP ADD	15NOV83	11	0.209	0.158	0.229
747	EUR TRNG BLDGS	15NOV83	11	0.436	0.383	0.622
748	SWD MAINT FAC MG RANGE	16NOV83	8	0.848	0.778	0.346
749	SWD ADAT ELEC EQUIP BLD	17NOV83	8	0.809	0.556	0.739
750	EUR READY BLDG	17NOV83	16	0.386	0.290	0.577
751	EUR SIGNAL INTELL	07DEC83	3	0.297	0.243	0.319
752	EUR EXT/INT LIGHTING	15DEC83	8	0.195	0.143	0.229
753	MRD COLD STRG WARE	28DEC83	5	0.429	0.393	0.549
754	SWD SENSITIVE INFO FAC	04JAN84	8	0.468	0.388	0.544
755	SAD AUTOMATED TNG CMD	05JAN84	8	0.241	0.275	0.250
756	SAD UPGRD ARR/DEP AFLD	17JAN84	2	0.732	0.812	0.806
757	EUR COAL HTG PLT	24JAN84	9	0.860	0.889	0.996
758	OHR REHAB APPLIED INST	25JAN84	22	0.884	0.555	0.957
759	EUR MTR MAINT SHOP	08FEB84	8	0.818	0.691	0.915
760	NAD EXP MOBIL SPT FAC	14FEB84	8	0.479	0.505	0.547
761	NAD ACRFT OPT CALIB LAB	16FEB84	14	0.697	0.599	0.587
762	EUR MCU HDST SUPPLY	28FEB84	8	0.340	0.334	0.422
763	MRD TRACKED VEH WASHBAC	12MAR84	6	0.520	0.460	0.637
764	SAD RELOCATE USABN	15MAR84	5	0.908	0.954	0.968
765	SPD ACADEMIC BLDG	27MAR84	9	0.767	0.658	0.970
766	EUR MAINT HGR ADDITION	05APR84	7	0.396	0.378	0.702
767	NAD FIRE PROTECTION SYS	25APR84	6	0.231	0.105	0.470
768	NAD FIRE STATION	25APR84	4	0.527	0.523	0.643
769	NAD TMDE CALIB/RPR FAC	26APR84	5	0.383	0.337	0.342
770	EUR SECURITY FENCE	09MAY84	8	0.186	0.181	0.446
771	SWD SECURITY PARK/AREA	22MAY84	6	0.298	0.271	0.400
772	SWD TOXIC CHEM MAINT PA	31MAY84	5	0.474	0.381	0.568
773	SAD CALIB/REPAIR FAC	05JUN84	6	0.376	0.316	0.269
774	SWD ITC EXPANSION FAC	13JUN84	3	0.753	0.610	0.738
775	NAD DASJ TRNG FAC	26JUN84	4	0.378	0.343	0.294
776	EUR PATRIOT IRP	22NOV83	6	0.205	0.142	0.288
777	SWD BINARY MUNITIONS	01DEC83	13	8.008	4.666	7.845
778	SWD CONTAIN HAZ WASTE	01DEC83	13	2.285	1.330	0.850
779	EUR EDUCATION FAC	07FEB84	13	0.324	0.307	0.514
780	MRD CORREC FAC MESS	22FEB84	6	4.289	4.011	5.400
781	EUR SECURE PARKING	17MAR84	17	1.678	1.393	4.039
782	NAD INSULATION WTRSEEP	24NOV83	8	0.153	0.146	0.250
783	SAD WPNS MAINT TRNG FAC	28DEC83	0	0.952	0.966	1.100
784	NAD WATER WELLS	02FEB84	0	3.485	3.485	3.900

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC	DESCRIP	DATE	NUM	GOV-	LOW-	PRO-
			BID	EST	BID	GAMI
785	OHR UN HQ & CLASSROOM	09FEB84	0	1.215	1.215	1.300
786	SAD INTELLIGENCE TRNG	16FEB84	0	0.959	0.959	1.200
787	NAD PHYSICAL FITNESS CN	21FEB84	0	1.578	1.578	1.800
788	OHR DINING FAC MOD	23FEB84	0	2.127	2.119	2.050
789	SAD CO ADMIN & SUPPLY	24FEB84	0	0.355	0.345	0.430
790	SWD REPLACE EXT LGHT	13MAR84	0	0.823	0.711	1.150
791	SPD UNACC OFFICER QTRS	14MAR84	0	5.900	5.800	5.400
792	NPD TEMP CONTROLS	14MAR84	0	1.492	1.473	1.450
793	SAD HARDSTAND	19APR84	0	0.263	0.293	0.370
794	OHR ENERGY EFFICIENT LT	20APR84	0	0.237	0.229	0.270
795	SAD CIDC FIELD OPER BLD	26APR84	0	2.060	2.122	2.600
796	SAD IRETS RANGES	30APR84	0	2.550	2.441	3.500
797	SPD FIRE STATION	10MAY84	0	0.902	0.831	0.850
798	MRD BULK FUEL STG FAC	29MAY84	0	2.937	2.925	3.000
799	SWD PHYSICAL FITNESS CN	31MAY84	0	0.306	0.305	0.310
800	SWD FIELD LIGHTING ECIP	25JUN84	0	0.644	0.671	0.700
801	POD COVERED STORAGE	20DEC83	0	0.434	0.341	0.630
802	POD CO ADMIN SUPPLY	20DEC83	0	0.374	0.339	0.450
803	POD COMMO/ELECT MAINT	20DEC83	0	0.170	0.152	0.200
804	POD A/C LIBRARY	26JAN84	0	0.330	0.225	0.620
805	POD PHYSICAL FITNESS CN	11FEB84	0	0.322	0.269	0.360
806	POD TACT EQUIP SHOP	16FEB84	0	0.554	0.480	0.610
807	POD CHAPEL/CKTY CTR	25FEB84	0	0.715	0.614	1.200
808	POD SECURITY LIGHTING	27FEB84	0	0.313	0.295	0.400
809	POD CO ADMIN & SUPPLY	27FEB84	0	0.423	0.363	0.470
810	POD GEN PURP AUDIT	28FEB84	0	0.459	0.435	0.690
811	POD PHYSICAL FITNESS CN	14MAR84	0	1.212	1.205	1.550
812	POD TACT EQUIP SHOP	14MAR84	0	4.043	3.407	4.750
813	POD TECH SUPPLY FAC	19MAR84	0	1.047	0.888	1.650
814	POD TACT EQUIP SHOP	21MAR84	0	0.322	0.333	1.000
815	POD PHYSICAL FITNESS CN	25APR84	0	1.517	1.410	1.950
816	POD GEN PURP AUDIT	25APR84	0	0.312	0.289	0.500
817	POD WAREHOUSE	05JUN84	0	0.635	0.558	0.750
818	POD TACT EQUIP SHOP	24JUN84	0	0.703	0.562	0.890
819	POD DIAG EQUIP FAC	31JAN83	0	0.393	0.334	0.449
820	POD TEST DIAGN EQUIP	02FEB84	0	0.307	0.271	0.336
821	POD TEST MEASUREMENT FA	15FEB84	0	0.374	0.333	0.417
822	POD UPGB HOSP POWER	15FEB84	0	0.742	0.671	0.846
823	POD TROOP AID STATION	22FEB84	0	0.626	0.495	0.863
824	POD TROOP AID STATION	22FEB84	0	0.726	0.539	0.905
825	POD AFKN RELAY TRANS	16MAY84	0	0.361	0.357	0.452
826	EUR FAC MODERNIZATION	14JUN84	0	0.250	0.210	0.315
827	NAD INTER-ARER COLL MOD	18JUN84	0	0.825	0.849	0.769

APPENDIX B

SINUSOIDAL FUNCTION

The sinusoidal function takes the general form:

$$Y = A + (B \cdot \sin(C \cdot X + D)) \quad (B.1)$$

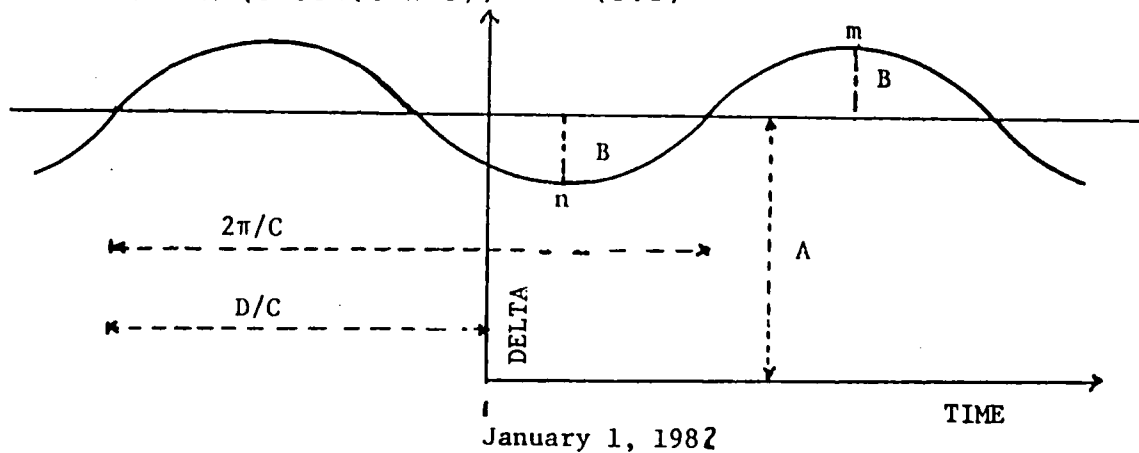


Figure B.1: General Sinusoidal Function

Where:

A = The shift above or below the X-axis.

B = The amplitude of the sinusoidal wave. The maximum variation of the wave function, above or below the mean value.

$2\pi/C$ = Cycle length of wave. In our case cycle length equals 1 year, so $2\pi/C = 1$ year, therefore, $C = 2\pi$.

D/C = Phase shift of the wave. In our case in time units of years.

A normal sine function has values for the variables:

$$A = 0;$$

$$B = 1;$$

$$C = 1; \text{ and}$$

$$D = 0.$$

This reduces the general sinusoidal function to: $Y = \sin X$, with an amplitude of 1, and a cycle length of 2π . This function is shown on Figure B-2. The addition of a phase shift of $D = \pi/2$ changes the equation to $Y = \sin(X + \pi/2)$. This causes the function to shift to the left of the origin by $\pi/2$ units, as shown on Figure B-3. Similarly, the subtraction of $D = \pi/2$ will cause the function to shift to the right by $\pi/2$ units, as shown on Figure B-4. Changes in the C parameter will cause the period of the function to increase or decrease. Setting $C = 2$ will half the cycle length. $2\pi/C = \text{cycle length}$ with $C = 2$ yields cycle length = π . This is shown on Figure B-5. Setting $C = 1/2$ will double the cycle length, $2\pi/.5 = 4\pi$ for a cycle length. This is shown on Figure B-6. Changes in the B parameter will cause the amplitude of the function to increase or decrease. Setting $B = 2$, will cause the function to double it's amplitude. This is shown on Figure B-7. Setting $B = 1/2$, will cause the function to half the amplitude of the function. This is shown on Figure B-8.

By varying the three parameters of the sinusoidal function, it is possible to fit the sinusoidal function to the data for seasonal model. In the analysis performed in this thesis, the cycle length was set to one year initially, as previous research indicated that an annual cycle was appropriate to the data. PROC NLIN (Non-Linear model fitting) was used to find estimates for amplitude, B, and phase shift, D/C.

