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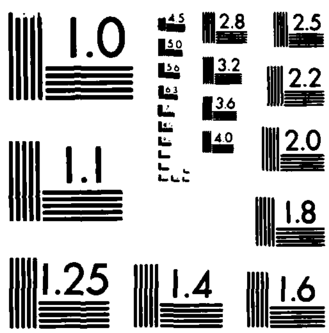
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Updated Development of Implicit Price
Deflators for Military Construction

by

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and
John F. Reimer, HQ. US Army Corps of Engineers

Presented at the
19th Annual Department of Defense
Cost Analysis Symposium
Xerox Training Center
Leesburg, Virginia
September 17 - 20 1985

UPDATED DEVELOPMENT OF IMPLICIT PRICE
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A-1

QUALITY INSPECTED 1

The results of the initial development of price deflators for military contruction were published in the November 1983 issue of the Survey of Current Business.[2)] This paper describes the further development of the price deflators, the comparison with the Engineering News Record Construction Index (ENR), the comparison of input construction wages indexes and construction material price indexes with the Bureau of Economic Analysis (BEA) military construction deflator, and the uses of the deflators by the military constructors. Also, the development of output Area Cost Factors (ACF) is described.

The original article emphasized the problems inherent in developing adequate deflators for military construction on a put-in place basis. These are worth repeating because they are still applicable.[3)]

"Difficulties in the development of price indexes for military construction are exacerbated by the particulary rapid-even abrupt-changes in its composition by type of structure and by the lack of similarity between many military structures and structures built in the private sector."

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1. Mr. Reimer is Chairman of the Tri-Services Committee on Cost Engineering

2. Abner Sachs and Richard C. Ziemer, Implicit Price Deflators for Military Construction, Survey of Current Business, Volume 63, No. 11, Bureau of Economic Analysis, Washington, D.C. November 1983.

3. Ibid

It should be noted that the end use of these deflators has been reinforced over the past several years by their increasing accuracy due to the prompt receipt of the construction reports (DD813) and the greater coverage of these reports due to the efforts of the Corps of Engineers and the Naval Facilities Engineering Command. Greater coverage of the construction projects results in more reliable indexes.

Headway has been made in generating indexes which apply specifically to military construction in Korea and Germany. The Korean deflators are developed in the same manner as those for the continental United States (CONUS); those for Germany are based on German government indexes modified by the foreign exchange rates. The goal for the next year is to replace the German proxy index with the same type as that developed for CONUS.

The deflators reported in the original article were based on 1972=100. BEA is rebasing the entire GNP deflator and its components with indexes based on 1982=100. All deflators in this paper have a 1982 base. The rebasing was done by developing new base prices for every military construction category in the BEA files. The total number of category codes for which base prices have been calculated has risen from approximately 180 to approximately 215. This gives coverage to approximately 95-percent of the military construction projects.

When comparisons are made bewteen the output military construction index and the input ENR Index and the price indexes for construction labor and materials, the impacts of exogenous variables becomes apparent. Table 1 lists the BEA military construction deflators, the Bureau of Labor Statistics (BLS) Construction Materials Index, the construction hourly wages index, and the ENR index. These data are shown graphically on Figure 1, the comparison of the military construction deflator with the

Table 1
Selected Indexes (1982=100)

CYYQ	BEA Defla-tion	BLS Const MRS	Const. Hourly Wages	ENR
1972 - 1	39.49	43.11	51.15	45.41
2	39.86	43.90	51.32	46.47
3	41.95	44.34	52.27	47.42
4	43.18	44.61	53.99	48.40
1973 - 1	44.44	46.10	54.51	49.84
2	46.64	48.65	54.17	50.95
3	49.15	48.39	55.29	51.22
4	49.62	49.36	56.75	51.78
1974 - 1	51.96	51.47	56.67	51.72
2	54.07	55.65	57.18	53.04
3	56.84	58.33	59.42	55.40
4	60.22	58.07	61.23	55.61
1975 - 1	61.05	59.34	61.66	56.31
2	59.04	60.53	62.26	57.67
3	59.11	60.66	63.47	59.41
4	59.26	61.28	64.24	60.52
1976 - 1	58.58	63.21	64.24	61.35
2	69.53	64.49	65.19	62.77
3	63.59	65.98	67.08	64.89
4	63.62	67.35	68.46	66.26
1977 - 1	64.76	68.71	68.63	66.25
2	65.95	70.08	68.72	67.68
3	66.25	72.50	70.10	69.86
4	66.48	73.24	71.30	72.09
1978 - 1	67.53	76.19	71.99	72.34
2	68.02	78.70	73.02	73.68
3	69.70	80.41	75.44	76.44
4	72.38	82.04	76.73	77.43
1979 - 1	75.44	84.81	77.50	78.07
2	78.81	86.92	78.45	79.28
3	83.35	88.42	80.69	83.27
4	84.79	89.26	82.00	85.24
1980 - 1	88.84	91.19	82.50	85.25
2	90.32	91.32	84.05	85.27
3	94.65	93.35	86.63	88.12
4	98.25	94.49	88.70	89.46
1981 - 1	99.34	96.51	90.08	90.24
2	101.00	98.80	91.02	92.89
3	100.68	99.07	94.29	95.49
4	100.40	98.89	96.71	97.18
1982 - 1	99.85	99.68	98.94	98.11
2	99.80	100.08	98.60	98.80
3	99.45	100.21	100.41	101.19
4	100.90	100.03	102.05	101.90

1982 Base (continued)

CYYQ	BEA Defla-tor	BLS Const MTLS	Const. Hourly Wages	ENR
1983 - 1	99.55	101.84	103.08	104.66
2	100.94	103.11	101.70	105.84
3	102.61	104.08	102.22	108.56
4	101.43	104.52	103.16	108.09
1984 - 1	103.44	105.80	101.96	107.79
2	105.49	106.59	103.00	108.34
3	108.05	106.63	103.77	108.61
4	109.47	106.59	104.20	108.54
1985 - 1	109.10	107.12	105.71	108.58
2	109.41	107.85	104.79	108.92
3	109.04	108.33	104.56	110.01