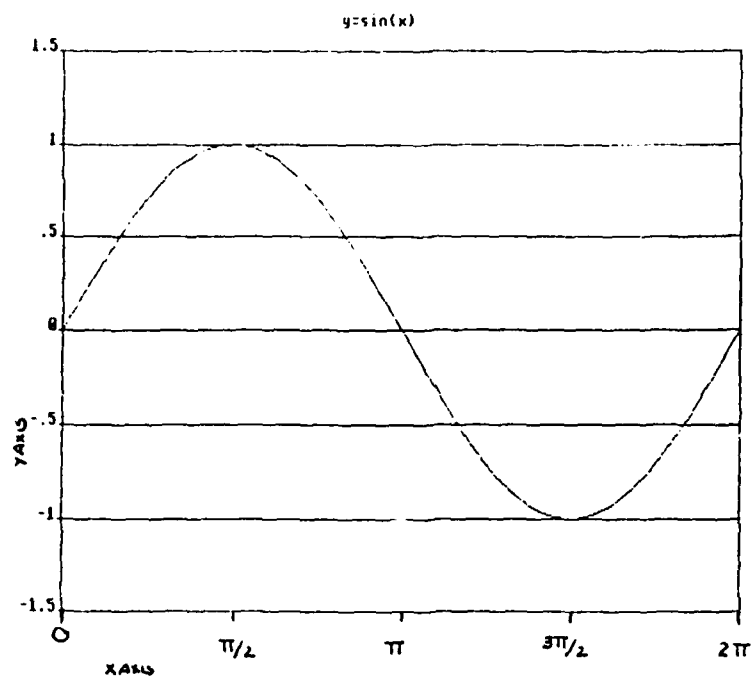


FIGURE B.2: $Y = \sin(X)$

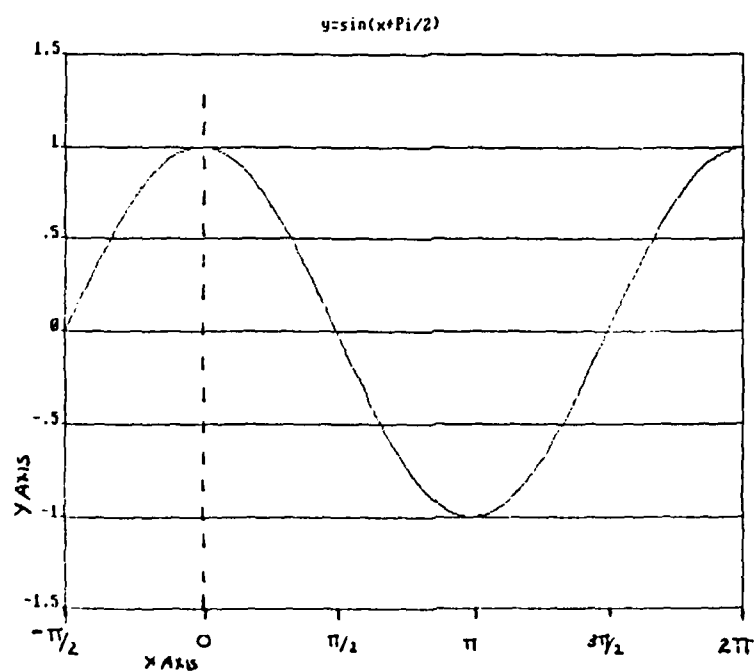


FIGURE B.3: $Y = \sin(X + D)$

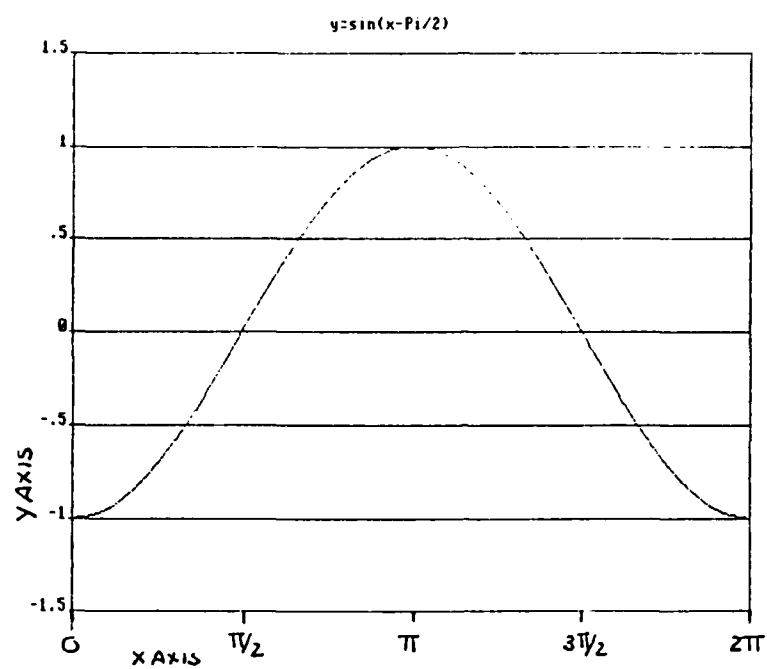


FIGURE B.4: $Y = \sin(X - D)$

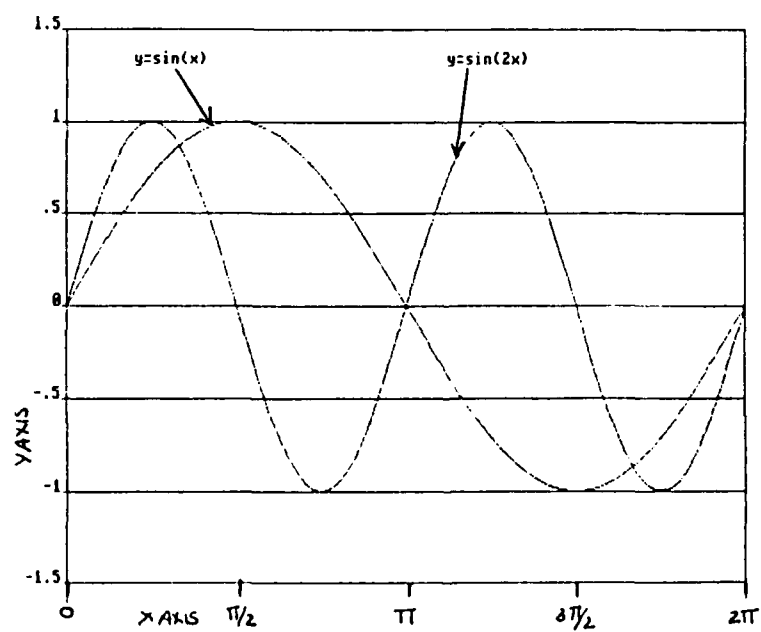


FIGURE B.5: $Y = \sin(2 \cdot X)$

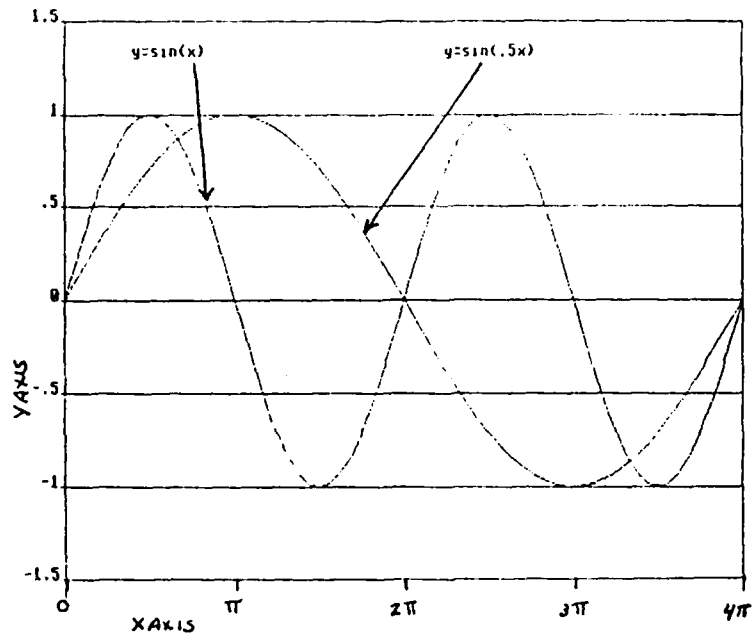


FIGURE B.6: $Y=\sin(.5 \cdot X)$

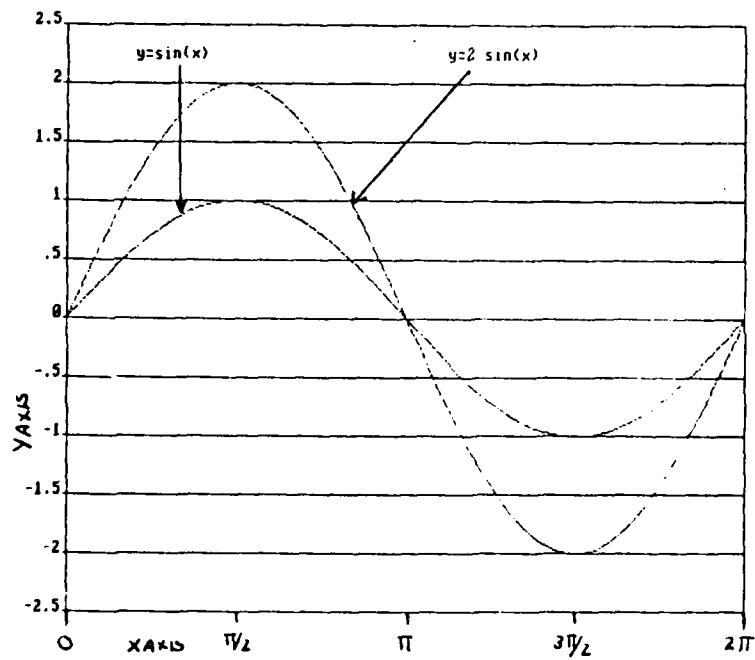


FIGURE B.7: $Y=2 \cdot \sin(X)$

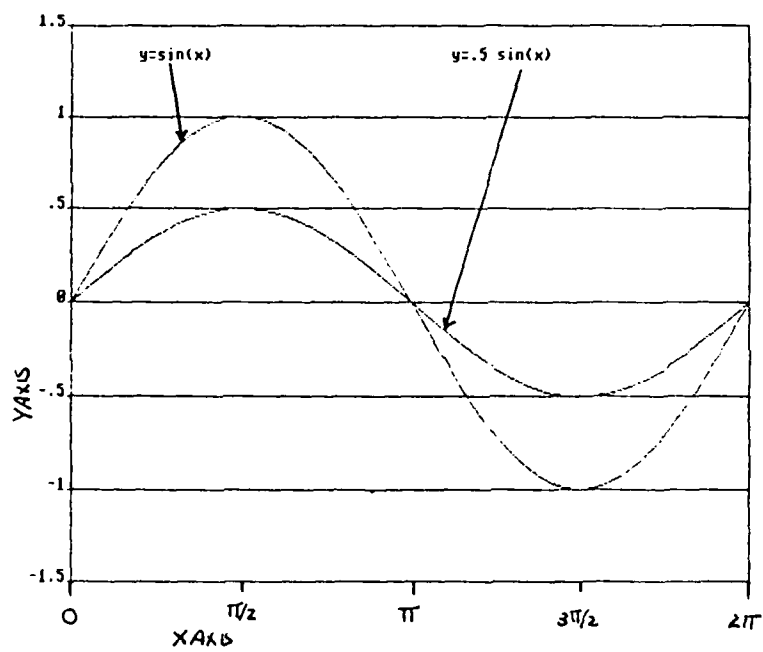


FIGURE B.8: $Y = .5 * \sin(X)$

APPENDIX C

PROGRESSIVE MODEL BUILDING

The method of progressive model building was used in this study. This method involves building a model, obtaining residual error terms from that model, building a model to explain these residuals, obtaining a next set of error terms, and so on until no further models are appropriate in explanation of error. Once a final model is decided upon, all terms are put into one final model, and new values for the parameters are obtained, as well as a final set of residual error terms. This procedure is shown below in equations C.1 to C.3.

$$\text{DELTA} = A + (B * X) + \text{RESID1 (linear model)} \quad (\text{C.1})$$

$$\text{RESID1} = C + (D * \text{SIN}(\text{TIME})) + \text{RESID2 (seasonal model)} \quad (\text{C.2})$$

$$\text{RESID2} = E + (F * (X ** 3)) + \text{RESID3 (other appropriate model)} \quad (\text{C.3})$$

The final Model with Revised Parameter Estimates is given in equation C.4.

$$\text{DELTA} = A1 + (B1 * X) + (D1 * \text{SIN}(\text{TIME})) + (F1 * (X ** 3)) + \text{RESID31} \quad (\text{C.4})$$

APPENDIX D
CUMULATIVE DENSITY FUNCTION

This is a relatively simple method to construct a cumulative distribution for data.

1. Calculate your response variable, in this case DELTA or DELTA1. Sort the variable from lowest value to highest value.
2. Number each observation, $I=1, 2, 3, \dots, N$.
3. Create the variable $PROB=(I-.5)/N$.
4. Plot PROB on the Y-Axis and DELTA on the X-Axis.

Figure D.1 was produced by this method. The cumulative distribution is then overlaid the R/S distribution, as shown in Figure D.2. This method is described by Larew in his text (3) and further studied by Ricer (6).

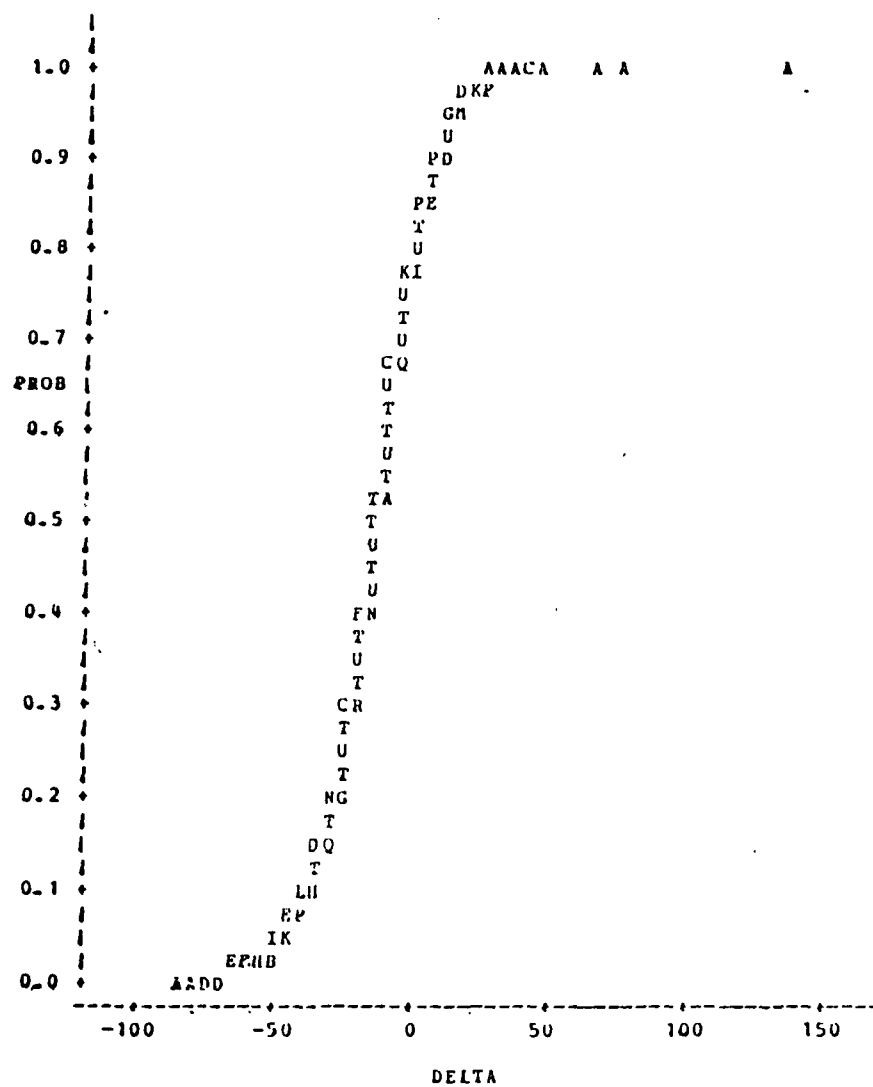


FIGURE D.1: Rank Ordered DELTA vs PROB

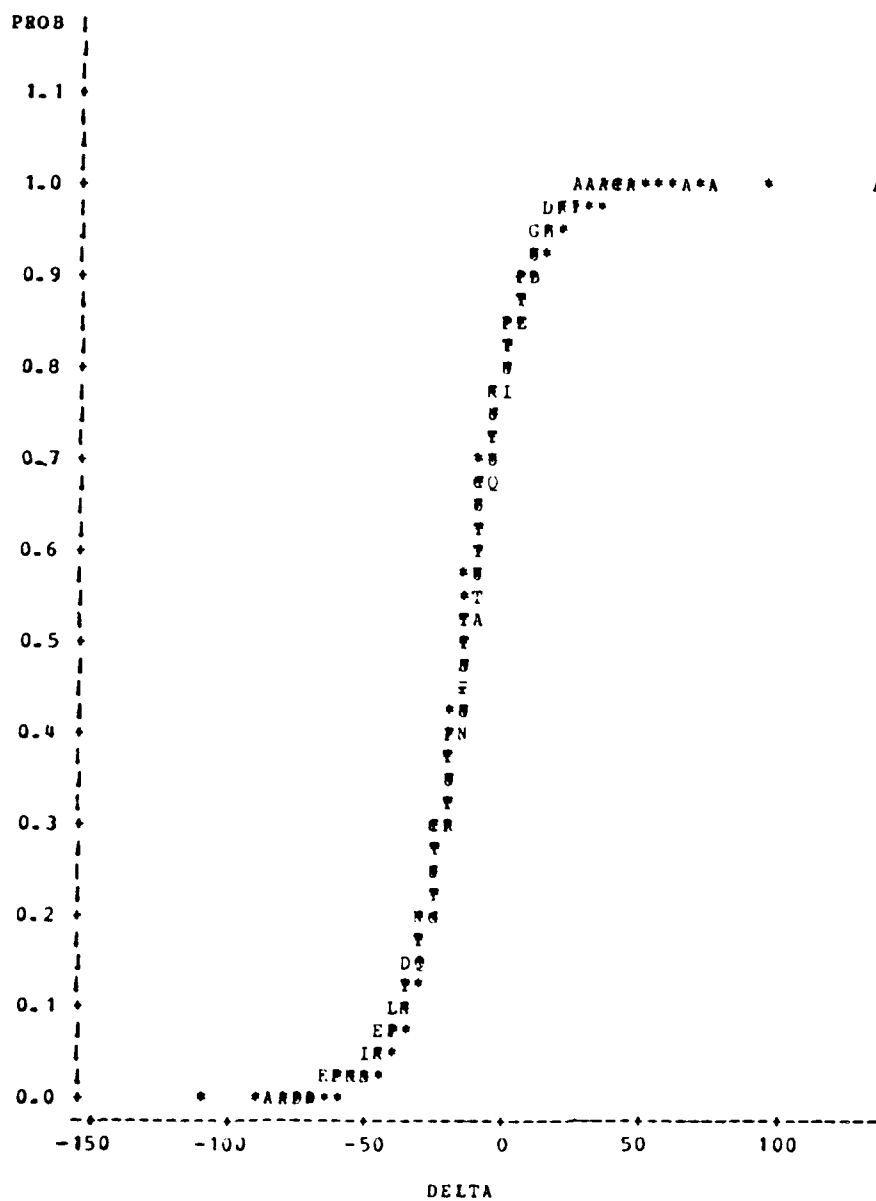


FIGURE D.2: Fitted Curve Overlay on Rank Ordered DELTA

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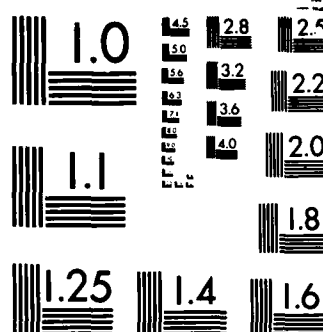
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APPENDIX E