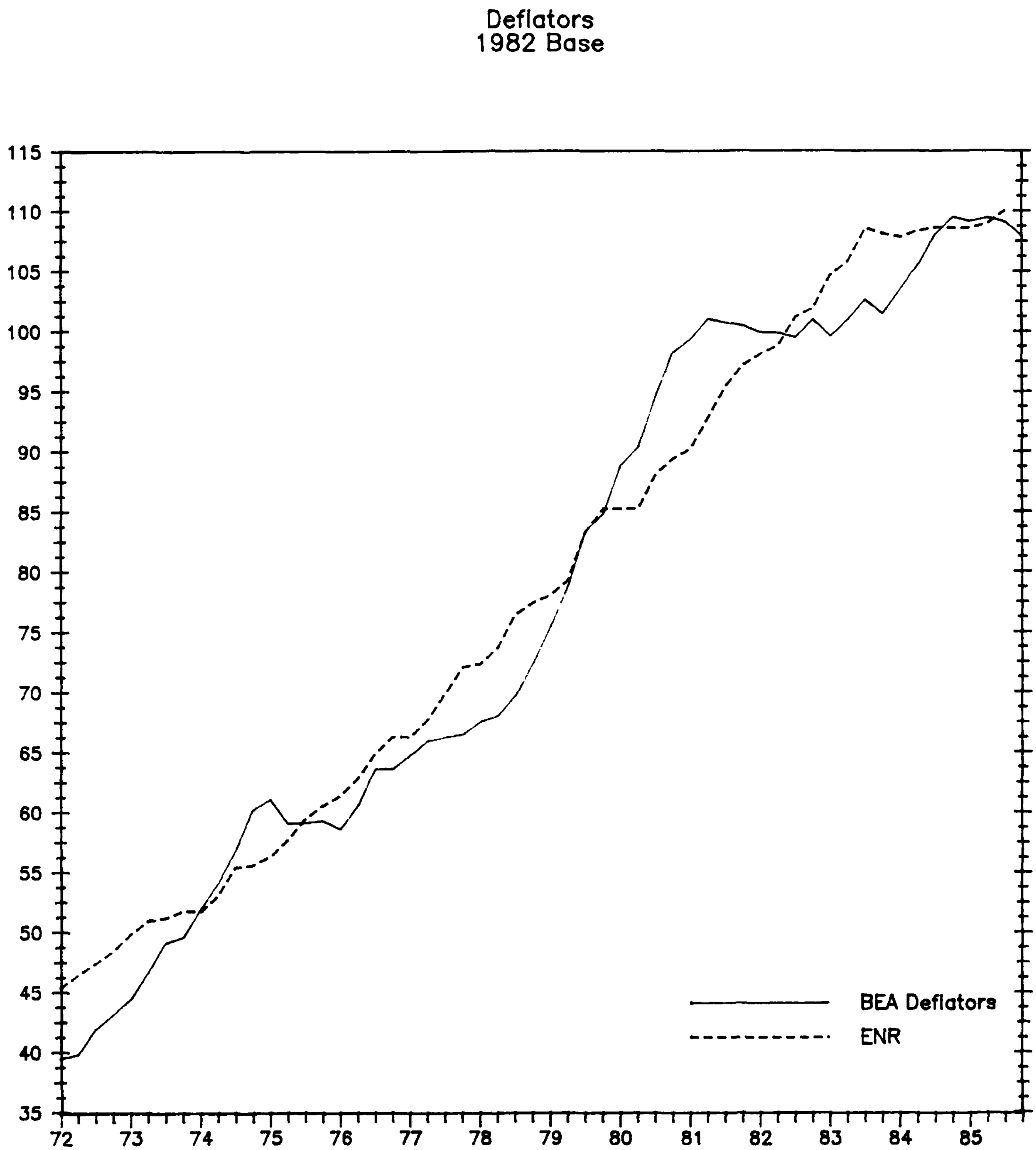
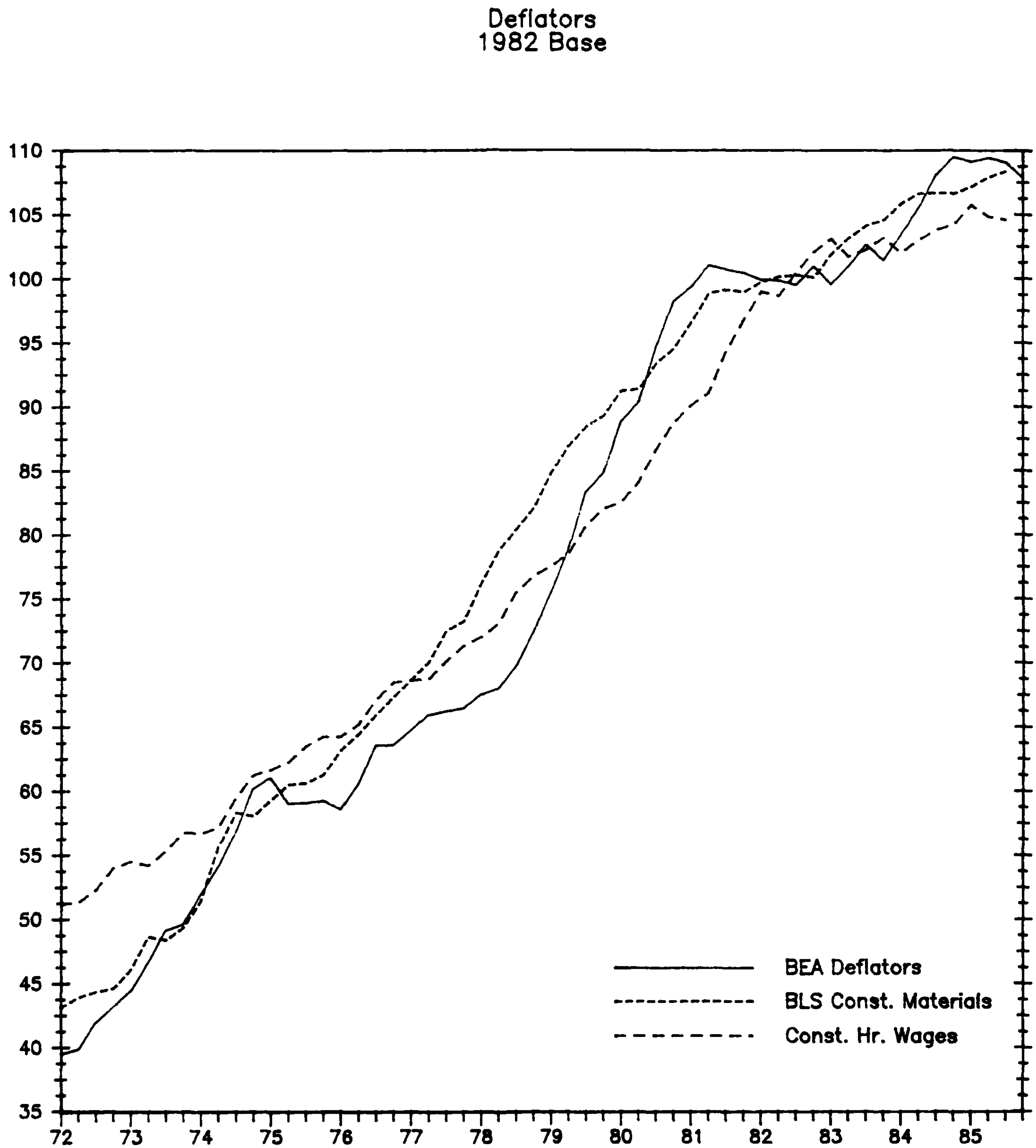

Deflators
1982 Base
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
72
73
74
75
76
77
78
79
80
81
82
83
84
85
BEA Deflators
ENR

FIGURE 1



Deflators
1982 Base
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
72
73
74
75
76
77
78
79
80
81
82
83
84
85
BEA Deflators
BLS Const. Materials
Const. Hr. Wages

FIGURE 2

ENR index, and figure 2, the comparison of the military construction deflator with the construction materials and construction wages indexes.

The ENR index measures price changes of specific inputs of lumber, concrete, steel and wage rates of carpenters, bricklayers, and ironworkers. Specifically it is an input index which measures portions of the inputs to the general construction materials and construction hourly wages indexes shown on figure 2. There are some periods where these input indexes show small decreases and some where they are relatively unchanged. However, they do not show the same fluctuations as the military construction index because they do not account for the impact of exogeneous changes on military construction prices. The impact of these changes over time are easily visible on the tables . For example, from the beginning of 1974 to the middle of 1975, military construction building prices were rising much faster than material and labor prices. When the price for military construction-in-place fell, it took almost four years to reach the level of increase of the input factors and it then rose at a much more rapid rate until the beginning of 1982 when the impact of the last recession was felt on the military pricing structure until the last quarter of 1983 when the prices started upward again at a rapid rate. The plateau in 1985 seems to be due to both a level price structure and incomplete data.

Some of the reasons for the fluctuations in the military construction prices are:

- Change in the economic climate which produced more bidders
- Geographic location of the projects (Severe unemployment areas)
- Changes in labor rates due to unemployment in the construction industry
- Fairly constant material prices due to the increasing value of the dollar in foreign exchange.

° Political considerations concerning location of base expansion

An interesting phenomenon showing the relative independence of the military construction prices in the economy is seen on figure 3. The solid line shows the Bureau of Census reported value of the seasonally adjusted construction-in-place in the United States. The dollar values have been reduced to an index with a 1982 base. Although the amount of construction varies considerably and the same types of skills and materials are used, the activity of the industry in the private sector appears to have little impact on the prices paid for military construction. This leads to the apparent conclusion that there is still considerable labor available at reasonable wages and that the material prices have not increased too greatly through the end of 1984. Figure 2 shows the beginning of the trend to price increases in military construction in 1985.

This observation is confirmed by calculating the yearly increase in the military construction deflator. The following data are based on fiscal years instead of calendar years in order to conform with the Federal budget and appropriation system.

Table 2 - Percent Change in Military Construction Deflator from the Previous Fiscal Year

Fiscal Year	Percent Change from Previous Year	
	BEA	OSD
1981	11.1	8.0
1982	0.2	7.6
1983	1.0	4.9
1984	3.9	3.8
1985	5.3*	3.7