CDF OF DIVISIONAL MODELS FOR DELTA AND DELTA1

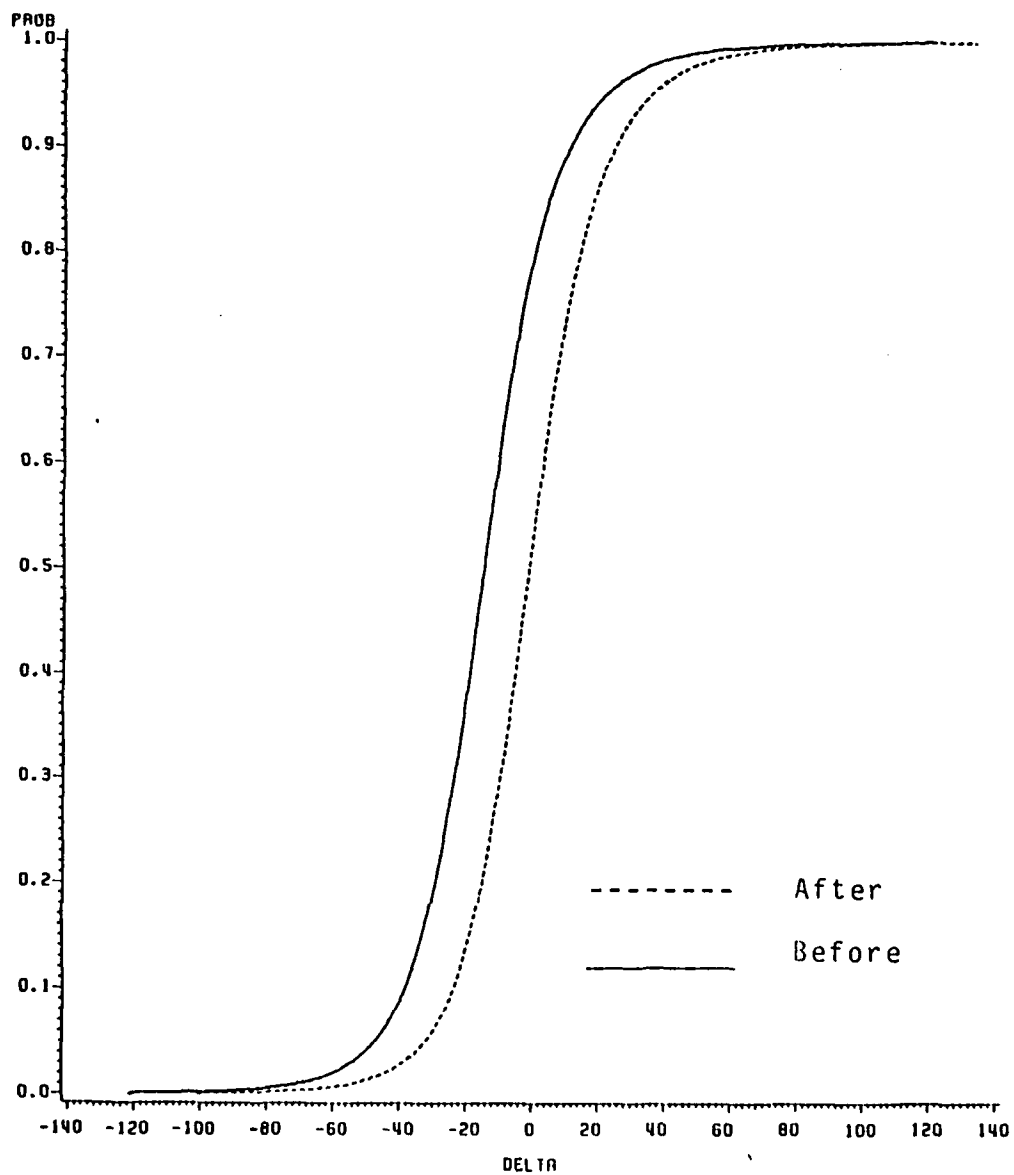


FIGURE E.1: DELTA Before and After Modeling--EUR

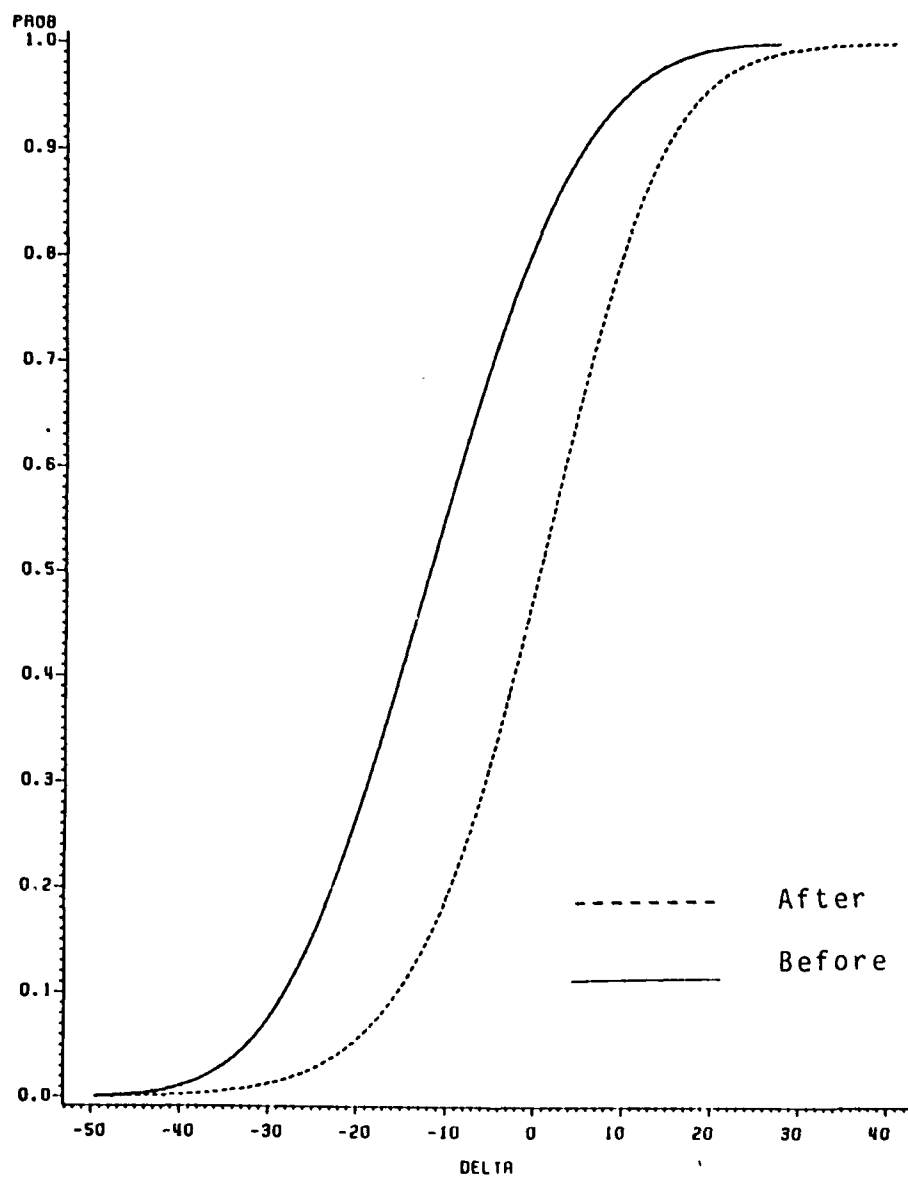


FIGURE E.2: DELTA Before and After Modeling--MRD

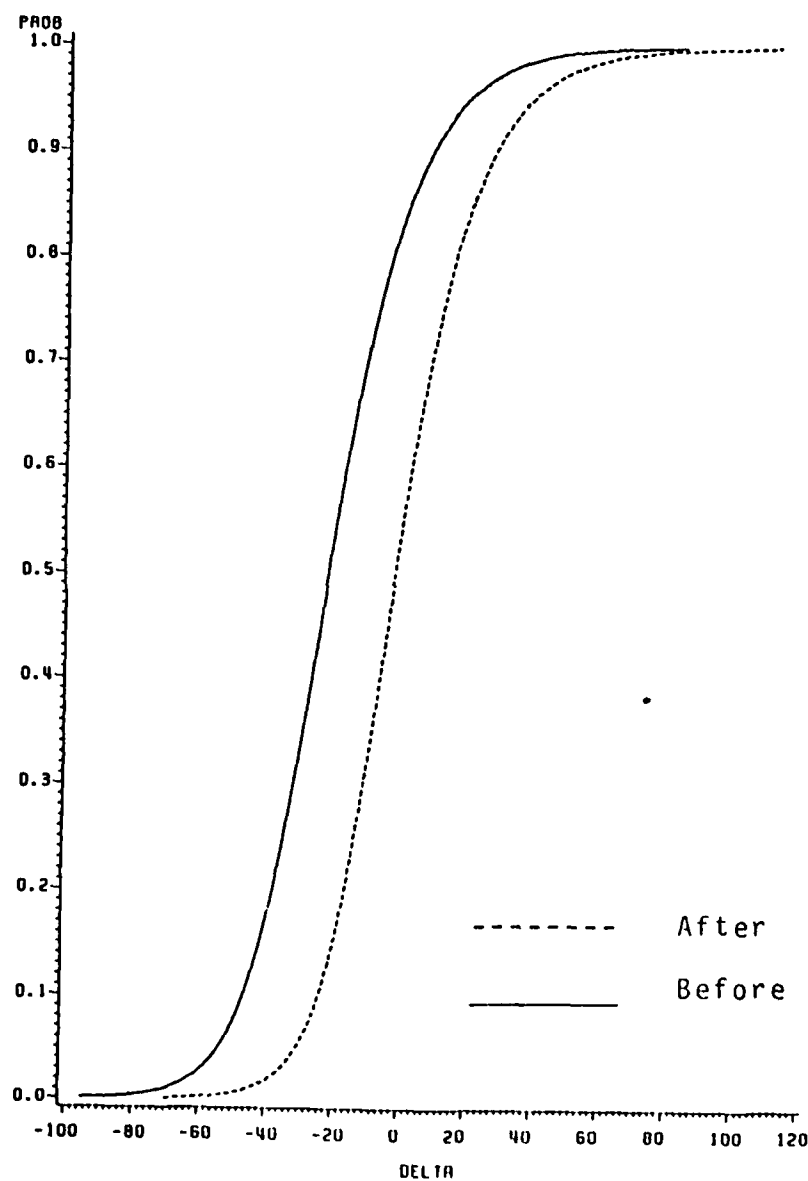


FIGURE E.3: DELTA Before and After Modeling--NAD

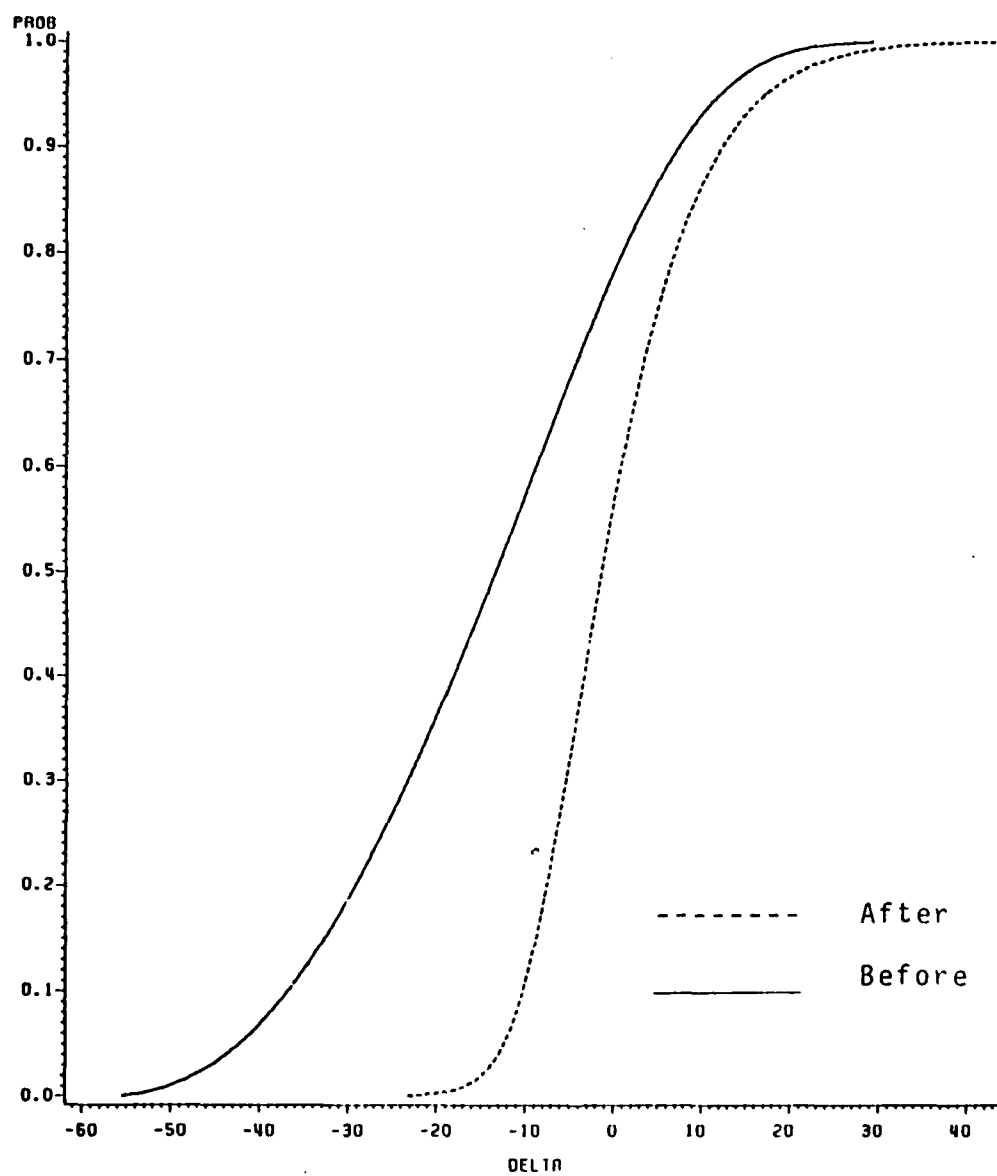


FIGURE E.4: DELTA Before and After Modeling--NPD