* Preliminary

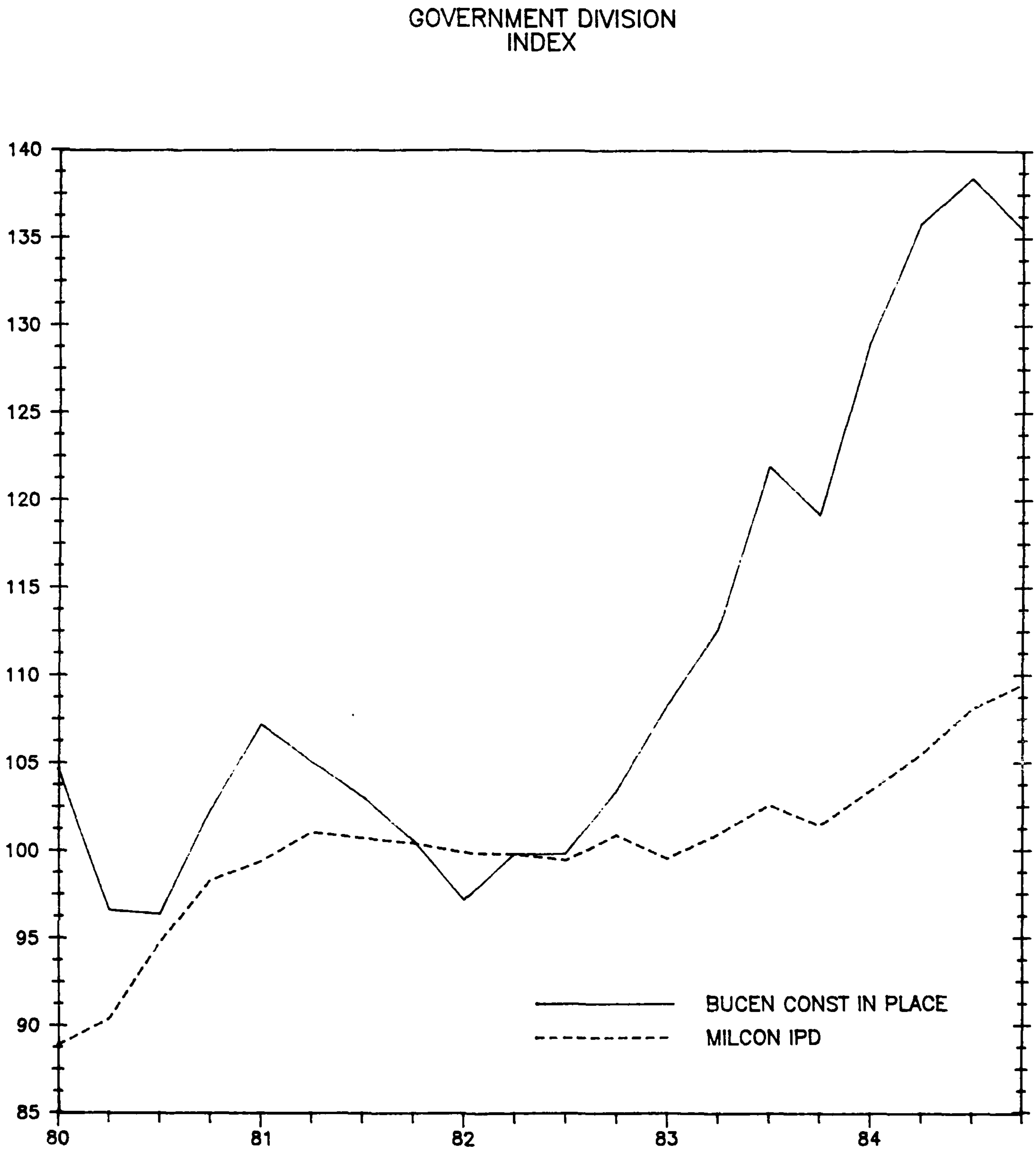
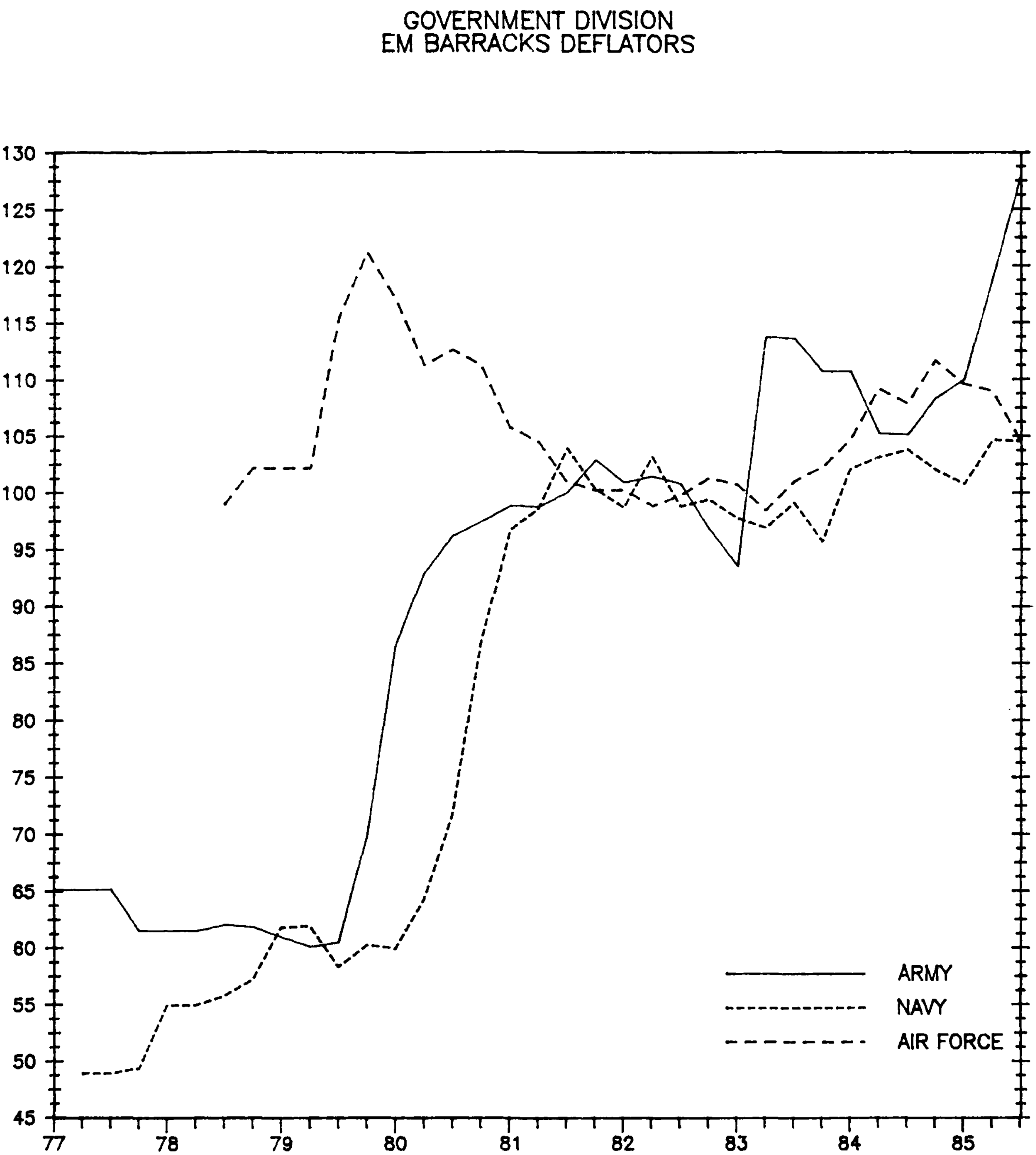

GOVERNMENT DIVISION
INDEX
140
135
130
125
120
115
110
105
100
95
90
85
80
81
82
83
84
BUCEN CONST IN PLACE
MILCON IPD

FIGURE 3


GOVERNMENT DIVISION
EM BARRACKS DEFLATORS
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
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77
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81
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ARMY
NAVY
AIR FORCE

FIGURE 4

GOVERNMENT DIVISION

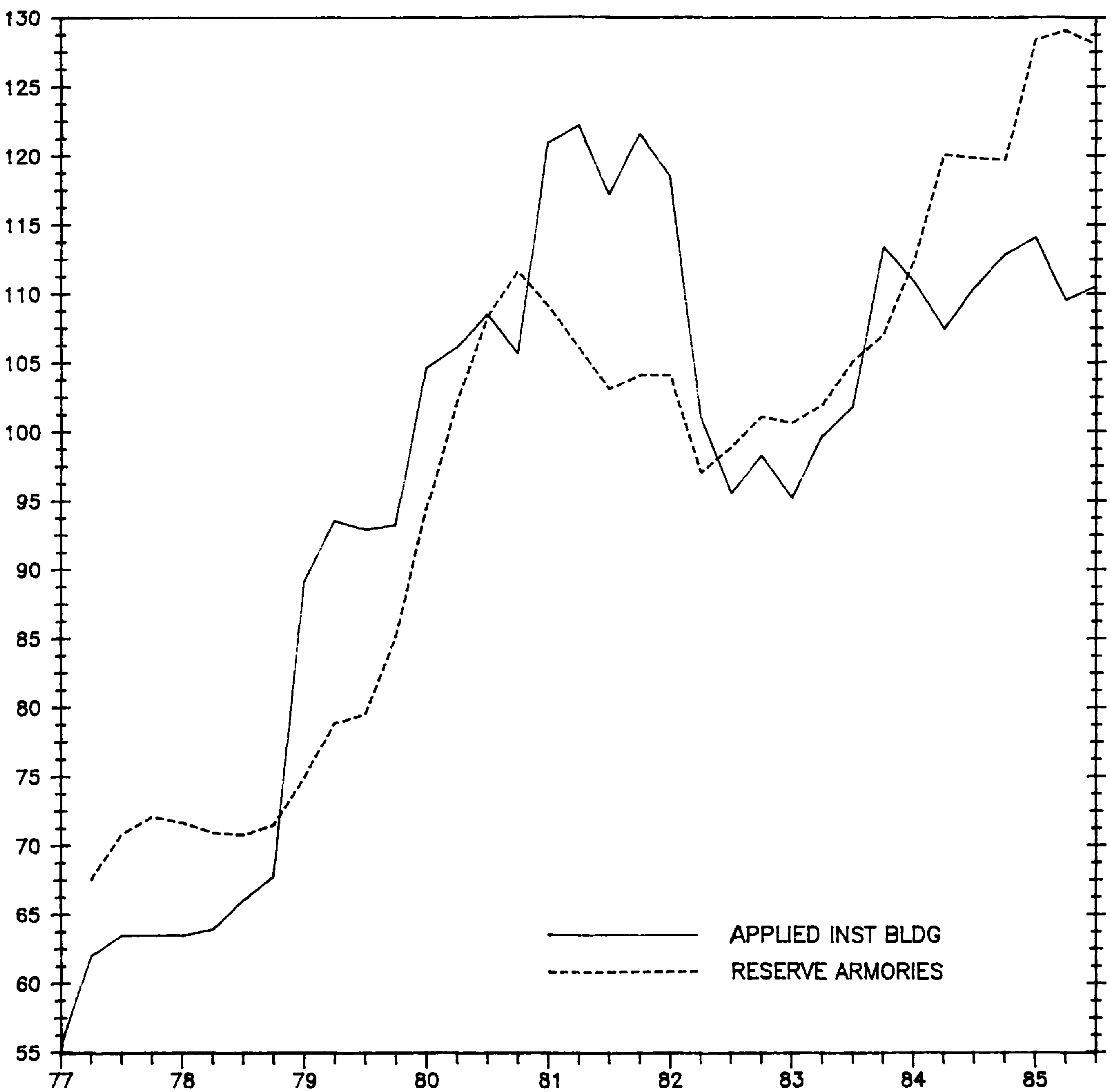

FIGURE 5

MAINTENANCE BUILDINGS

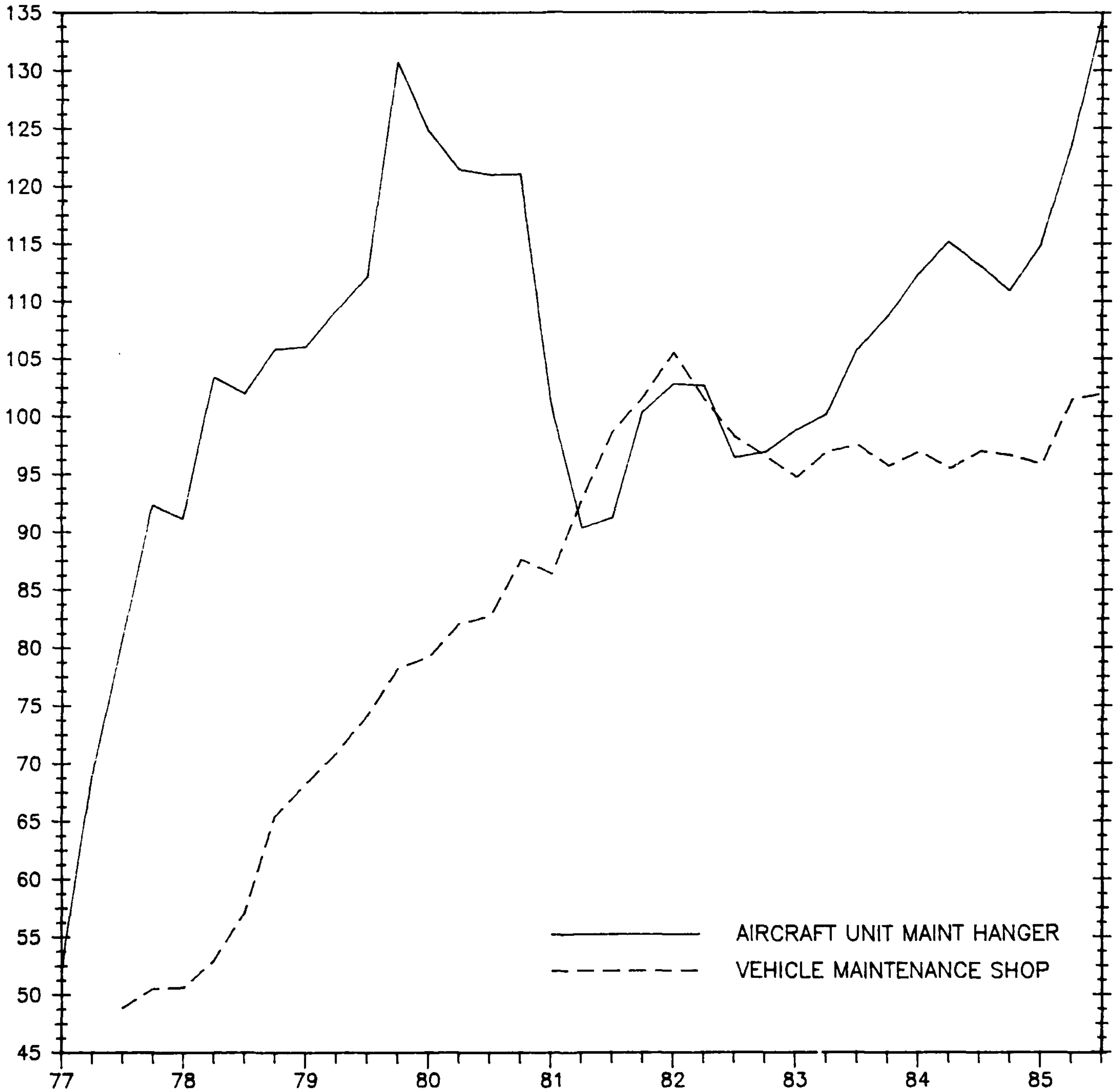

FIGURE 6

MILCON

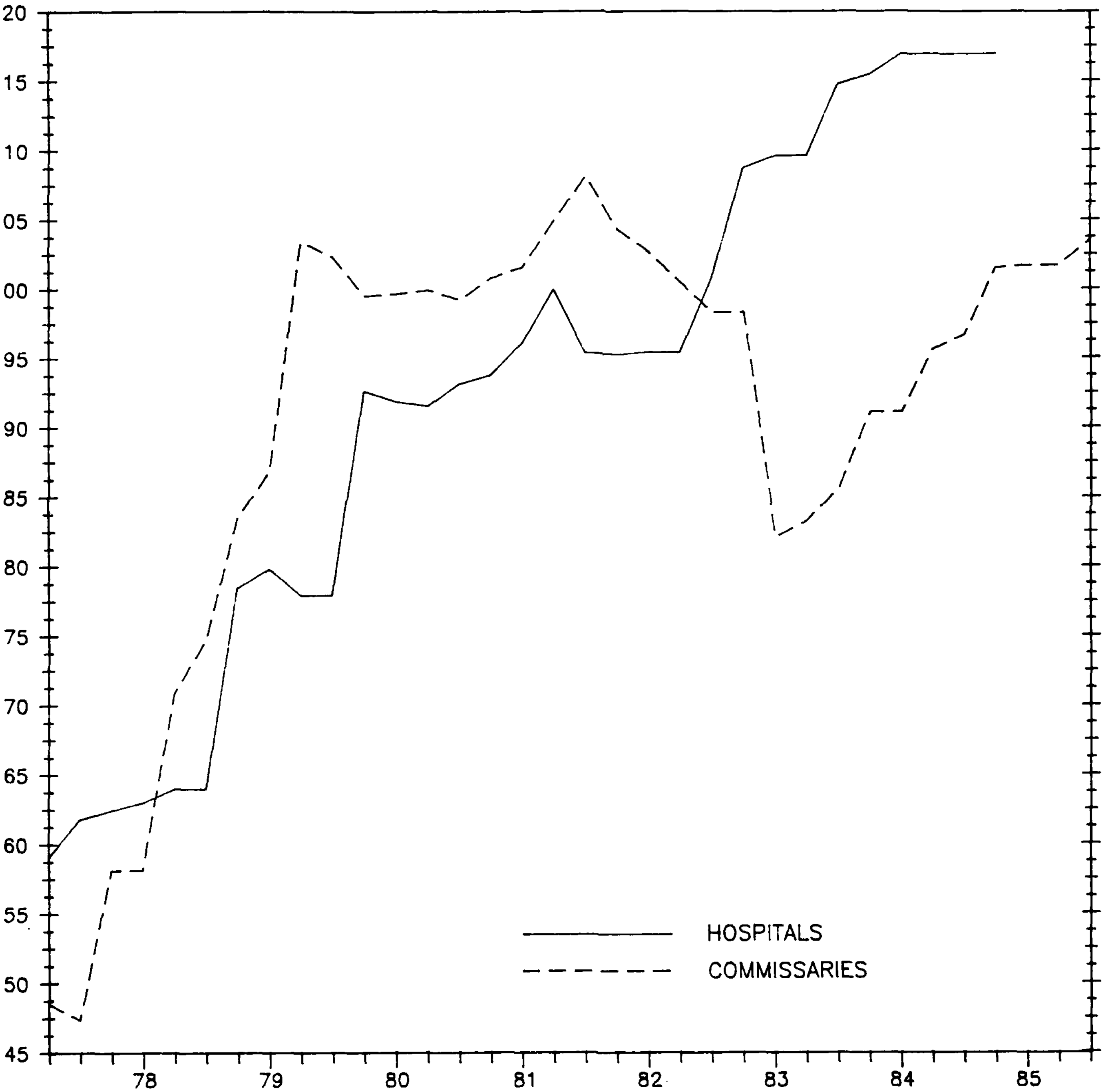

FIGURE 7

It is obvious from the yearly increases that the low bids on projects are increasing at a rate somewhat greater than both the OSD estimate for 1985 and the reported Consumer Price Index for the last two periods. The reported data indicate that the military construction deflator may increase at an even greater rate in the future fiscal years.