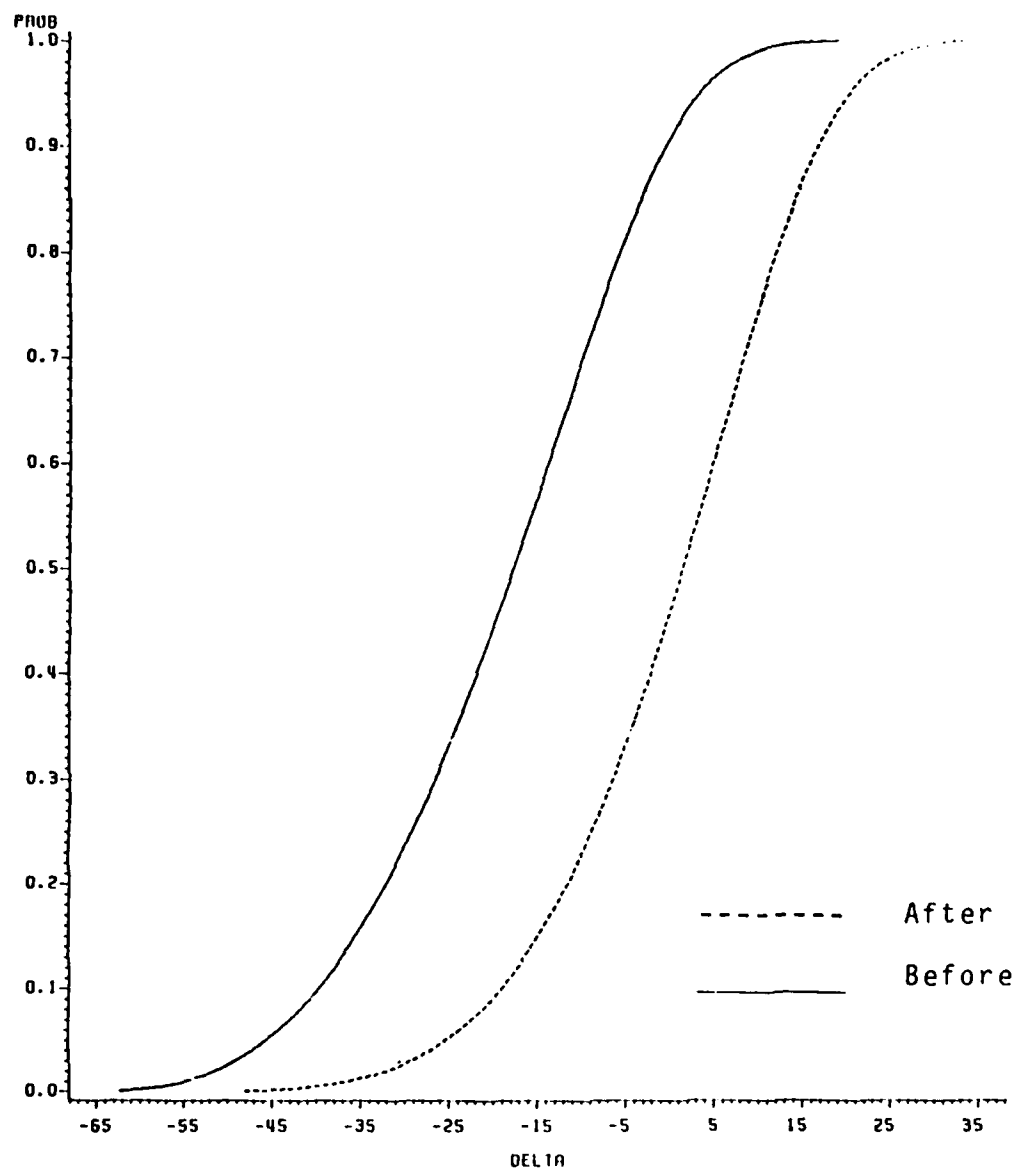


FIGURE E.5: DELTA Before and After Modeling--OHR

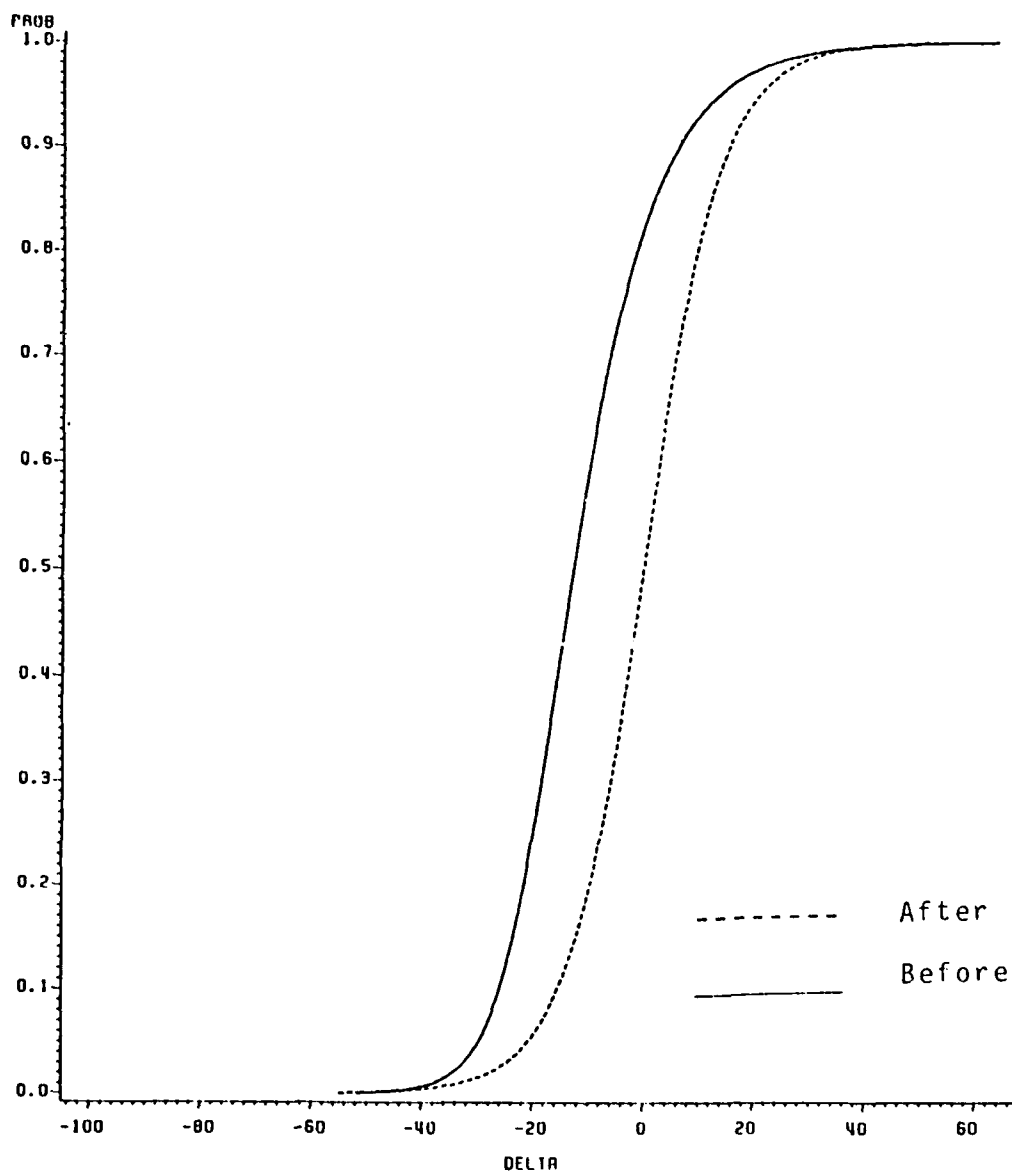


FIGURE E.6: DELTA Before and After Modeling--POD

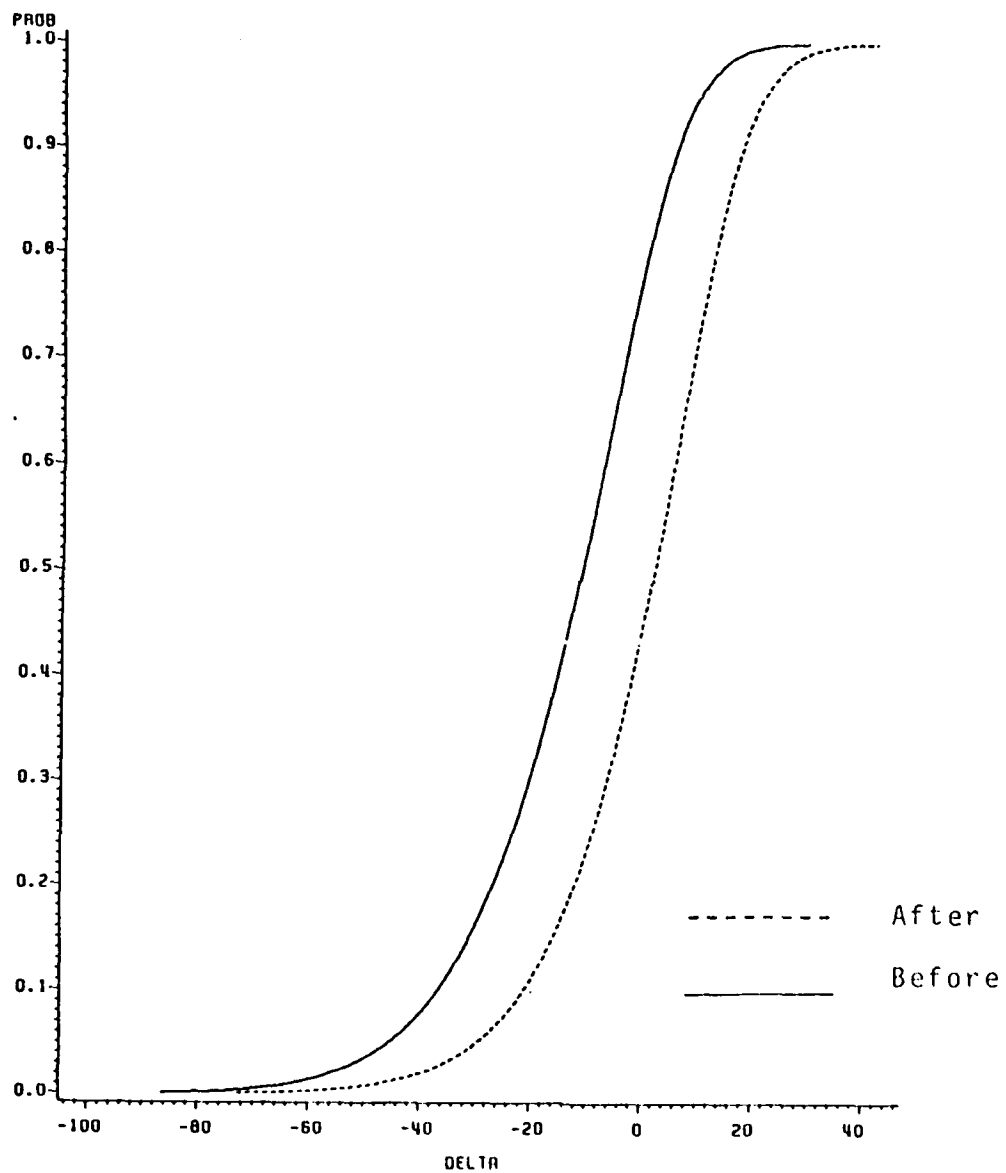


FIGURE E.7: DELTA Before and After Modeling--SAD

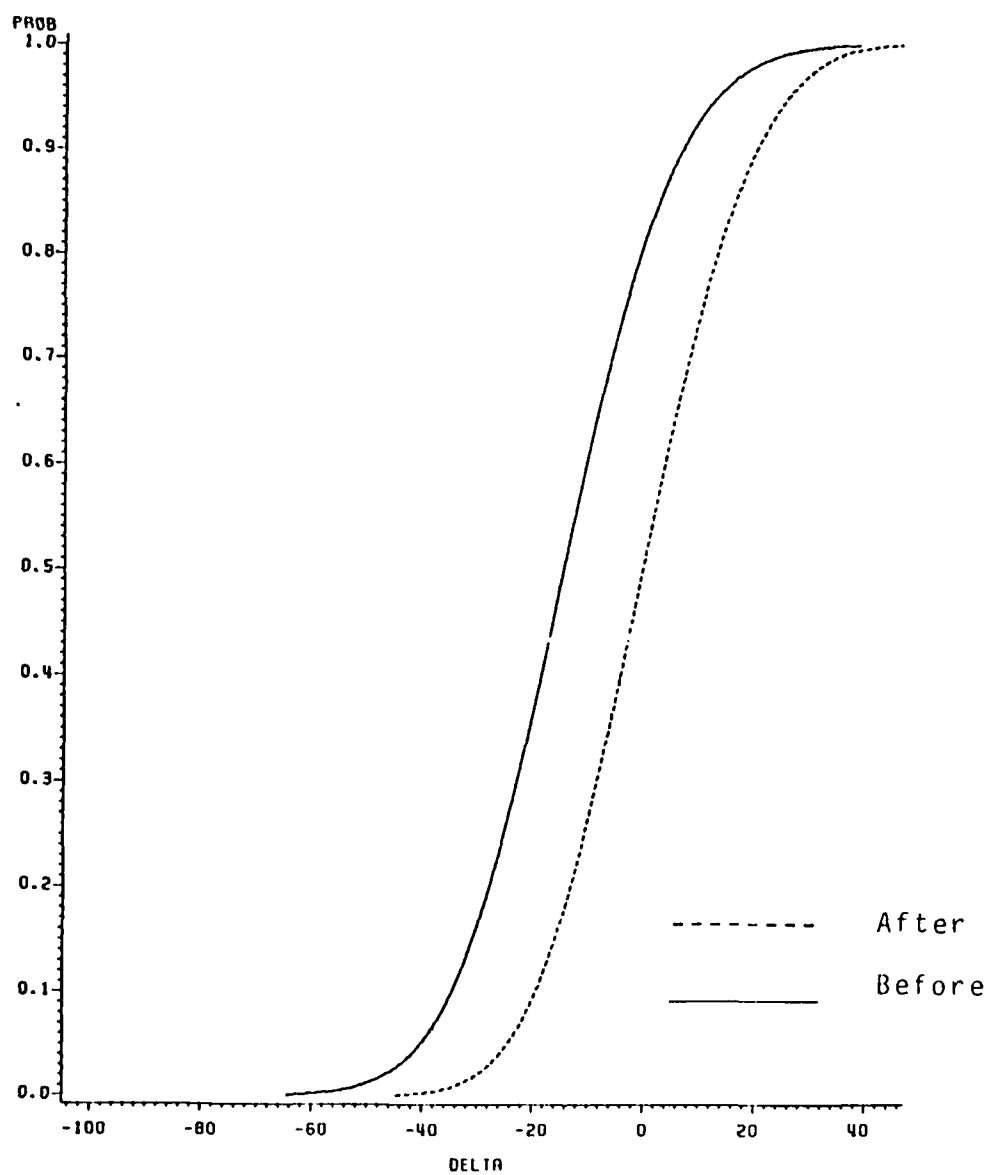


FIGURE E.8: DELTA Before and After Modeling--SPD

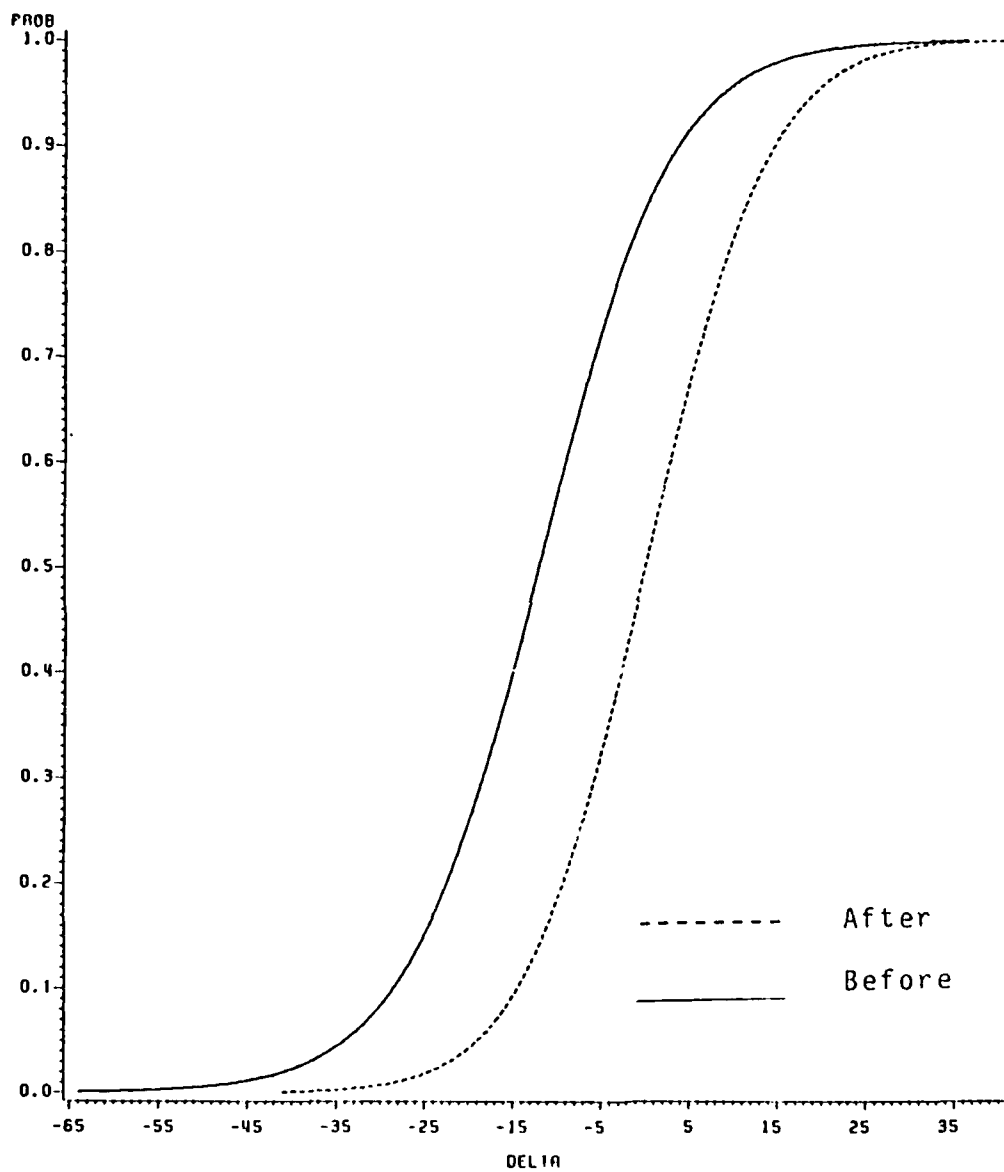