Another product which is available from the data files is a deflator for specific types of military construction, i.e. for specific 5-digit category codes. For sake of brevity, the data are not included but the results are shown on figures 4 through 7. Figure 4 shows the variation among enlisted barracks (BEQ) for each of the services. At the present time, each military service has a different specification for its barracks and therefore a different base price and deflator. Figure 5 shows the deflators for Applied Instruction Buildings (Army Category Code 17130) and Reserve Armories (Army Category Code 17140). Figure 6 shows the deflators for two types of maintenance buildings, the Aircraft Unit Maintenance Hangar (Army Category Code 21110) and Vehicle Maintenance Shops (Army Category Code 21410). Figure 7 shows the deflators for Hospitals (Army Category Code 51010) and for Commissaries (Army Category Code 74021). None of these deflators have been normalized for geographic locations. They represent the actual dollars per square foot of construction within the five-foot theoretical building line.

The construction services develop an Area Cost Factor (ACF) in order to compensate for the differing prices due to geographic locations. Their present system is a labor/material factor based on input prices and adjusted for seismic, climatic, weather and other location factors as well as labor availability and labor productivity. The ACF used by the three services is based on data from 144 cities (3 in each state) set equal to 1.00. BEA was asked to develop an output factor based on the actual prices

Table 2. - Selected Area Cost Factors By Military Installation

	EM Barracks (72111)		Vehicle Maint. Shop (21410)	
	ACF 84	ACF 85	ACF 84	ACF 85
Redstone Aresenal, ALA	1.10	1.07	-	-
Ft. Irwin, CAL	1.17	1.14	-	-
Cp. Pendleton, CAL	0.98	1.01	1.10	1.09
El Toro, CAL	1.17	1.18	1.15	1.13
Twenty Nine Palms, CAL	1.20	1.16	1.16	1.14
San Diego, CAL	1.21	1.21	-	-
Ft. Ord, CAL	1.13	1.09		-
Eglin AFB, FLA	-	-	1.04	1.02
Mayport, FLA	1.05	1.05	-	-
Orlando, FLA	1.00	1.06	-	-
Ft. Benning, GA	0.95	0.91	0.95	0.94
Ft. Stewart, GA	0.91	0.88	0.99	0.99
Scott AFB, ILL	-	-	1.14	1.12
Gt. Lakes, ILL	1.10	1.10	-	-
Ft. Ben Harrison, IND	1.27	1.24	-	
Ft. Campbell, KY	0.96	0.93	1.09	1.09
Ft. Polie, LA		-	1.04	1.03
Aberdeen PG, MD	0.96	0.99	-	-
Cherry Pt, NC	-	-	0.87	0.87
Cp. Lejeune, NC	0.82	0.81	0.91	0.89
Ft. Bragg, NC	1.17	1.13	0.96	0.95
New River, NC	0.93	0.89	-	-
Seneca AD, NY	1.28	1.24	-	-
Ft Drum, NY	1.23	1.21	-	-
Ft. Drum, NY	1.23	1.21	0.80	0.79
Ft. Sill, OK	0.76	0.74	1.03	1.02
Charleston, SC	0.93	0.93	-	-
Parris Island, SC	1.01	1.02	-	-
Millington, TENN	1.03	1.03	-	-
Carswell AFB, TEX	-	-	1.01	0.99
Laughlin AFB, TEX	1.02	1.04	-	
Lackland AFB, TEX	0.95	0.98	-	-
Sheppard AFB, TEX	0.94	0.95	-	
Ft. Story, VA	0.89	0.86	1.30	1.29
Quantico, VA	1.05	1.10	-	-
Portsmouth, VA	0.92	0.91	-	
Bremerton, Wash	1.38	1.37	-	-
McChord AFB, Wash	-	-	0.97	0.96

Table 3 - Selected Area Cost Factors by Military Installation

	ACF 84	ACF 85
Camp Pendleton, CAL	1.02	1.02
San Diego, CAL	1.04	1.03
Eglin AFB, FLA	1.00	1.00
Jacksonville, FLA	1.04	1.03
Ft. Benning, GA	0.91	0.92
Ft. Stewart, GA	0.98	0.96
Ft. Riley, KAN	1.10	1.08
Ft. Polk, LA	1.00	1.01
Ft. Drum, NY	1.14	1.13
Cp. Lejeune, NC	0.95	0.94
Ft. Bragg, NC	0.87	0.91
Cherry Point, NC	0.90	0.88
Charleston Navy Sta., SC	1.04	1.02
Parris Island, SC	1.00	1.01
Carswell AFB, TEX	0.99	0.97
Ft. Hood, TEX	1.04	1.03
Bergstrom AFB, TEX	0.98	0.97
Norfolk, VA, Area	1.02	1.01
Bremerton, Wash., Area	1.11	1.09

Table 4 Selected Area Cost Factors By State

State	ACF 84	ACF 85
Alabama	1.01	1.01
California	1.05	1.05
Colorado	1.01	1.03
Florida	1.01	1.00
Georgia	0.98	0.98
Louisiana	1.03	1.02
Maryland	1.06	1.04
New Jersey	1.08	1.06
New York	1.08	1.08
North Carolina	0.93	0.93
Oklahoma	1.05	1.06
South Carolina	1.02	1.01
Texas	1.03	1.03
Virginia	1.02	1.02
Washington	1.08	1.06

in a given area. The BEA ACF averages the price for each category code throughout the conterminous United States for a five-year period and compares the price for each category at a specific installation and state for that category with the national level. It then averages each category level to a total average for all categories at each installation so that there is an ACF for each installation. It also averages the total of each installation to an ACF for each state. Each data piece is presently limited to plus or minus 25-percent of the average national price for each military construction code. The computer program allows adjustment of this factor to any desired range.

Table 2 lists the ACF for enlisted barracks and vehicle maintenance shops for two 5-year periods at selected installations; Table 3 lists the ACF for selected installations for the same period; and table 4 lists the ACF for selected states for the same period. It should be noted that these ACF's show consistency over the reported periods and that they can constitute a check on the input ACF's to determine the reasons for any major inconsistencies.

BEA is not permitted to supply forecasts of the components of the Gross National Product (GNP). These types of forecasts are made by economic analysts such as Data Resources, Incorporated, Chase Econometrics, etc. Therefore, there are software systems which are available commercially that could be used to forecast military construction future trends by category code or by entire program year. In addition, there are several software packages which are adaptable to most computer systems which are able to produce similar forecasts on government-owned computers.

There is a need to improve the accuracy of long-term construction price forecasting in order to evaluate the military construction program for presentation to Congress. Because the initial requirements for budget presentation are done approximately two years before the budget is reviewed by Congress, more accurate forecasting should result in fewer deviations from the appropriations for military construction.

Problems associated with adequate price forecasts have been prevalent since the oil embargo of 1976. At that time prices were rising at the rate of 1-percent each month. This impact on price could not have been foreseen regardless of any forecast model available. Since that time, the greatest impact on military construction prices has been the overview by Congress resulting from passage of the Codification Act, PUblic Law 97-214. From 1978 through 1981, there has been double-digit inflation and high unemployment. Control of inflation with continued unemployment resulted in construction bids by contractors that were between 60-70 percent of the programmed amount. Thus, the construction program costs were inaccurate because the unit prices were considerably lower than estimated.

Military construction designers are able to estimate current prices for labor, materials, equipment and overhead fairly accurately. They are unable to forecast economic conditions which have an impact on overall costs of construction and consequently on the changes in unit prices. Another serious problem exists because military construction is small compared to the total amount of domestic construction. Therefore, use of any standard construction index would not be applicable.[4)] Figure 3 illustrates this problem. The BEA Military Construction Index reflects only the prices paid for military construction-in-place. The Bureau of the Census data show the total amount of domestic construction-in-place on a seasonally adjusted annual rate. This covers a range from approximately

4) Ibid p. 15

$225 billion to $309 billion on an annual basis. The total military program is approximately $3.6 billion on an annual basis. It is true that general business conditions and the price structure for the inputs to military construction are impacted by the construction activity in the private sector. Nevertheless, because the military program is so small compared to the total, an adequate forecast model is essential to adequate estimating so as the reflect the impact on military construction purchases and to increase the accuracy of long-term estimates required for budget presentations.

To understand the problem faced by the military estimates, there follows a brief description of the construction program.

The Military Construction, Army Program has grown in six years from FY 1980 at $.0727 billion to Fy 1985 at $1.593 billion. (Table 5). The Army Program has more than doubled. The low bid current Working Estimate (CWE) versus Programmed Amount (PA) has fallen from 101 percent in FY 1980; dipped to a low of 74 percent in FY 1983; and is at 86.9 percent as of the third quarter of FY 1985. It is significant to note this upturn in CWE/PA. An example of the recent upturn is based on samples of 34 bids received for the Minor Military Construction, Army (MMCA) Program which show a CWE versus PA of 106.9
percent. The peculiarity of this sample is that these projects are estimated and bid within 60-90 days so that the error introduced by long forecasts is minimal. It is indicative of the fact that the "good bids" in FY 1985 are about over. Prices are rising in the construction industry. The Corps of Engineers also is the design-construction agent for :

TABLE 5

FIVE YEAR MCA APPROPRIATIONS AND LOW BID CWE VS. PA

FISCAL YEAR	APPROPRIATIONS	CWE/PA%
1980	$727,399	101.0
1981	900,766	91.0
1982	950,701	75.0
1983	929,700	74.0
(*)	(121,080)	
1984	1,184,140	76.3
**	(95,800)	
(*)	(193,620)	
1985	1,593,137	86.9
(*)	(210,000)	

NOTE:

(*) CONGRESS DIRECTED TO BE FUNDED FROM SAVINGS.

(**) CONGRESSIONAL CUTS.

	costs ($000)
Army Family Housing Program	$45,000
Army Reserve Program	$40,000
Air Force Program	$2,000,000
Military Construction, Army	$1,600,000
Totalling:	$3,680,000

All of these programs are effectd by programming guidance with regard to escalation rates, foreign currency rates of exchange (except the Reserve Program) and changes in the construction market place. For every percentage point in error, $36.8 million dollars of MILCON Program is lost! Table 5 shows that the Congress has directed that the Army provide "savings" to pay for $524,700,000 authorized facilities projects for which no appropriations were received. The Army is starting this new period of increased prices without any savings.

The unit cost for each of 215 category code type of facilities constructed by the Tri-Services can be plotted in respect to time, as illustrated on Figures 4, 5, 6 and 7. The price data have been tracked since 1970 and constitute more than sixty observations by quarters. This data base could be used as source data and by use of commercially available forecast modelling system software, such as Box-Jenkins, ARIMA or any double-regression model, forecasts of future prices for like facilities could be projected to any fiscal year program. This forecast modelling system could also use current Office of the Secretary of Defense (OSD) programming guidance for any out-year program. This method of forecasting could be investigated in FY 1986, with resources provided, and the results shared with the Tri-Services and OSD. These forecast unit prices when combined with the newly developed Area Cost Factors (ACF) could greatly improve the accuracy of MILCON estimates.

The Codification Act passed by the Congress in FY 1984 will have a tremendous influence on the accuracy of cost estimates in the MILCON Program. It is now a requirement that projects submitted to the Congress be at 35 percent design, and that the estimate be based upon that design. Presently, facilities must have as minimum design requirements, a footprint; sections showing foundations, walls, roofs, interior walls, heating, ventilating, and air conditioning sizes; electrical lighting layout, power, communications, and control and alarm requirements; and utility siting requirements - all will be available to the cost engineer for quantification and pricing. From these design data will come estimates with greater accuracy. Some of these estiates are beginning to show up in the MILCON Program bid results. These estimates will not be truly tested until the FY 1986 bids are received. It is expected that these estimates will provide a CWE versus PA of 95 to 100 percent.

There are three procedural changes which, when prices change, would reduce to a tehcnical minimum the loss of funds appropriated for MILCON construction.

- Revise the Authorization/Appropriation cycle to permit authorization the first year (based on concept design estimates) and readjust appropriations the second year (based on final design estimates) just prior to construction advertisement.
- Require the services to provide a prioritized list of projects beyond the budget request to be authorized without appropriations and for which program savings which may accrue can be automatically applied up to the budget request.

° Negotiate Architect - Engineer (A-E) contract to include an incentive clause which would reward/penalize the A-E if the approved CWE based on concept design did not/did exceed the CWE at final design and the CWE at bid opening. The A-E community provides this service to the private sector when they design to cost. This service would assure accuracy of cost estimates and insure against the loss of appropriated dollars.

Although the thought of changing both the budgetary and legal process may seem to be too great a task it is recommended that an ad hoc panel level study this issue and the recommended changes. The A-E incentive contracting authority is presently being studied by OSD; this only needs expansion to all the Tri-Services.

In periods of economic unrest, no one can accurately predict the future. An adequate price forecast model together with the three suggestions may serve as a source of enlightenment which can (1) reduce the loss of authorized MILCON facilities, and (2) greatly increase the accuracy of our budget estimates.

By ABNER SACHS and RICHARD C. ZIEMER

Implicit Price Deflators for Military Construction

DEVELOPMENT of reliable price indexes for construction is a longstanding problem. This article describes recent work in this area that was part of a major project to develop price indexes for national defense purchases. This project, started in the mid-1970's by BEA in cooperation with the Department of Defense (DOD), developed price indexes at a detailed level using data provided by DOD.[1]

In 1980, BEA began showing detail for national defense purchases for the period beginning in 1972. (See, for example in the July 1983 SURVEY OF CURRENT BUSINESS, tables 3.9 (current dollars), 3.10 (constant dollars), and 7.15 (implicit price deflators).) Purchases of structures are shown with a two-way breakdown: military facilities and other.[2] The military facilities component, the subject of this article and hereafter referred to as "military construction," consists of the facilities built to assist, enhance, or house the activities that are required by the military services to accomplish their mission. These facilities, which account for about 1½ percent of national defense purchases, are heterogeneous. They range from office buildings and laboratories, which have private-sector counterparts, to specialized training facilities and ammunition storage igloos, which are unique to the military services. Also, they range in complexity from missile production and maintenance facilities to common lumber storage sheds.

National defense purchases of structures, like other structures components in the national income and product accounts (NIPA's), consist of new construction, on a put-in-place basis, and net purchases of existing structures. In recent years, net purchases of existing structures have accounted for a negligible part of the total. Construction done by DOD employees (force account construction) and DOD purchases of construction materials are not included in purchases of structures; they appear in other national defense components. Because most military construction is done under long-term, firm fixed-price contracts, the put-in-place value will reflect the expected prices of construction material and labor at the time the contract was negotiated and not necessarily the current market prices.

Table 1 shows dollar amounts for selected components of military construction in 1972–82. In most years, troop housing accounts for the largest or second largest amount. With more variation from year to year, training facilities, hospitals and infirmaries, administration buildings, and production facilities account for substantial amounts. The variations in composition reflect—although with a lag because they are on a put-in-place basis—the changes in requirements as evidenced in the annual military construction appropriation. Particularly noticeable are the considerable changes in construction of troop housing, ammunition facilities, and missile system facilities.

Construction prices

Price indexes for the various types of construction not only contribute to the measurement of overall price changes in the economy, but also are needed to prepare constant-dollar estimates of construction and estimates of the value of the stock of structures. The derivation of appropriate price indexes for construction is difficult. A summary of the difficulties appeared in the August 1974 issue of the SURVEY, following a comprehensive examination by BEA and the Bureau of the Census of construction price information.

"The preparation of good prices indexes for the various types of construction is extremely difficult. The essence of price measurement is that a time series of price observations be obtained for products of the same specifications. This is easily done for homogeneous products (coal, sugar, wheat), but the output of construction is one of the most heterogeneous that must be faced in price measurement. Houses are rarely built with the same specifications for more than a year or two; factories, office buildings, and shopping centers are almost never built twice with the same specifications. Hence, the proper measurement of price change in construction is at the 'frontier' and requires special techniques not normally used in preparing price indexes."[3]

Difficulties in the development of price indexes for military construction are exacerbated by the particularly rapid—even abrupt—changes in its composition by type of structure and by the lack of similarity between many military structures and structures built in the private sector.

The 1974 SURVEY article listed six criteria that were developed as part of the comprehensive review to serve as guides in selecting appropriate price indexes. These criteria were used in the development of the military construction price indexes discussed later.

1. A description of the work appears in *Price Changes of Defense Purchases of the United States*, U.S. Department of Commerce, Bureau of Economic Analysis (Washington, D.C.: U.S. GPO, 1979).

2. The "other" component of national defense purchases of structures includes family housing, nuclear fuel production facilities, and net purchases of used structures.