FIGURE E.9: DELTA Before and After Modeling--SWD

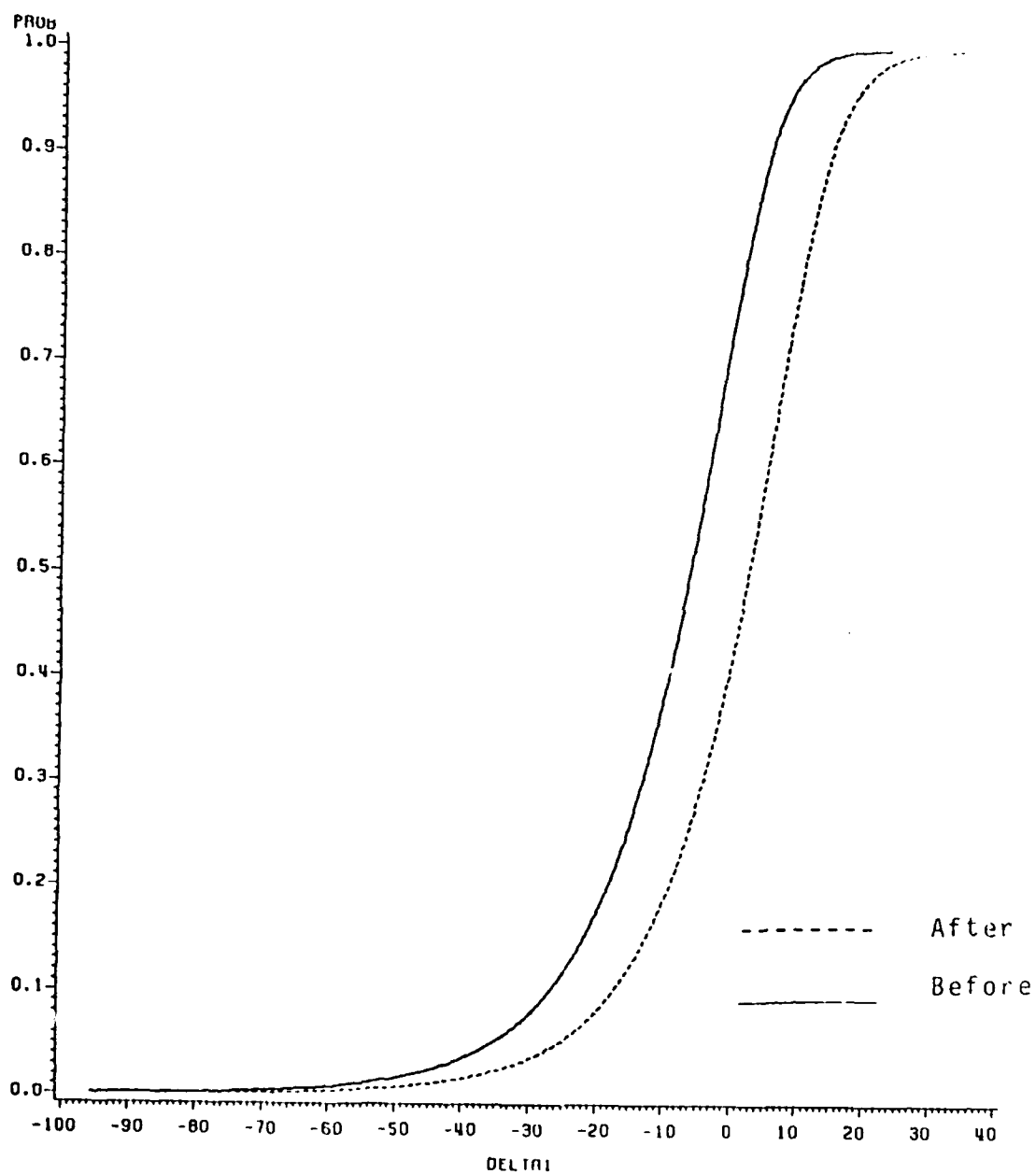


FIGURE E.10: DELTA1 Before and After Modeling--EUR

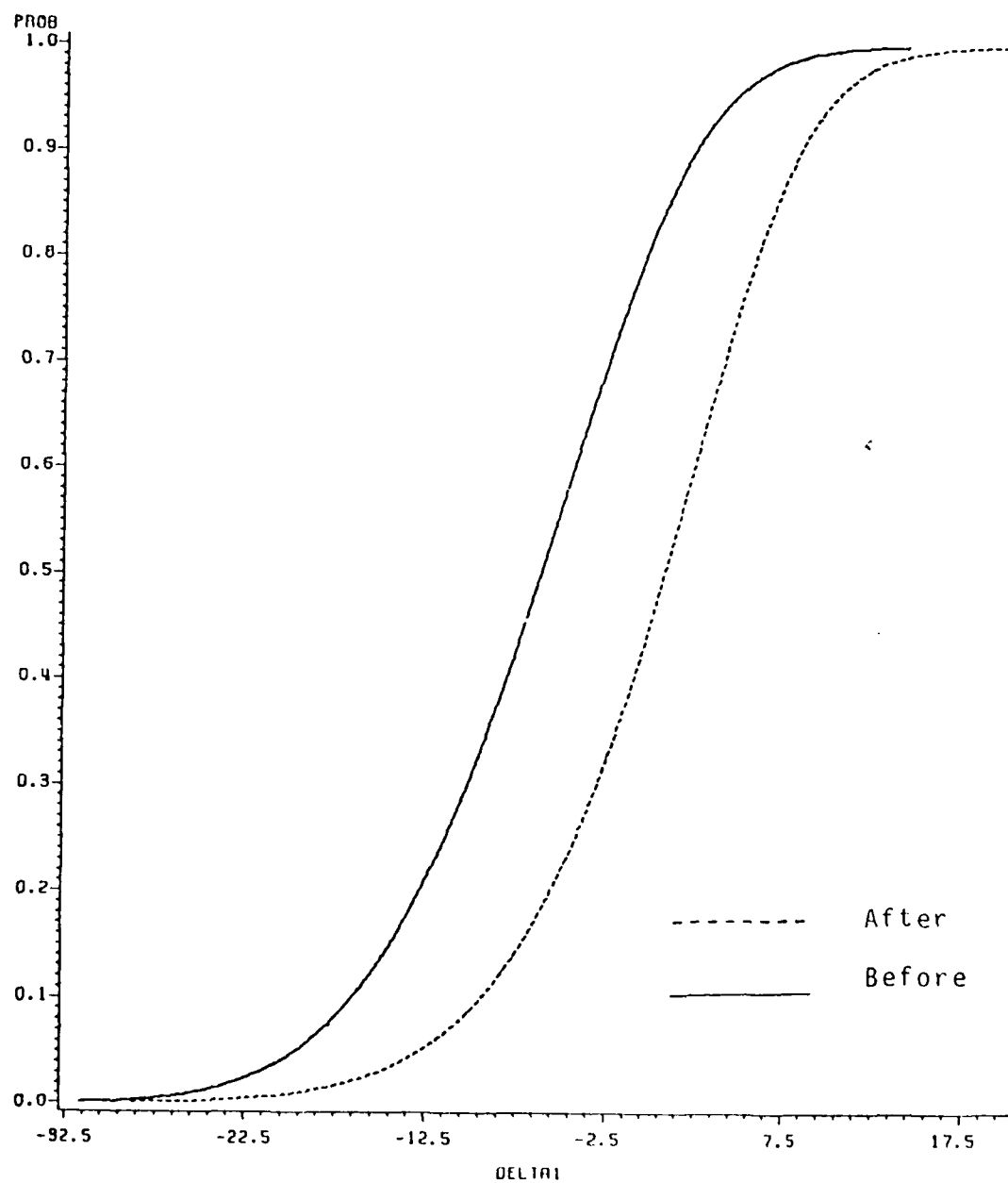


FIGURE E.11: DELTA1 Before and After Modeling--MRD

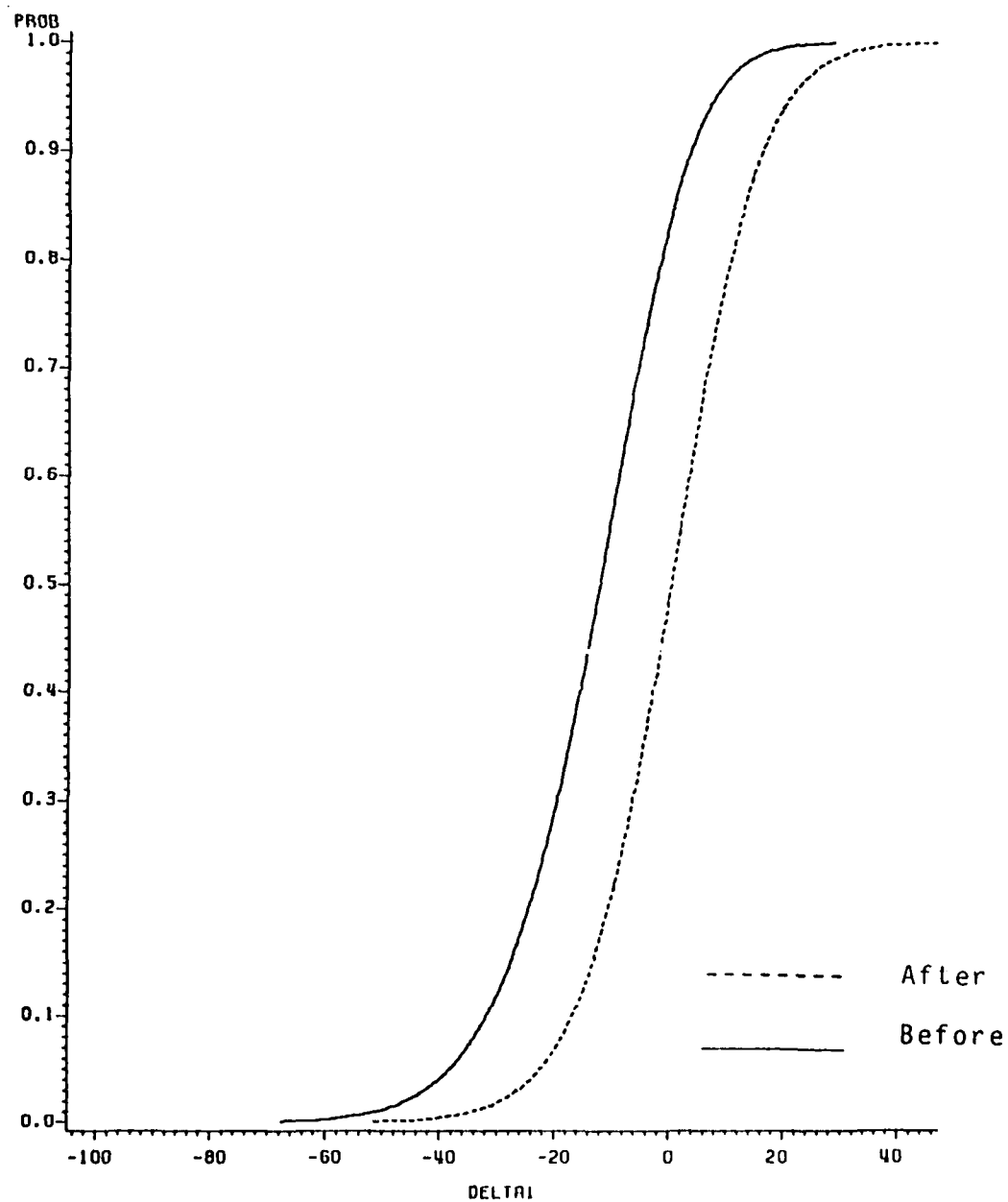


FIGURE E.12: DELTA1 Before and After Modeling--NAD

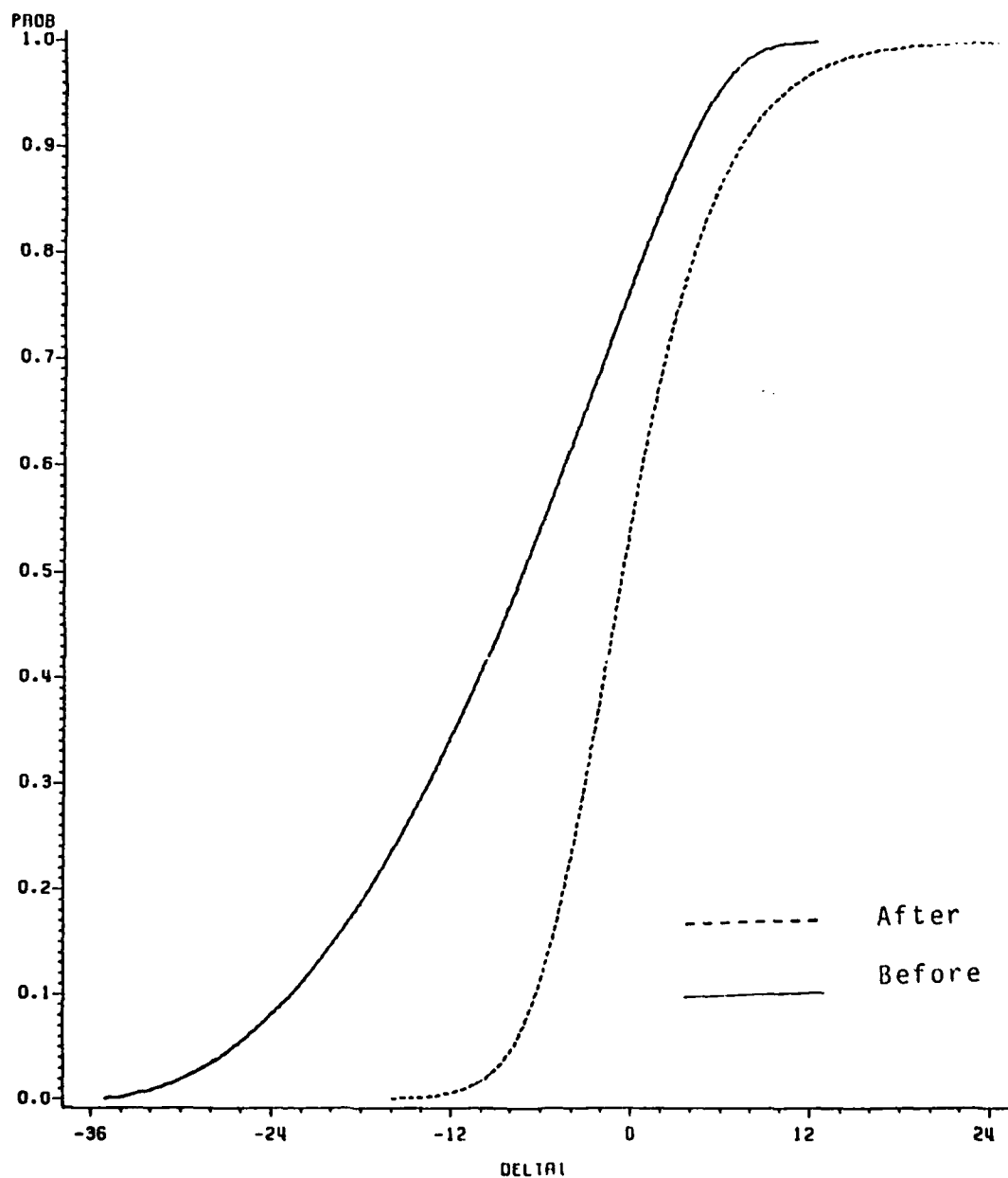


FIGURE E.13: DELTA1 Before and After Modeling--NPD

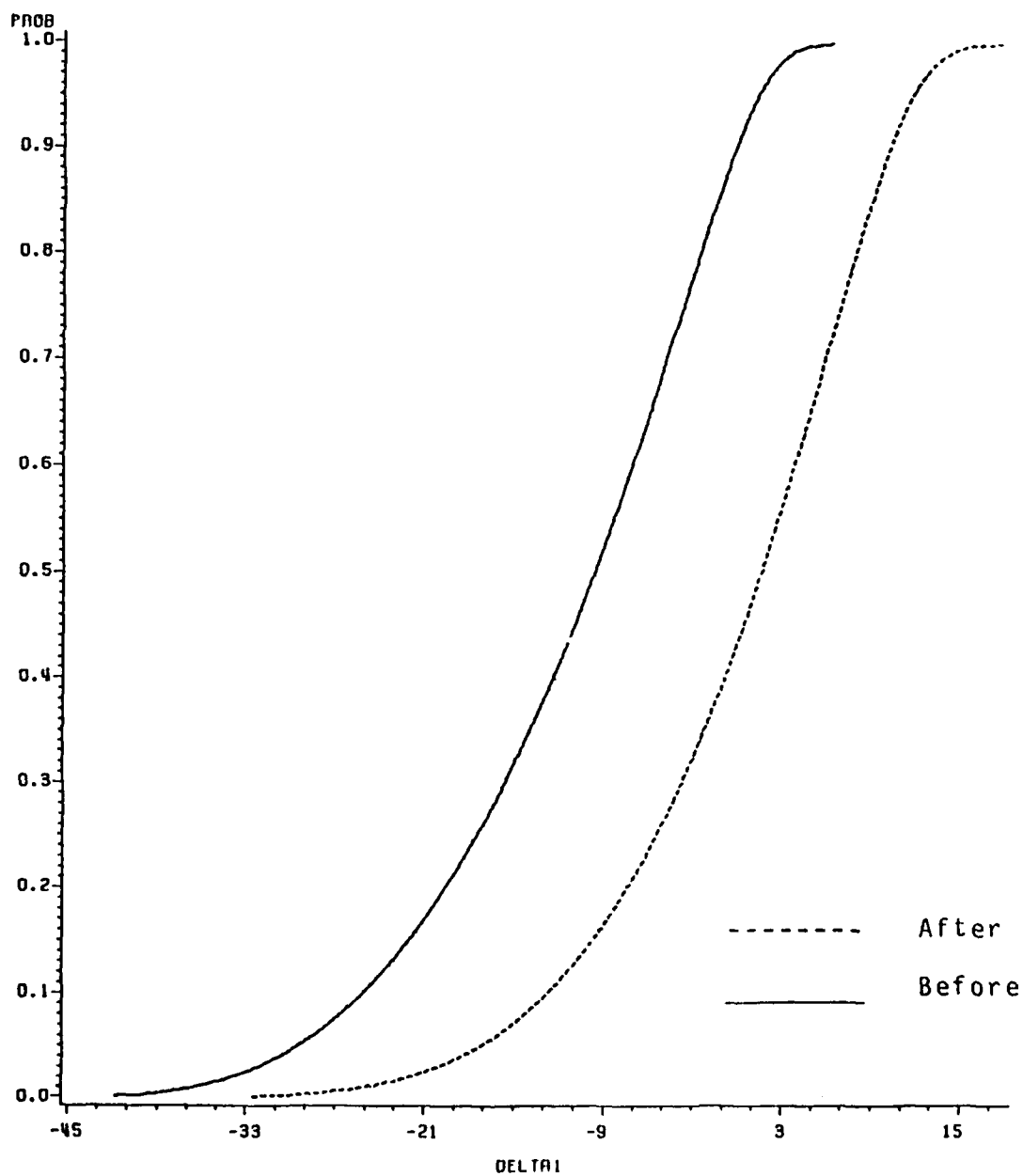


FIGURE E.14: DELTA1 Before and After Modeling--OHR

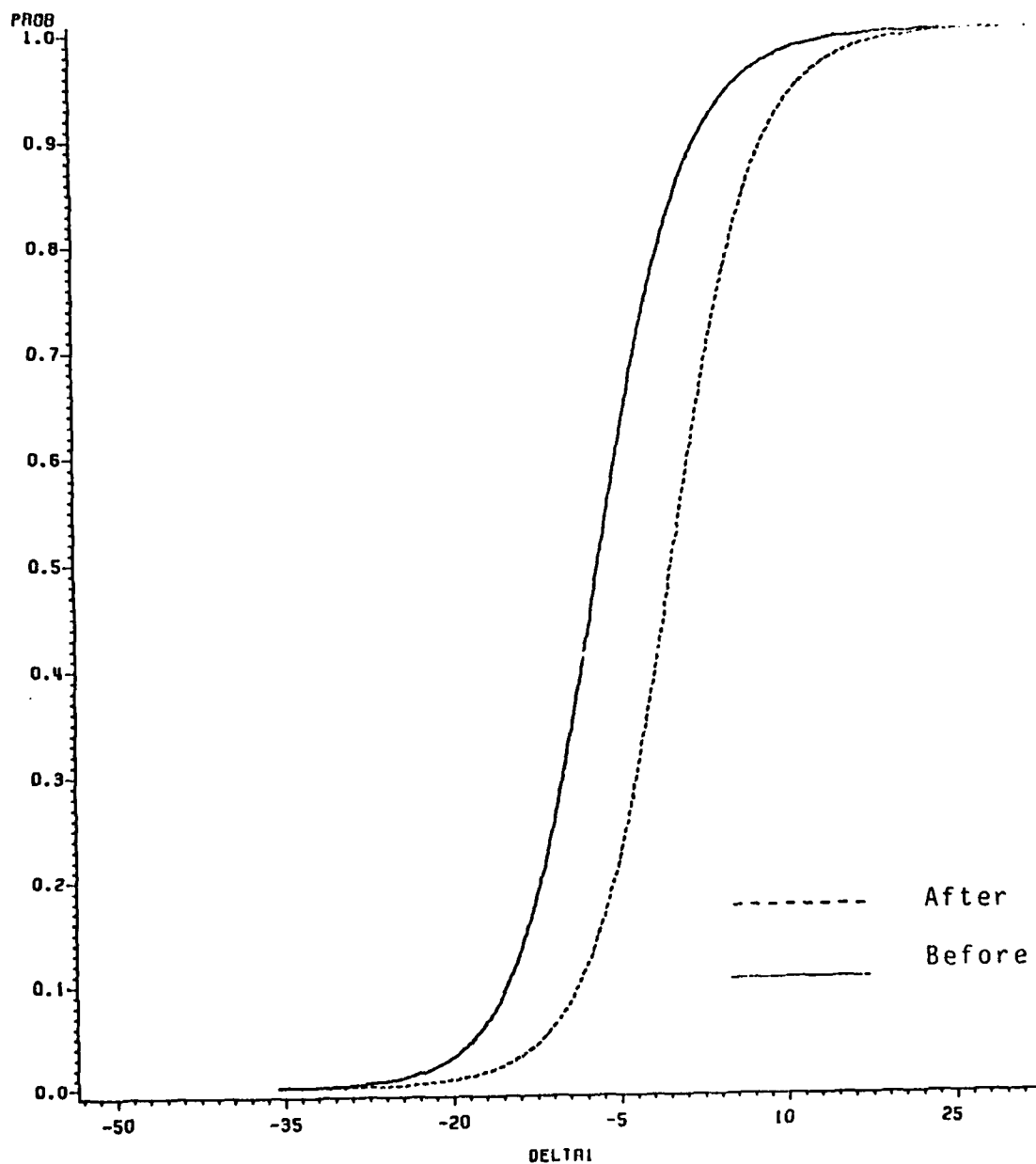


FIGURE E.15: DELTA1 Before and After Modeling--POD

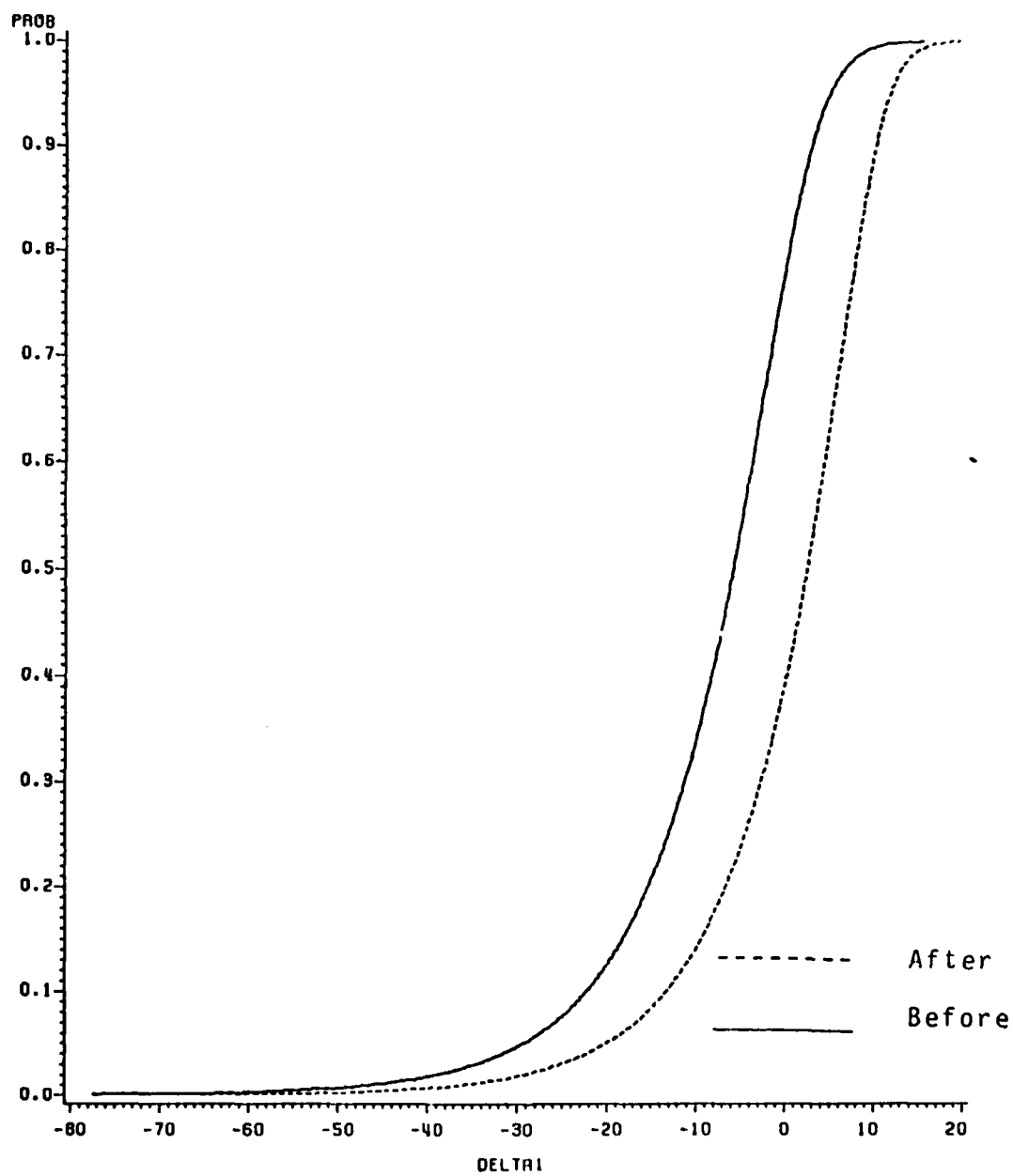


FIGURE E.16: DELTA1 Before and After Modeling--SAD

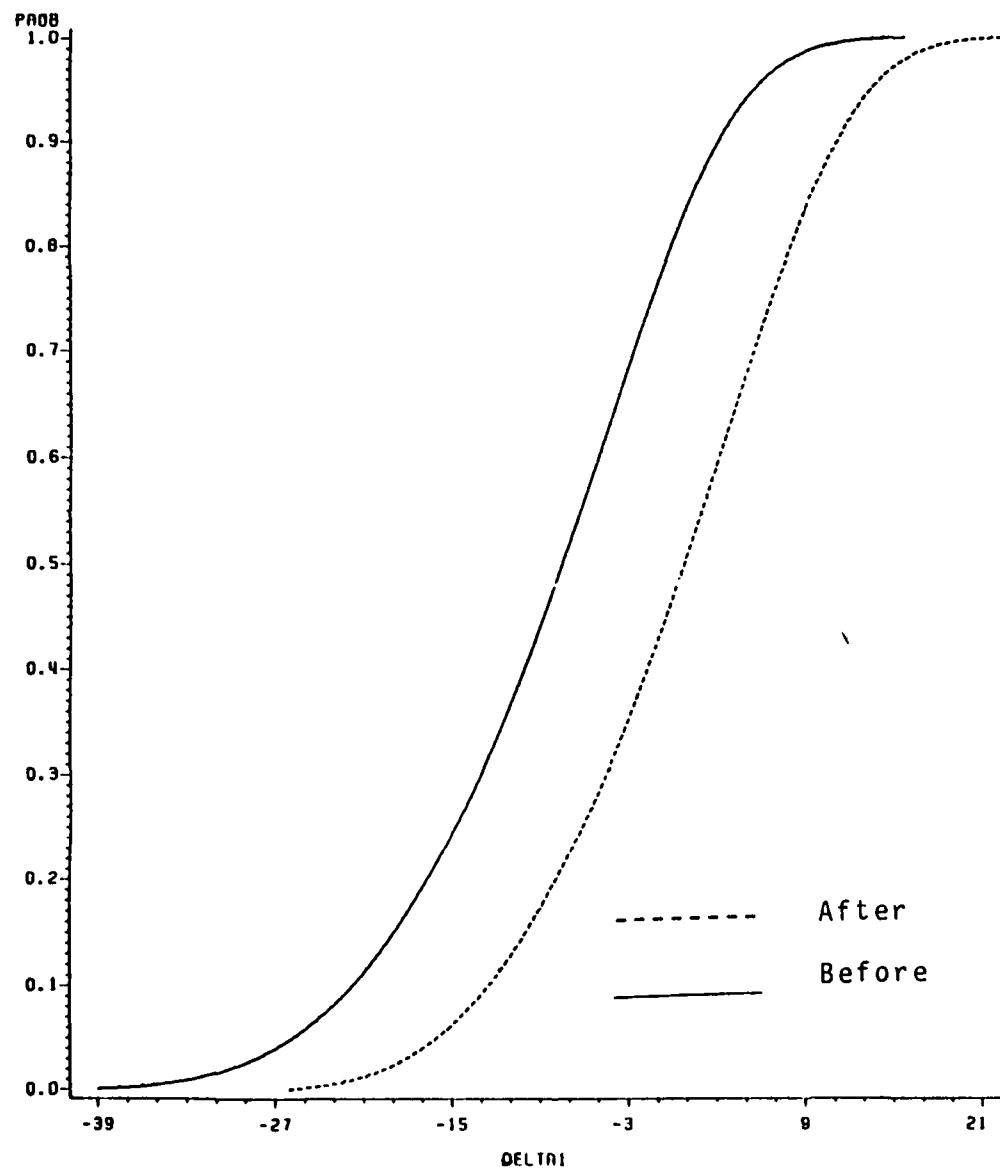


FIGURE E.17: DELTA1 Before and After Modeling--SPD