3. "Revised Deflators for New Construction, 1947–73," Survey 54 (August 1974, Part I): 19

Table 1.—Military Construction, by Type of Facility, 1972–82

[Millions of dollars]

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Military construction [1]	970	1192	1253	1093	1550	1585	1644	1667	2128	1960	2323
Troop housing	185	239	249	342	185	50	107	191	211	325	402
Hospitals and infirmaries	70	83	58	68	101	86	84	103	99	111	121
Production facilities	33	36	25	25	28	31	51	115	190	209	190
Maintenance facilities	41	36	60	70	42	60	65	67	58	71	93
Training facilities	40	48	69	70	64	134	110	221	82	99	196
Administration buildings	29	54	55	30	34	75	70	159	151	209	167
Roads and streets	18	11	12	15	8	10	10	67	39	21	21
Airport runways	34	21	14	80	17	27	48	32	15	84	58
Missile system facilities	5	4	2	4	3	11	7	39	117	99	69
Electronic and communication facilities	14	11	10	11	10	23	25	47	61	84	93
Ammunition facilities	4	5	8	12	26	61	68	59	136	40	33
Research and development buildings	24	19	16	24	56	184	61	25	41	52	59
Warehouses	16	18	21	81	19	13	44	63	110	111	72
Other [2]	458	607	652	261	961	821	894	479	818	445	749

1. This total is the "military facilities" component of structures in Table 5.9 of the National Income and Product Accounts in the July 1983 SURVEY OF CURRENT BUSINESS.
2. Includes airfield structures, laboratories, recreational buildings, religious facilities, fuel supply facilities, and other miscellaneous construction.

- "The indexes should represent, as nearly as possible, actual prices paid for the actual products of construction that they are being used to deflate.
- The indexes should be based on data from scientific samples.
- Government agencies should compile the indexes and have the details of the procedures available for review. Where no appropriate Government-compiled index exists, details of the privately compiled index should be readily available.
- The indexes should be available with reasonably good frequency and timing.
- The indexes should represent national price trends.
- The indexes should measure construction with fixed specifications. If the specifications change, the indexes should be adjusted to eliminate the effect of the change."

Index development

The development of the price indexes for military construction was done in three phases: review of existing price indexes, with the conclusion that none were suitable; testing of alternative types of new price indexes, with the conclusion that an output price index was the only type for which the data available were usable; and preparation of the output price index.

Review of existing price indexes.—Some of the available construction price indexes—for example, the *Engineering News Record* (ENR) Building Cost Index—are weighted input price indexes. The ENR index measures price change for certain inputs to construction, such as materials (lumber, concrete and steel) and labor (wage rates for carpenters, bricklayers and ironworkers) rather than prices of outputs. As is typical of input price indexes, it does not allow for changes in the productivity of labor, changes in the composition of materials used, or other technological change. Further, it does not include costs other than materials and labor—for example, shipping costs, overhead, or profit. If price changes for these costs do not move the same way as the measured prices, input price indexes may not accurately reflect the output price of construction. There is no reason to assume that these prices will move the same way and, therefore, this type of index was rejected.

Other types of available construction price indexes, while appropriate for the deflation of private or other government purchases of new construction, were found to be inappropriate for deflation of military construction. Some of these indexes, such as the Federal Energy Regulatory Commission Pipeline Cost Index, were for a type of construction not purchased by the military. In other cases, the indexes reviewed might be considered satisfactory for certain categories of military construction, but these indexes were rejected when an alternative was found that applied specifically to military construction. Following is a brief description of a few of the most popular construction price indexes and the reason for rejecting them.

1. The *Boeckh Index* for commercial and factory buildings is a fixed-weighted index of actual material and labor prices paid by contractors in 20 cities in the United States. It includes overhead costs, sales taxes, insurance costs, social security costs, and profits. It may have applicability to the small number of these types of buildings built by the military, and could have been used if an alternative were not available.

2. The *Turner Index* is based on the construction of a hypothetical 40-story structural steel office building with fixed specifications. It is a modified fixed-weighted index using prices for materials, labor rates, construction loan interest, overhead, and profit. It takes into account changes in productivity and materials. This index was rejected because the techniques used for constructing structures of this height are not applicable to any known military construction projects.

3. The *Federal Highway Administration Composite Index* is a national construction cost index that measures cost changes for furnishing and installing fixed quantities of excavation, concrete and bituminous paving, structural concrete, reinforcing steel, and structural steel for a composite mile of highway construction. Like the *Boeckh Index*, it may have applicability to a small part of military construction and could have been used if an alternative were not available.

Testing of alternative types of new price indexes.—Development of new price indexes seemed to be the only option open. Three types of indexes were examined: an input price index, a hedonic price index, and an output price index. For reasons explained below, the data available did not support the preparation of either a comprehensive input price index or a hedonic price index. In contrast, the data required to support the preparation of an output price index did seem to be available.

A comprehensive input price index is one that—unlike the ENR index but like the Turner Index—would include all inputs to construction, including overhead and profit. The approach that was explored would have drawn upon the documents that contractors are required to submit to DOD for approval. The documents list the quantity and type of materials, unit price, labor hours, wage rates, and other costs. Construction components include items such as painting, drywall finishing, flooring, and roofing. However, review of a substantial number of these documents indicated that the prices listed may not have been those that were actually paid by the contractor, that labor hours were estimated, and, most importantly, not all of the contractors submitted these documents after the contract was awarded.

A hedonic price index is one that calculates the price of a typical good by a multiple regression technique. Regression equations are applied to the price-determining characteristics of a good and its total price. Thus, given the implicit price paid by the purchaser for each of the characteristics, a current price for a fixed set of characteristics can be estimated. Such an index requires comparison of a large number of observations of similar items in one period with a large number of similar items in the base period. Because of the sharp changes in the composition of military construction projects, a sufficient number of observations for any specific type of structure was not available over the necessary period of time.

Preparation of the output price index.—Based on type of use and other characteristics, DOD maintains a very detailed list of categories for the construction it purchases, and each construction project is assigned a category code from this list. Further, for each of these categories, DOD maintains performance specifications. Such specifications relate, for example, for troop housing, to the number of occupants per bathroom and the permissible levels of noise transmission, rather than to whether walls are constructed of lath and plaster or of gypsum board. As a result, the builder of each project is able to bid and use the least costly alternatives for materials, installation, and construction that meet the performance specifications for the finished project. Some variation among individual projects in the same construction category may be allowed. In troop housing, for example, there can be differences in the placement of the bathrooms, in the type of roofing, or in type of curtain walls. The variation must not, however, affect compliance with the performance specifications for that category.

Accordingly, it was possible to use the construction category data, because, with some adjustments to be described, they met the requirement for specification pricing: that the unit being priced have fixed characteristics. The price per physical unit (for example, the price per square foot of troop housing or per cubic yard of runway) was used as the appropriate price. The resulting price index then reflects changes in productivity, capital or labor substitution, profit margins, overhead costs, and regional labor rates.

Among the approximately 850 construction category codes used by DOD, some had not been used and others had very few entries. Of the total, 181 category codes, which encompass approximately 90 percent of the annual purchases of construction, were selected for use in price specification.

The data required to calculate the price index are available from the construction contract and are supplied to BEA on DOD's DD813 reports. An initial report is required by DOD from its contracting offices within 40 days after the award of the contract for the project and a final report is required within 60 days after acceptance of the facility by DOD.[4] The DD813 lists the title of the project; the category code; where the facility is built; the date of contract award; the construction period in days or the completion date; the size of the facility in square feet, barrels, or cubic yards; and dollar cost, separately for the facility, planning (architect/engineer costs), support facilities, and contingencies.

For most categories, there are a large number of observations available each year. However, because of the changes in composition in the military construction programs, the number of yearly observations for a particular category is not consistent. In some cases, gaps occur when no construction in a category occurs for a period of several years. In other cases, the construction program was expanded rapidly, and a large number of projects in specific categories were built. Two examples of the latter resulted from the introduction of the all-volunteer Army and the introduction of new missiles into the inventory. The all-volunteer Army was accompanied by new types of housing—more private rooms instead of open barracks. The introduction of new missiles required a large increase in missile assembly, maintenance, and storage facilities.

Performance specifications for a given category may, of course, change over time. For example, for troop housing, the specification might change from communal baths on each floor to private baths for each room. Under DOD procedures, a significant change in specification must be approved at the headquarters level in Washington, D.C. and concurrence obtained from the appropriate Assistant Secretary of Defense. For any specification change that this procedure signals, an estimate of the cost impact of the change is made by DOD, and that is used by BEA to adjust the unit price. For major specification changes, a new category code is assigned by DOD and the series is linked by BEA into the data base. For example, the policy of training Army Reserve units as an integral part of the Regular Army resulted in the need for a different type of troop housing. These "summer barracks" have much more austere specifications—for example, no heating or air conditioning—than regular barracks.

4. Current-period NIPA estimates of military construction utilize the initial reports and subsequent July revisions utilize the final reports.

The new category for "summer barracks" was linked into the troop housing facility class by BEA.

The unit price used to calculate the index for each construction category is the dollars per square foot (or other unit measure) for a given project. Planning, support facilities, and contingencies are not included in the unit price. Computer programs were developed for data entry and correction, allocation of the total cost throughout the construction period, calculation of the price in the base year (in this case, 1972), and aggregation of the category price indexes. The category price indexes are aggregated to facilities, by type, and to total military construction using current-period weights. This procedure yields implicit price deflators (table 2).[5] (Alternatively, the category indexes may be aggregated using fixed weights. This procedure was used, with 1977 weights, to prepare the fixed-weighted price indexes for purchases of structures introduced in "National Defense Purchases: Detailed Quarterly Estimates, 1977-82" in the November 1982 SURVEY. Further work on fixed-weighted price indexes, including extension of the indexes to years before 1977, is planned.)

The price indexes for military construction meet all six criteria listed earlier:

- Initial data received give the contract price for construction of the facility. When the final construction report is received, the data are corrected to show the actual price paid by the government.
- Universe pricing, rather than scientific sampling, was used. The universe pricing is based on the system of mandatory reporting of construction data to DOD. For recent years, about 90 percent of these data have been incorporated by BEA into the price indexes; the percentage is lower for earlier years.
- The indexes are prepared by BEA. This article serves to describe the broad outlines of the procedure, and a detailed methodological statement is available from BEA.
- The indexes are available quarterly.
- The universe of domestic military construction is included.
- As described, construction categories meet the requirement of fixed specifications. When specifications change, adjustments are made to eliminate the effect of the change.

5 Details of the methodology and programming are available by writing to the Government Division, Bureau of Economic Analysis, U.S. Department of Commerce, Washington, D.C. 20230.

Table. 2—Implicit Price Deflators for Military Construction, 1972-82

Year	1972=100
1972	100.0
1973	115.2
1974	130.7
1975	143.6
1976	144.9
1977	150.3
1978	159.6
1979	183.4
1980	202.8
1981	218.0
1982	217.7

Results

Table 3 shows price indexes for selected military construction categories. The price for construction of troop housing increased slightly more rapidly than did the price for total military construction over the 1972-82 period. Within troop housing, the price for construction of Navy enlisted quarters increased faster than that for Army enlisted quarters—148 percent compared with 138 percent. The difference in the rate of increase may be attributed to geographic influences. Navy facilities generally are constructed in urban coastal areas and Army facilities are constructed in more rural areas. In general, construction costs have risen faster in urban areas. The price for constructing Navy quarters, after declining for a few years, turned up sharply in 1979. The price of Army quarters, which had also been declining, did not turn up until 1980. Several projects were started in those years, as other projects, at lower prices, were being completed. This combination caused prices to rise sharply—23 percent for Navy quarters in 1979 and 58 percent for Army quarters in 1980.

The price for construction of military hospitals increased from 1972 through 1975 at an average annual rate of 9½ percent. After 1975, the price of hospital construction varied some—particulary in 1978—but the 1979 price differed little from the 1975 price. Then, from 1979 to 1982, the price increased at an average annual rate of 12 percent. Similar to troop housing, several major projects—which can take from 3 to 6 years—were started in the early

Table 3.—Price Indexes for Selected Military Construction Categories, 1972-82

[1972=100]

Year	Troop housing		Hospitals and infirmaries		Maintenance facilities		Training facilities		Ammunition facilities
	Bachelor enlisted quarters, Army (.0185)[1]	Bachelor enlisted quarters, Navy (.0341)	Hospitals (.0340)	Dental clinics (.0022)	Military reserve maintenance shops (.0014)	Tactical equipment maintenance shops (.0121)	Applied instruction buildings (.0095)	Reserve training centers (.0095)	Guided missile magazines (.00[illegible])
1972	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	[illegible]
1973	115.2	109.9	118.2	112.7	96.6	105.7	126.7	117.1	.....
1974	129.0	126.2	146.0	135.4	139.9	121.7	151.2	135.9	[illegible]
1975	147.9	154.1	168.9	136.4	167.1	154.7	157.6	135.1	[illegible]
1976	152.2	158.5	169.2	133.1	189.7	165.9	163.0	134.7	[illegible]
1977	147.9	143.7	163.6	146.7	156.0	169.9	176.9	135.6	
1978	141.3	139.2	150.5	170.7	139.5	186.3	192.5	130.6	[illegible]
1979	140.7	171.5	167.2	197.0	179.5	239.1	234.6	143.7	[illegible]
1980	222.4	193.3	215.2	221.6	221.4	277.8	259.7	187.6	[illegible]
1981	227.5	250.5	224.5	268.5	203.[illegible]	317.9	262.7	189.3	[illegible]
1982	237.6	248.1	234.3	253.3	163.[illegible]	326.8	262.4	176.0	[illegible]

NOTE.—Each type of facility shown includes categories other than those shown.

1 The 1982 weight of each category, expressed as a decimal, in total military construction.

1970's and lower priced projects were completed; this combination caused prices to increase sharply in the early 1970's. Few new hospitals were begun after 1975 and the price of construction was relatively flat until 1980, when new hospital construction again picked up.

The price change for construction of dental clinics did not approach that of hospitals until 1978, when the price index for dental clinics was 13½ percent higher than that for hopitals. The price of dental clinics continued to accelerate and by 1982, the price index was 21 percent higher than for hospitals.

The price for construction of reserve maintenance shops increased more rapidly than that for tactical equipment maintenance shops in the 1972-76 period—at an average annual rate of 17½ percent compared with 13½ percent. After 1976, the change in the price for reserve maintenance shops was somewhat erratic, and by 1982, the price index was 14 percent below the index in 1976. However, the price for tactical equipment maintenance shops continued to increase at about the same pace as in the early 1970's, and by 1982 the price index was nearly double the index in 1976.

The price for construction of applied instruction buildings increased continuously, at an average annual rate of 10 percent over the 1972-82 period. Prices increased more rapidly, however, in the first half of the period—at an annual rate of 12 percent—than in the second half—at a rate of 8 percent. In contrast, the price for construction of reserve training centers, although increasing over the entire period at an annual rate of about 6 percent, did show some declines. Two factors may explain the difference in the rate of change in the two indexes: geographic location and complexity of the type of structure. Applied instruction buildings are generally constructed in urban areas and reserve training centers are generally constructed outside urban areas. As stated earlier, in general, construction costs have risen faster in urban areas. Applied instruction buildings are more complex than reserves centers; the former contain built-in equipment necessary for the specialized training. The prices of specialized equipment have, in general, increased more rapidly than basic construction prices.

The price for the construction of guided missile facilities is shown in table 3 to illustrate the abrupt changes that occur in the prices of a type of construction that is unique to the military services. The step increases in the index are indicative of new groups of guided missile magazines being constructed. The magazines are highly sophisticated storage installations that are built intermittently as the need occurs. Because demand for them is not steady and because of the complexity of construction techniques, there are very few bidders for each of these projects—implying little price competition. Also, there is a substantial amount of highly specialized equipment included in the construction of the magazines, and prices for this type of equipment have increased rapidly.

Uses

The flexible computer programs developed for the military construction index produce a wide variety of individual construction category indexes, aggregated deflators for types of facilities, and an overall military construction deflator for each quarter. The overall military construction deflator and category indexes are of substantial interest to agencies directly engaged in planning military construction or in providing oversight. For example, these indexes are regularly provided to the U.S. Army Corps of Engineers, the Naval Facilities Engineering Command, and the DOD Tri-Services Committee on Cost Engineering. The overall military construction deflators are used for forecasting future cost trends and for determining future overall construction budget requirements. The category indexes are used for forecasting price escalation for specific types of construction. In addition, they serve as checks on price abberations. When a particular price is markedly high or low, DOD questions the contracting district to determine the cause.

Future work

The cooperation between BEA and DOD originally worked out in the defense price project continues. The military services are attempting to obtain more timely and complete reporting of projects in order to develop more accurate files of the necessary data. Cooperative arrangements are underway with two DOD agencies to transfer the DD813 information via links between their computer and BEA's. Completely integrated files will permit either the DOD user or BEA to develop programs and results that best suit their needs as well as to do timely checks on the accuracy of the data.

Deflators for overseas construction projects would be of substantial interest, and work on them has started. To date, these projects have not been priced because of the lack of adequate information; in effect, overseas construction has been deflated by the domestic category indexes. The military services (particularly the Corps of Engineers) have informed their overseas construction offices of the requirements for adequate reporting and the methodology to be used. Some data have been received, but the quantity is inadequate for either developing prices for the base year or for coverage of any construction category. The ultimate goal is the development of separate deflators for overseas construction in at least two areas, Europe and the Far East.

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