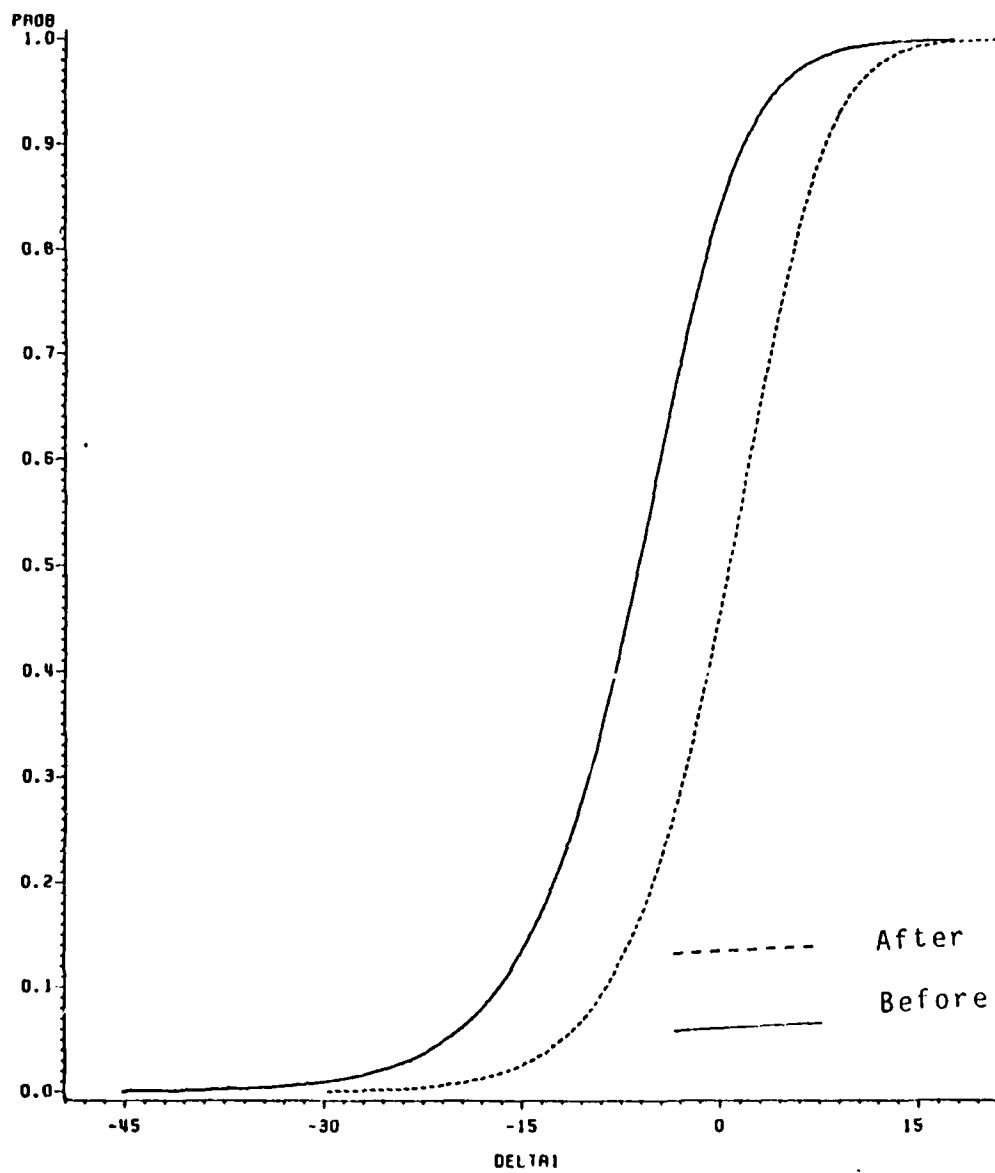


FIGURE E.18: DELTA1 Before and After Modeling--SWD

APPENDIX F

CDF OF POOLED RESIDUALS AND OVERALL MODEL

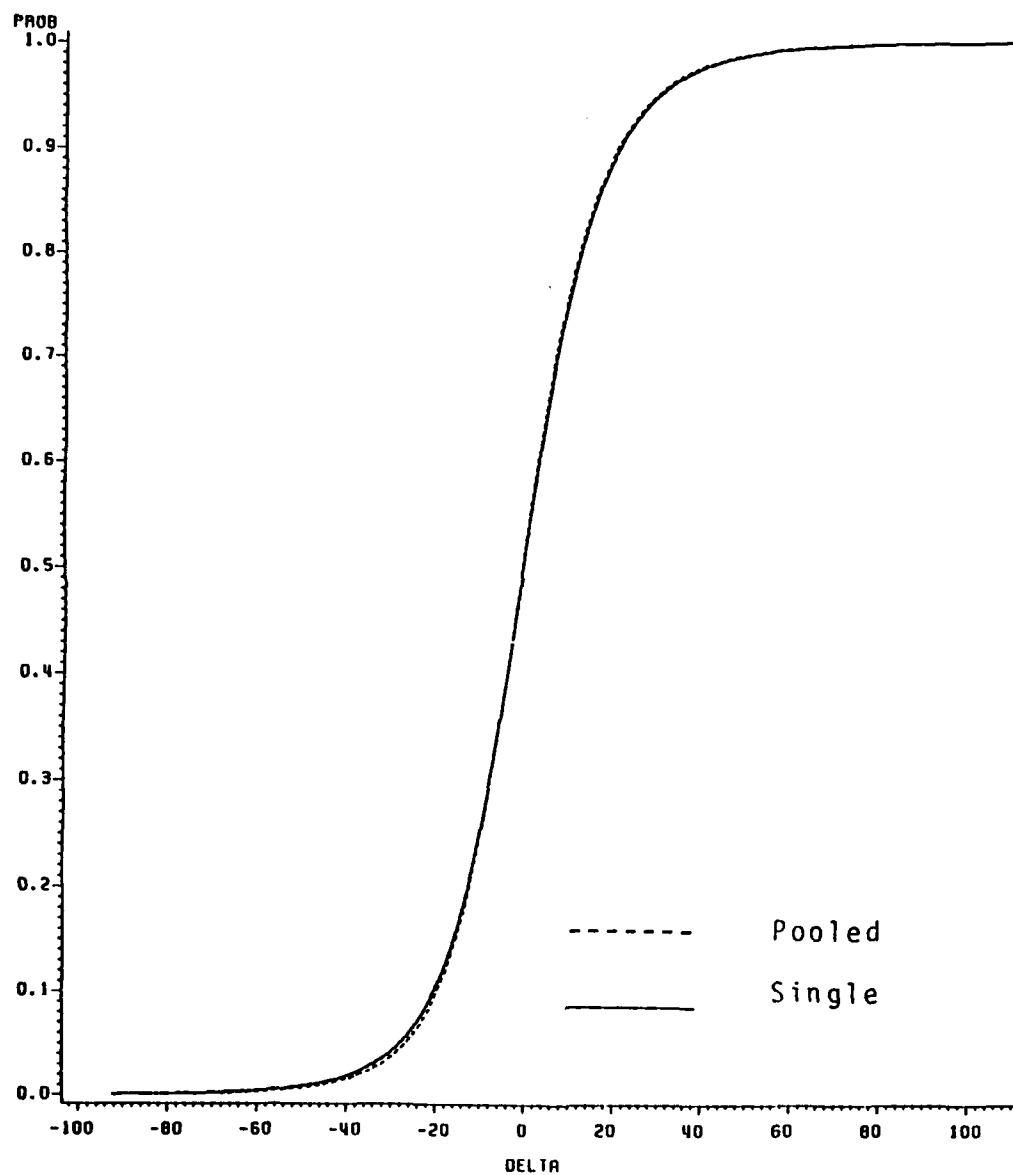


FIGURE F.1: Pooled Residuals and Overall Model--DELTA

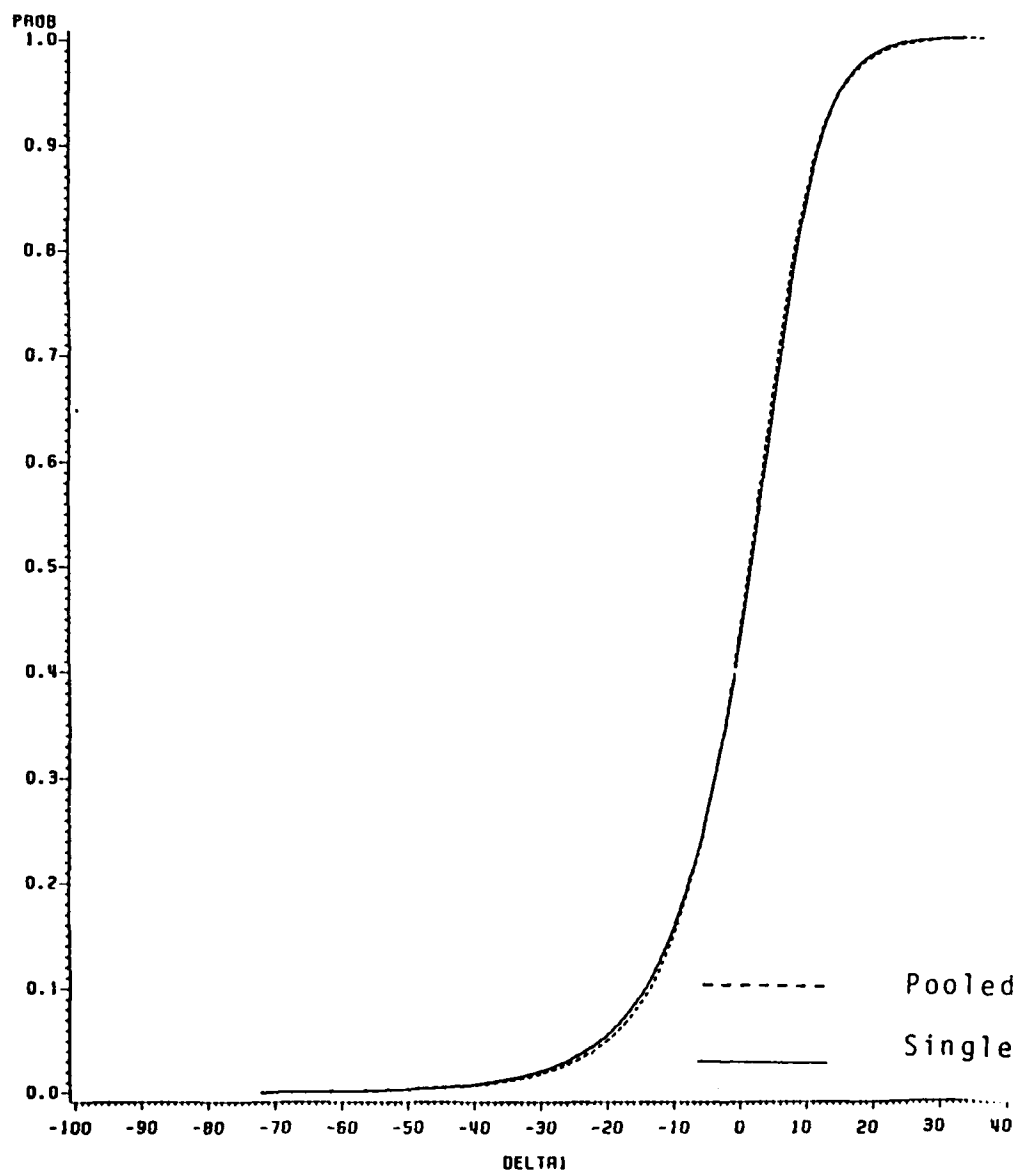


FIGURE F.2: Pooled Residuals and Overall Model--DELTA1

END

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